IEEE

BHI-BSN 2022

IEEE-EMBS INTERNATIONAL CONFERENCE ON BIOMEDICAL AND HEALTH INFORMATICS (BHI'22)
JOINTLY ORGANISED WITH THE IEEE-EMBS INTERNATIONAL CONFERENCE ON WEARABLE AND IMPLANTABLE BODY SENSOR NETWORKS (BSN'22)

Ioannina, Greece | September 27-30, 2022

BHI-BSN 2022 CONFERENCE PROGRAM

Please visit our website for more information!

bhi-bsn-2022.org

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Welcome Letter

Dear Colleagues,

On behalf of the Organizing Committees, we are honored and delighted to welcome you to two flagship conferences of the IEEE Engineering in Medicine and Biology Society (EMBS), the **Biomedical and Health Informatics Conference** and the **International Conference on Wearable and Implantable Body Sensor Networks** (**IEEE BHI-BSN 2022**). This is the 4th time that these two conferences are co-located with a grand vision that jointly, they provide a better forum for exchanging exciting ideas and advances. These conferences will be held at Du Lac Conference Center, Ioannina, Greece from 27 – 30 September, 2022 https://bhi-bsn-2022.org/.

Biomedical and Health Informatics (**BHI)** encompasses methods and systems that communicate and process data to extract information and knowledge for health, healthcare, life sciences and biomedicine. After a series of successful meetings in Hong Kong in Asia, Valencia in Spain, Las Vegas, Orlando and Chicago in the USA, BHI comes in Ioannina, Greece in 2022.

BHI2022 has 7 oral sessions and 10 special sessions covering Biomedical Big Data and AI (Deep Learning and Shallow ML), Clinical Informatics, Public Health Informatics, Translational Bioinformatics, Imaging Informatics, Biomedical Signal Processing and Sensor Informatics, Behavioral Informatics, Mental Health Informatics, Rehabilitation Informatics, Disease Oriented Informatics, Cognitive AI, Intelligent Mixed and Extended Reality, Digital Health and Digital Twin, Precision Systems Medicine, Biomedical Data Harmonization and FHIR, Causal Inference and Explainable AI, Biomedical Data Quality Control and Integration, Reinforcement Learning and Real-Time Decision Making, Federated and Swarm Learning, Edge Computing, Biomedical Data Science and Engineering Education and Multiscale Modeling. The workshop "Co-designing for gender equality: towards gender balance in scientific careers, decision making bodies and R&I content" focuses on the inspiration of women to be the new leaders in the field. One special virtual session will be also held on "AI-driven Informatics, Sensing, Imaging and Big Data Analytics for Fighting the COVID-19 Pandemic" which is organized by BHI2022 based on the relative special issue of the IEEE Journal of Biomedical and Health Informatics.

This year in **BHI2022**, 367 4-page papers have been submitted. After a rigorous peer-review contacted by the **BHI2022** technical program committee 115 4-page paper were accepted (31.3% acceptance rate). Only 11.7% of the submitted papers were selected. 123 1-page abstracts were submitted for poster presentations and 38 special session 1-page abstracts were included in the program.

BSN2022 has 3 oral sessions, featuring papers and presentations covering prototyping of body-worn, ingestible and implantable sensor networks, Novel chemical, biological and textile body sensors, Flexible and/or stretchable electronic sensors and systems, Ultra-low-power or battery-less solutions for longitudinal studies, Machine learning, deep learning and decision support algorithms, Body area communication protocols, models and theories, Security, privacy and trust in body sensor network; and Medical/wellness applications from pre-natal health to elderly care. One special virtual session will be also held on "Innovation and Business Opportunities in Digital Health Technology".

In BSN2022 this year, 63 4-page papers have been submitted. All submissions were reviewed by the BSN2022 technical program committee. 38 4-page papers have been accepted (60.3%) as oral presentations and 12 1-page abstracts were submitted for poster presentation.

BHI2022 and BSN2022 have commonly organized 7 workshops and 3 of these workshops will be hybrid for those who were not able to come due to COVID related restrictions in their countries. Additionally, due to COVID constraints, 4 hybrid oral sessions have been planned including both papers of BHI2022 and BSN2022.

The **BHI2022** and **BSN2022** organizing committees (OCs) greatly appreciate multiple sponsors IEEE, IEEE – EMBS, IEEE Digital Reality, IEEE Digital Privacy, Biomedical Research Institute – Foundation of Research and Technology, Hellas (BRI – FORTH), Unit of Medical Technology and Intelligent Information Systems (MEDLAB) and Rizarios Foundation. We thank also IEEE Journal of Biomedical Health Informatics, IEEE Open Journal of Engineering in Medicine and Biology and General Secretariat of the Region of Epirus, Municipality of Ioannina, Ephorate of Antiquities of Ioannina, Lyceum Club of Greek Women to provide support to BHI, BSN as the fast-growing discipline.

We organized multiple exciting joint events for our participants:

(1) Nine (9) distinguished plenary keynote speakers from academic institutions, the high-tech industry, health care industry, medical society, and government agency to share their insights and accomplishments in research innovation, commercial development, and their vision in future directions in healthcare.

(2) Nine (10) featured sessions and activities are organized to assist participants to excel and grow:
- "Future Trends Panel"
- "Industrial Panel"
- "Industrial Panel"
- "Career Development Panel"
- "Digital Reality Panel"
- "European Health Data Space Panel"
- "Privacy Challenges in the Digital Health Transformation Panel"
- "Meeting with the Editor-in-Chiefs"
- "Technical Committee BHI Meeting"
- "Technical Committee BSN Meeting"
- "EMB/GR meeting"

In addition, we have organized the following to further promote knowledge sharing, innovation, and networking among conference attendees:

(1) All accepted poster papers will be given the opportunity to have an oral presentation in special e-poster sessions.
(2) All posters are accessible through the installed infrastructure.
(3) All papers and posters complying with the conference guideline are eligible for awards selection.
(4) Selected papers of the two conferences will also be invited to submit as a full paper to two flagship journals in the fields: *IEEE Journal of Biomedical and Health Informatics* and *IEEE Open Journal of Engineering in Medicine and Biology*.
(5) Lunches, coffee-breaks, welcome reception, Gala dinner, social events are provided for participants to promote fruitful scientific networking in an informal and relax context.
(6) Irene of Aristophanes will be presented in the ancient theater of Dodona only for the conference's participants.
(7) Four special hybrid tracks are provided for those who were not able to come due to COVID related restrictions in their countries

We want to express our deepest appreciation to the members of the **BHI-BSN** steering committee, **BHI2022** and **BSN2022** organizing committees and technical program committees, as well as to all the reviewers for their dedication and hard work in creating an excellent scientific program. We want to thank all authors who submitted papers, and all of you for being here to take part in BHI-BSN2022 to share your work.

We look forward to meeting you all for this exciting and memorable event!

	BHI2022	BSN2022
Conference Co-Chairs	Dimitris I. Fotiadis, Constantinos S. Pattichis May D. Wang	Paolo Bonato Canan Dagdeviren Emil Jovanov

Editor's Notes & Ethics Statement

The IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI'22) jointly organised with the 18th IEEE-EMBS International Conference on Wearable and Implantable Body Sensor Networks (BSN'22) of the IEEE Engineering in Medicine and Biology Society hosted an electronic paper submission process for the conference. It was the responsibility of the submitting Author to ensure the document was viewable and without errors that would prevent the Conference from including the paper in the Digital Proceedings or Website. In the event a paper was submitted that could not be viewed or printed properly, the Conference elected to only publish the abstract of the paper in the Proceedings. All conference papers were peer-reviewed by experts chosen by the BHI/BSN Conference Editorial Board for all contributed and Special Session papers.

The EMBS AdCom approved the following Code of Ethics to provide a guideline of ethical consideration for all members and to establish its support for ethical conduct in research.

Patients and Human Subjects

1. Respect human dignity and privacy of patients and human subjects.

Information

2. Ensure proper safeguarding of all confidential information, including information pertinent to patients, subjects, commercial entities, and trade secrets.

Environment

3. Promote a culture of cost-effectiveness.
4. Support the preservation of a healthy environment.

Research

5. Engage in research aimed at advancing the contribution of science and technology to improving healthcare provision.
6. Report research results with scientific integrity and proper due credit.
7. Observe the rights of human research subjects and strive for a balance between benefits and potential harm.
8. Ensure a responsible and humane use of animals in research.
9. Conduct clinical research studies in accordance with Good Laboratory Practices (GLP) and Good Clinical Practices (GCP).

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Conference Venue

Du Lac Congress & Spa has become a true landmark of Ioannina city; in a place where the past meets the present, there in the reflection of the lake, and in the living, breathing cultural life of the city. Expertly balancing the modern with the classic, and unpretentiously luxurious, it provides coziness and relaxation for its guests.

Social Event

Date: Wednesday, September 28, 2022

Time: 20:00 – 22:00

Location: The Ancient Theatre of Dodona

Theatrical Performance "Eirini"

Press Release – Summer Tour

«PEACE»
by Aristophanes
Summer Tour in Greece

A play for children and teenagers

"Peace", one of the most anti-war plays of all time, nowadays more relevant than ever, is a hymn to concord, love and altruism. It is presented as a modern fairy tale, utterly connected to the everyday life of today's children and teenagers, social media, videogames, kpop etc., that marginalizes violence, aggression and hatred.

We are living in the era of the corona virus, the era of dozens of war zones, economic depression and a semi-broken education system, following the two years of the pandemic. Trygaeus decides to ride his beetle and travel to Olympus to meet with the gods and ask for their help in order to solve his financial problems. Once he arrives, he sadly finds out that the only god left up there is Hermes. The rest of the gods have left Olympus, because they have gotten mad at humans. Zeus' duties have been passed on to Mr War, who has already succeeded in imprisoning Peace. Mr War's only concern is to make people miserable.

Trygaios returns to earth and looks for allies, so that they can work together to free Peace, along with the help of Justice. Despite the many and successive difficulties they encounter, the liberation of Peace is crowned with success. However, our heroes' adventures continue, as they are have to deal with the new order of things which might be beneficial for the vast majority, but there are still people who are against it.

Aristophanes, through his works, criticizes, satirizes and comments on the current affairs of his time, always aiming to purge the political system and improve society as a whole. This adaptation of "Peace" has been created taking into consideration the interests of children and teenagers. The play is framed by contemporary references that concern today's children, such as social media, health, technology, education, social exclusion and many more. The peaceful message of love and concord, that is emitted through the play, is transmitted through modern elements and examples with which children can identify.

Playwright: Aristophanes
Adaptation: *The Young Quill* Team

Director: Aikaterini Papageorgiou
Scenic and Costume Designer: Elli Embedokli
Original Music: Giannis Hristodoulopoulos
Choreographer: Hrisiis Liatziviri
Music Coaching: Christina Kostea
Lighting Designer: Kostis Mousikos
Assistant Director: Efi Leonida

Actors (alphabetically): Nikos Yalelis, Kostas Koutroulis, Christina Kostea, Tasos Lekas, Fanis Milleounis, George Paterakis

Photographer: Elina Gounanli
Graphic Design: INDIGOCREATIVE
Communication: Elina Lazaridou

Dodona Theater

The theater of Dodona is one of the largest and best preserved ancient Greek theater, with a capacity of approximately 18.000 people. It was built in the 3rd BC. century, by Pyrrhus, king of Epirus. The theater was destroyed twice, by the Aetolians, in 219 BC, and 167 BC, by the Roman general Emilius Pavlos. The monument was initially excavated by the archaeologist K. Karapanos, in 1875-1878. Later, the professor of archeology D. Evagelidis and S. Dakaris (1929-1932) investigated the site, who continued their excavation activity after the Second World War, also contributing to the restoration of the theater.

The huge hollow of the theater was formed in a natural cavity at the foot of Mount Tomaros. The building material of the cave is mainly the micritic off-white limestone, but gray limestone is also found in the construction of the passages, the stage and some seats of the cave. In order to create a larger hollow (135 m diameter), a retaining wall was built around the perimeter with towers on the facade.. Four horizontal aisles divide the hollow into three sections with 55 rows of seats (in total. The two lower sections are divided by stairs into 9 stands and the upper into 18. The towers at the ends of the hollow had stairs for the arrival and departure of the spectators. In the lower section there were seats for official and honored persons (presidency).

The orchestra, built with a center, has the shape of an incomplete circle (diameter 18.70 m). In its periphery there is a drainage channel for rainwater that is led out of the theater into the karst subsoil of the area. In the center, the base of the altar of Dionysus (thymeli) is preserved.

The rectangular stage (31.20 m x 9.10 m) originally had two square backdrops and four pegs in between to support a wooden foreground. On either side were the entrances to the orchestra (alley). After the destruction of the Aitolians (219 BC), the scene acquires a stone foreground with 18 Ionic semi-columns and two auxiliary additions at the ends of the backdrops. Two monumental propylaea with double entrances made of Ionic semi-columns are built in the passageways. Part of the stage to the south is a Doric arcade with eight-sided columns, which communicated with the stage with an arched gate.

In the Augustan years the theater was turned into an arena for beast fights and duels. In its lower part, a wall was built to protect the spectators, which cut off the proscenium and the stage and created an oval arena. The backstage areas were converted into triangular animal-keeping rooms, while a rectangular alcove was constructed in the center of the arena wall to shelter the contestants.

Program at a Glance

Greece Time EEST	Tuesday, September 27, 2022 Workshops			
8:30-17:00	**Registration** (**Room:** FOYER ERATO)			
9:00-10:30	Physical based machine learning in bioengineering and bioinformatics **Organiser:** Nenad Filipovic, University of Kragujevac, Serbia (**Room:** EUTERPI A')	The potential of enabling technologies in tailoring and adapting neuromotor and cognitive rehabilitation in children **Organisers:** Ilaria Bortone, and Lucia Billeci, National Research Council (IFC-CNR), Italy (**Room:** EUTERPI B')	Developing open, standard-based, interoperable Cancer Imaging Repositories in Europe: Issues, Experiences and Challenges and R&I content **Organisers:** Manolis Tsiknakis, FORTH-ICS & Hellenic Mediterranean University, Greece; Karim Lekadir, University of Barcelona, Spain (**Room:** EUTERPI)	Co-designing for gender equality: towards gender balance in scientific careers, decision making bodies and R&I content **Organisers:** Maria Fernanda Cabrera-Umpierrez, Universidad Politecnica de Madrid, Spain; Yolanda Ursa, INMARK, Spain (**Room:** PANDORA B')
10:30-11:00	**Coffee Break** (**Room:** FOYER PANDORA)			
11:00-12:30	Physical based machine learning in bioengineering and bioinformatics **Organiser:** Nenad Filipovic, University of Kragujevac, Serbia (**Room:** EUTERPI A')	The potential of enabling technologies in tailoring and adapting neuromotor and cognitive rehabilitation in children **Organisers:** Ilaria Bortone, and Lucia Billeci, National Research Council (IFC-CNR), Italy (**Room:** EUTERPI B')	Developing open, standard-based, interoperable Cancer Imaging Repositories in Europe: Issues, Experiences and Challenges and R&I content **Organisers:** Manolis Tsiknakis, FORTH-ICS & Hellenic Mediterranean University, Greece; Karim Lekadir, University of Barcelona, Spain (**Room:** EUTERPI)	Co-designing for gender equality: towards gender balance in scientific careers, decision making bodies and R&I content **Organisers:** Maria Fernanda Cabrera-Umpierrez, Universidad Politecnica de Madrid, Spain; Yolanda Ursa, INMARK, Spain (**Room:** PANDORA B')
12:30-13:30	**Lunch** (**Room:** FOYER PANDORA)			
13:30-15:00	Understanding Inner States of Humans using Measurements of “Invisibles” – ”Empatho-Kinaesthetic” **Organisers:** Bjoern M. Eskofier, Anne Koelewijn, and Martin Vossiek, FAU, Germany **Co-Organizers** Daniel Kraus and Falk Pulsmeye, FAU, Germany (**Room:** EUTERPI A')	Enhancing high value care system through knowledge extraction from health care data using process mining techniques **Organisers:** Vicente Traver Salcedo, Universitat Politecnica de Valencia, Spain; Paulo Carvalho, University of Coimbra, Portugal (**Room:** EUTERPI B')	Developing open, standard-based, interoperable Cancer Imaging Repositories in Europe: Issues, Experiences and Challenges and R&I content **Organisers:** Manolis Tsiknakis, FORTH-ICS & Hellenic Mediterranean University, Greece; Karim Lekadir, University of Barcelona, Spain (**Room:** EUTERPI)	Digital health and clinical trials **Organisers:** Paolo Bonato, Harvard Medical School, US; Valeria De Luca, Novartis Institutes for BioMedical Research, US (coffee break will provided in the room) (**Room:** PANDORA B')
15:00-15:30	**Coffee Break** (**Room:** FOYER PANDORA)			
15:30-17:00	Understanding Inner States of Humans using Measurements of “Invisibles” – ”Empatho-Kinaesthetic” **Organisers:** Bjoern M. Eskofier, Anne Koelewijn, and Martin Vossiek, FAU, Germany **Co-Organizers** Daniel Kraus and Falk Pulsmeye, FAU, Germany (**Room:** EUTERPI A')	Enhancing high value care system through knowledge extraction from health care data using process mining techniques **Organisers:** Vicente Traver Salcedo, Universitat Politecnica de Valencia, Spain; Paulo Carvalho, University of Coimbra, Portugal (**Room:** EUTERPI B')	Developing open, standard-based, interoperable Cancer Imaging Repositories in Europe: Issues, Experiences and Challenges and R&I content **Organisers:** Manolis Tsiknakis, FORTH-ICS & Hellenic Mediterranean University, Greece; Karim Lekadir, University of Barcelona, Spain (**Room:** EUTERPI)	
				Location
18:00-20:00	**Opening Ceremony** **Opening - Welcome to Ioannina** **Metin Akay,** EMBS President, University of Houston, USA **Moyses Elissaf,** Mayor of the Municipality of Ioannina, Greece **Savvas Christoforidis,** Director, BRI - FORTH, Greece **BHI 10-Year Anniversary Celebration - Panel: Future Directions in Biomedical Health Informatics** (**Chair: May D. Wang,** Georgia Institute of Technology and Emory Univ., USA) **Metin Akay,** EMBS President, University of Houston, USA; **Yuan-Ting Zhang**, Founding BHI2012 Chair and JBHI Past EiC, City University of Hong Kong, Hong Kong, China; **Stephen T.C. Wong**, Past BHI-TC (2015-2016), and Past BHI (2016) Chair, Houston Methodist and Weill Cornell Medicine; **Andrew F. Laine**, Past EMBS President, Past BHI-TC Chair (2017-2020), Columbia University, USA; **Constantinos Pattichis,** BHI Chair (2021-2022), University of Cyprus, Cyprus; **Panel Discussion:** Future Directions.			**Room: ERATO**

	Welcome To BHI-BSN2022 **Dimitrios I. Fotiadis**, BHI2022 Chair, IEEE JBHI EiC, Univ. of Ioannina, FORTH, Greece; **Paolo Bonato,** BSN2022 Chair, OJEMB EiC, Harvard Medical School, USA (**Room:** ERATO)	
20:00-22:00	**Welcome Reception** (**Room:** CAFE BISTROT LA BUVETTE)	**Venue Restaurant - Swimming Pool**

Program at a Glance

Wednesday, September 28, 2022			
8:30-18:45	**Registration** (**Room:** FOYER ERATO)		
8:30-9:15	**Opening Keynote:** Indoor Radar Sensing of Elderly People: Overcoming the Barriers in Home Care Technology **Prof. George Karagiannides,** ECE Department of Aristotle University of Thessaloniki, Greece **Chair: Constantinos Pattichis,** BHI Chair (2021-2022), University of Cyprus, Cyprus (**Room:** ERATO)		
9:15-10:15	**Industrial Panel** **Moderator: Athos Antoniades**, Stremble Ventures Ltd, Cyprus **Panelists: Anca Bucur**, Philips Research, Netherlands; **Sergio Guillen**, TSB RTLS Systems (My Sphera), Spain; **Nenad Filipovic**, BIORC Ltd., Serbia (**Room:** ERATO)		
10:15-10:30	**Coffee Break** (**Room:** FOYER ERATO)		
10:30-12:00	**BHI Session # 1** Biomedical Signal Processing and Sensor Informatics **Chairs:** Bjoern M. Eskofier, FAU, Germany; George Matsopoulos, National Technical University of Athens, Greece (**Room:** POLYMNIA)	**Special Session** Integrated AI and modelling for disease prediction **Chair**: Nenad Filipovic, University of Kragujevac, Serbia (**Room:** KLEIO)	**Virtual Session # 1** Big Data and AI **Chairs:** Maria Fernanda Cabrera, Tech Univ of Madrid, Spain; Themistoklis Exarchos, Ionian University, Greece (**Room:** PANDORA C')
12:00-13:30	**BSN Session # 1** Intelligent Wearable Sensing Technology **Chairs:** Addythia Saphala, FAU, Germany;Sunghoon Ivan Lee, University of Massachusetts Amherst, USA (**Room:** POLYMNIA)	**Special Session** Advanced AIoT systems for non-communicable diseases **Chairs:** Ming Huang, Nara Institute of Science and Technology, Japan; Toshiyo Tamura,Waseda University, Japan; Xin Zhu, The University of Aizu, Japan (**Room**: KLEIO)	**Virtual Session # 2** Recent Developments in Health Technology (I) **Chairs:** Dimitrios Koutsouris, National Technical University of Athens, Greece; Antonis Sakellarios, University of Ioannina, Greece (**Room:** PANDORA C')
13:30-14:45	**Lunch** **Career Development Panel** **Moderator: Metin Akay**, EMBS President, University of Houston, USA **Panelist: Jeff Armitstead**, ResMed Ltd.; **Valeria De Luca**, Novartis Institutes for Biomedical Research; **Maria Eugenia (Xenia) BELTRÁN**, Universidad Politécnica de Madrid; **May Dongmei Wang,** BHI-TC Chair, Georgia Institute of Technology and Emory Univ.; **Stephen Wong**, Past BHI-TC (2015-2016), and Past BHI (2016) Chair, Houston Methodist and Weill Cornell Medicine; **George Matsopoulos,** National Technical University of Athens, Greece; **Kathy Grise**, IEEE Future Directions Senior Program Director (**Room**: PANDORA A')		
14:45-15:30	**Keynote Lecture (Virtual):** Harnessing ultrasound for modulation of the central and peripheral nervous system **Prof. Elisa Konofagou,** Columbia University, USA **Chair: May D. Wang,** BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA (**Room**: ERATO)		
15:30-17:00	**BHI Session #2** Big Data and AI (I) **Chairs:** Jie Liang, University of Illinois at Chicago, USA; Fahad Saeed, Florida International University, USA (**Room:** POLYMNIA)	**Special Session** Radar-Based Activity Recognition and Health Monitoring **Chairs**: Sevgi Z Zubeyde Gurbuz, University of Alabama, USA (**Room:** KLEIO)	**Digital Reality Panel** (Sponsored by IEEE Future Directions DRI): Driving Improved Health via Technologies – Metaverse, Digital Twins, Intelligent Reality, Immersive Reality, and Leveraging Intelligent Informatics **Moderator:** Kathy Grise, IEEE Future Directions Senior Program Director **Panelists:** Metin Akay, EMBS President, University of Houston, USA; Nicholas Napp, Founder, CEO Xmark Labs; Roberto Saracco, University of Trento; May Dongmei Wang; BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA (**Room:** PANDORA C')
17:00-17:15	**Coffee Break** (**Room:** FOYER ERATO)		
17:15-18:45	**Poster Session # 1 & Reception posters finger food** (**Room:** FOYER ERATO)		
18:45-19:15	**Buses from Venue to Dodona Ancient Theater** (**Location:** ENTRANCE OF THE VENUE)		
20:00-22:00	**Theatrical Performance "Eirini" - Aristophanes, Dodona Ancient Theater** (**Location:** DODONI VILLAGE)		

Program at a Glance

Thursday, September 29, 2022			
8:30-19:30	**Registration** (**Room**: FOYER ERATO)		
8:30-9:15	**Keynote Lecture:** Bioelectronic tools to study the gut-brain axis **Prof. Roisin M. Owens,** Department of Chemical Engineering and Biotechnology, University of Cambridge, Cambridge CB3 0AS, United Kingdom **Chair: Paolo Bonato,** BSN2022 Chair, Harvard Medical School, USA (**Room**: ERATO)		
9:15-10:00	**Keynote Lecture:** AI in Clinical Medicine: Lessons Learned this Decade and Future Paradigm for Clinical Impact **Prof. Anthony C. Chang**, Founder of AIMed, Chief Intelligence and Innovation Officer (CIIO) and Medical Director of the Heart Failure Program, Children's Hospital of Orange County, USA **Chair: May D. Wang,** BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA (**Room**: ERATO)		
10:00-10:15	**Coffee Break** (**Room**: FOYER ERATO)		
10:15-11:45	**BHI Session # 3** Clinical Informatics **Chairs:** George Matsopoulos, National Technical University of Athens, Greece; Toshiyo Tamura, Chiba University, Japan (**Room**: POLYMNIA)	**Special Session** Atherosclerotic Cardiovascular Disease Risk Assessment **Chairs:** Efthyvoulos Kyriacou,Cyprus University of Technology, Cyprus; Spyretta Golemati, National and Kapodistrian University of Athens, Greece (**Room**: KLEIO)	**Virtual Session # 3** Machine learning, deep learning and decision support **Chairs:** Jessilyn Dunn, Duke University, USA; Edward Sazonov, Univ of Alabama, USA (**Room:** PANDORA C')
11:45-13:15	**BSN Session # 2** Developing Novel Body-Worn Sensors **Chairs:** Maximilian Reiser, HAW Landshut, Germany; Rita Paradiso, Smartex s.r.l., Italy (**Room:** POLYMNIA)	**Special Session** European Alliance of Medical and Biological Engineering Society Fellows Class of 2022 **Chairs:** Françoise Peyrin, University of Lyon, France; Jari Hyttinen, University of Technology, Tampere, Finland (**Room:** KLEIO)	**Virtual Session # 4** Biomedical Modeling and Sensor Informatics **Chairs:** Leandro Pecchia, Leandro Pecchia, Universitá Campus Biomedico di Roma, Italy; Dimitrios Koutsouris, National Technical University of Athens, Greece (**Room:** PANDORA C')
13:15-14:15	**Lunch** **European Health Data Space Panel** **Moderator:** Christos N. Schizas, President of the Cyprus National eHealth Authority, Cyprus **Panelists**: **Yiannos Tolias**, Legal Officer, European Commission's DG SANTE; **Dimitris Koutsouris**, Professor of Computer Engineering; **Giuseppe Fico,** Assistant Professor of Biomedical Engineering; **Alexander Berler**, Strategic Business Development Director at IHE Catalyst AISBL; **Minas Kyriakides**, Expert on health data management, National eHealth Authority, Cyprus (**Room:** PANDORA A')		
14:15-15:00	**Keynote Lecture:** Building trustworthy AI systems with reliable components **Prof. Riccardo Bellazzi,** University of Pavia, Italy **Chair: Constantinos Pattichis,** BHI Chair (2021-2022), University of Cyprus, Cyprus (**Room:** ERATO)		
15:00-16:30	**Special Session** Towards the European Health Data Space: Challenges, Opportunities for Biomedical and Health Informatics **Chairs:** Giuseppe Fico, Universidad Politécnica de Madrid, Spain; Francisco Lupiañez-Villanueva,Open University of Catalunya, Spain (**Room:** POLYMNIA)	**Special Session** Biomedical image and signal methods and applications for analysing human abnormal body responses **Chairs**: Fabrizio Pancaldi, University of Modena and Reggio Emilia, Italy; Michalis Zervakis, Technical University of Crete, Greece (**Room:** KLEIO)	**Virtual Session # 5** Recent Developments in Health Technology (II) **Featured Virtual Talk (I)** Designing Digital Tools for ADRDs that Double as Assessments and Interventions **Invited Speaker: Diane Cook**, Washington State University, USA **Chairs:** Themistoklis Exarchos, Ionian University, Greece; Antonis Sakellarios, University of Ioannina, Greece (**Room:** PANDORA C')
16:30-16:45	**Coffee Break** (**Room**: FOYER ERATO)		
16:45-18:30	**Poster Session # 2** (**Room:** FOYER ERATO)		
18:30-19:30	Technical Committee BHI Meeting (Closed Meeting) (**Room:** POLYMNIA)		Technical Committee BSN Meeting (Closed Meeting) (**Room:** KLEIO)
20:00-22:30	**Gala Dinner** (**Room:** Venue Restaurant - Swimming Pool)		

Program at a Glance

Friday, September 30, 2022			
8:30-18:00	**Registration** (**Room**: FOYER ERATO)		
8:30-9:15	**Keynote Lecture (Virtual):** AI-enabled Sensing and Interventions for Global Health. **Prof. Jeffrey Palmer**, Massachusetts Institute of Technology Lincoln Laboratory, USA **Chair: Paolo Bonato,** BSN2022 Chair, Harvard Medical School, USA (**Room:** ERATO)		
9:15-10:00	**Keynote Lecture (Virtual):** Deep Learning based Medical Image Reconstruction **Prof. Dinggang Shen**, School of BME, ShanghaiTech University, China, Shanghai United Imaging Intelligence Co., Ltd., China **Chair: Constantinos Pattichis,** BHI Chair (2021-2022), University of Cyprus, Cyprus (**Room:** ERATO)		
10:00-10:15	**Coffee Break** (**Room:** FOYER ERATO)		
10:15-11:45	**BSN Session #3** Analyzing Wearable Sensor Data Using Machine Learning Algorithms **Chairs:** Giovanni Magenes, University of Pavia, Italy; Clauirton De Albuquerque Siebra,University of Geneva, Switzerland (**Room:** POLYMNIA)	**Special Session** Emerging National EHR System Integration Towards Achieving The European Health Data Space **Chairs:** Costantinos S. Pattichis and Maria Papaioannou, University of Cyprus, Cyprus (**Room**: KLEIO)	**Featured Virtual Talk (II)** Near-human Sensing in Fabric Smart Space **Invited Speaker: Min Chen,** Huazhong University of Science and Technology, China **Chairs**: Manolis Tsiknakis, Hellenic Mediterranean University and FORTH, Greece.; Themistoklis Exarchos, Ionian University, Greece (**Room**: PANDORA C')
11:45-13:15	**BHI Session # 4** Imaging Informatics **Chairs:** Andreas Panayides, Co-founder and R&D Director, 3AE Health LTD (3AHealth), Cyprus; Nenad D. Filipovic University of Kragujevac, Serbia (**Room:** POLYMNIA)	**BHI Session # 5** Big Data and AI (II) **Chairs:** Manolis Tsiknakis, Foundation for Research and Technology Hellas, Greece; Bjoern Eskofier, FAU, Germany (**Room:** KLEIO)	**Privacy Challenges in the Digital Health Transformation Panel** (Sponsored by IEEE Future Directions DPI) **Moderator:** Neeli Prasad, Chair, Healthcare Subgroup, IEEE Digital Privacy Initiative **Panelists:** Dan Bogdanov, Cybernetica; Agata Ferretti, ETH Zurich; Charalampos Z. Patrikakis, University of West Attica; Matthias Simon, University of Bielefeld Medical Center OWL (**Room**: PANDORA C')
13:15-14:15	**Lunch** **Meeting with EiCs:** **Dimitrios I. Fotiadis,** JBHI EiC, Univ. of Ioannina, FORTH, Greece; **Paolo Bonato,** OJEMB EiC, Harvard Medical School, USA (**Room**: PANDORA A')		
14:15-15:45	**Special Session** Artificial intelligence and Real World data for personalised support of patients with cardiovascular diseases **Chairs**: Manolis Tsiknakis, Hellenic Mediterranean University & FORTH-ICS, Greece; Yorgos Goletsis; University of Ioannina, Greece (**Room**: POLYMNIA)	**Special Session** Digital Transformation and Industry 4.0 for Health Technology Management and Clinical Engineering **Chairs**: Giuseppe Fico,Universidad Politécnica de Madrid,Spain; Leandro Pecchia, Universitá Campus Biomedico di Roma, Italy (**Room**: KLEIO)	**General Assembly** (**Room:** PANDORA C')
15:45-17:15	**BHI Session #6** Behavioral, Translational and Public Informatics **Chairs:** Constantinos S. Pattichis, University of Cyprus, Cyprus; Arredondo Waldmeyer, Maria Teresa; Universidad Politécnica de Madrid, Spain (**Room:** POLYMNIA)	**BHI Session # 7** Big Data and AI (III) **Chairs:** Hassan Ghasemzadeh Washington State University, USA; Marios Pattichis, University of New Mexico, USA (**Room:** KLEIO)	**Virtual Session by BSN** Innovation and Business Opportunities in Digital Health Technology **Chairs:** Paolo Bonato, BSN2022 Chair, OJEMB EiC, Harvard Medical School, USA; Ali Hashemi, Managing Director at Polymath Ventures, Colombia (**Room:** PANDORA C')
17:15-17:30	**Coffee Break** (**Room:** FOYER ERATO)		
17:30-18:00	**Closing Ceremony: Best Paper, Best Poster Awards** (**Room:** ERATO)		

Keynote Speakers

Indoor Radar Sensing of Elderly People: Overcoming the Barriers in Home Care Technology

Date: Wednesday, September 28, 2022

Time: 8:30 – 9:15

Location: ERATO

Prof. George Karagiannidis
Aristotle University of Thessaloniki, Greece

Abstract: The use of new technologies in monitoring of elderly people has significantly grown in the last years. Although indoor radar monitoring is still in its early stage of development, it carries great potential to be one of the leading technologies in the future. In this presentation, the basics and the advantages of indoor radar sensing, compared to other existing technologies as cameras and wearable devices, will be provided and discussed.

CV: Dr. George K. Karagiannidis was born in Pithagorion, Samos Island, Greece. He received the University Diploma (5 years) and PhD degree, both in electrical and computer engineering from the University of Patras, in 1987 and 1999, respectively. From 2000 to 2004, he was a Senior Researcher at the Institute for Space Applications and Remote Sensing, National Observatory of Athens, Greece. In June 2004, he joined the faculty of Aristotle University of Thessaloniki, Greece where he is currently Professor in the Electrical & Computer Engineering Dept. and Head of Wireless Communications & Information Processing (WCIP) Group. He is also Honorary Professor at South West Jiaotong University, Chengdu, China.

His research interests fall in the broad area of Digital Communications Systems and Signal processing, with emphasis on Wireless Communications, Optical Wireless Communications, Wireless Power Transfer and Applications and Communications & Signal Processing for Biomedical Engineering.

Dr. Karagiannidis has published and presented more than 550 technical papers in scientific journals and international conferences. His work has received more than 28000 citations, with h-index=89 (Source: Google Scholar).

Dr. Karagiannidis has been involved as General Chair, Technical Program Chair and member of Technical Program Committees in several IEEE and non-IEEE conferences. In the past, he was Editor in several IEEE journals and from 2012 to 2015 he was the Editor-in Chief of IEEE Communications Letters. Currently, he serves as Associate Editor-in Chief of IEEE Open Journal of Communications Society. He is an IEEE Fellow, recognized for his “Contributions to the performance analysis of wireless communication systems”. He is one of the most highly-cited authors across all areas of Electrical Engineering, recognized as Web-of-Science Highly Cited Researcher in the last seven consecutive years 2015-2021.

Harnessing ultrasound for modulation of the central and peripheral nervous system

Date: Wednesday, September 28, 2022

Time: 14:45 – 15:30

Location: ERATO

Prof. Elisa E. Konofagou
Columbia University, USA

Abstract: Focused ultrasound (FUS) neuromodulation has previously been proposed as a promising technique to drive neuronal activity and has been shown throughout a breadth of applications including in mice, rats, non-human primates and humans as a novel technique for the noninvasive manipulation of neuronal activity using ultrasound. Our group and others have demonstrated excitation of both the central (CNS) and peripheral nervous system (PNS). In the CNS, motor- and cognitive-related brain regions of mice were induced by targeting specific brain structures. Higher acoustic pressures increased the success rate. Pupil dilation was observed when neuromodulating regions in the brain covering the superior colliculus and other anxiety-related structures such as hippocampus and locus coeruleus. In the PNS, we showed for the first time stimulation of the sciatic nerve with FUS eliciting a physiological motor response was recorded in vivo. Clipping the sciatic nerve downstream of stimulation eliminated EMG activity during FUS stimulation. Peak-to-peak EMG responses and latencies were comparable to conventional electrical stimulation methods. Histology along with behavioral and thermal testing did not indicate damage to the nerve or surrounding regions. Finally, underlying mechanisms on the Piezo2 channel and clinical studies on pain mitigation will be shown. Our studies demonstrate the capability of FUS to modulate target specific regions in both the brain and the periphery with several potential clinical applications.

CV: Elisa Konofagou is the Robert and Margaret Hariri Professor of Biomedical Engineering and Professor Radiology as well as Director of the Ultrasound and Elasticity Imaging Laboratory at Columbia University in New York City. Her main interests are in the development of novel elasticity imaging techniques and therapeutic ultrasound methods and more notably focused ultrasound in the brain for drug delivery and stimulation, myocardial elastography, electromechanical and pulse wave imaging, harmonic motion imaging with several clinical collaborations in the Columbia Presbyterian Medical Center and elsewhere. Elisa is a Member of the National Academy of Medicine, an Elected Fellow of the American Institute of Biological and Medical Engineering, a member of the IEEE in Engineering in Medicine and Biology, IEEE in Ultrasonics, Ferroelectrics and Frequency Control Society, the Acoustical Society of America and the American Institute of Ultrasound in Medicine. She has co-authored over 250 published articles in the aforementioned fields. Prof. Konofagou is also a technical committee member of the Acoustical Society of America, the International Society of Therapeutic Ultrasound, the IEEE Engineering in Medicine and Biology conference (EMBC), the IEEE International Ultrasonics Symposium and the American Association of Physicists in Medicine (AAPM). Elisa serves as Associate Editor in the journals of IEEE Transactions in Ultrasonics, Ferroelectrics and Frequency Control, Ultrasonic Imaging and Medical Physics, and is recipient of awards such as the CAREER award by the National Science Foundation (NSF), the Nagy award by the National Institutes of Health (NIH) and the IEEE-EMBS Technological Achievement Award as well as additional recognitions by the American Heart Association, the Acoustical Society of America, the American Institute of Ultrasound in Medicine, the American Association of Physicists in Medicine, the Wallace H. Coulter foundation, the Bodossaki foundation, the Society of Photo-optical Instrumentation Engineers (SPIE) and the Radiological Society of North America (RSNA).

Bioelectronic tools to study the gut-brain axis

Date: Thursday, September 29, 2022

Time: 8:30 – 9:15

Location: ERATO

Prof. Roisin M. Owens
University of Cambridge, United Kingdom

Abstract: Polymeric electroactive materials and devices can bridge the gap between hard inflexible materials used for physical transducers and soft, compliant biological tissues. An additional advantage of these electronic materials is their flexibility for processing and fabrication in a wide range of formats. In this presentation, I will discuss our recent progress generating 3D conducting polymer devices, to simultaneously host and monitor complex multi-cellular models of tissues and organs. Electrophysiological recording of parameters such as tissue impedance, epithelial and endothelial barrier tissue integrity and neuronal activity, are all made possible thanks to the conducting polymer devices and are validated with traditional biological readouts such as immunofluorescence or cytokine analysis. Building on our previous work that showcased a bioelectronic model of the human intestine, we are now incorporating elements of the microbiome and the immune system as well as the enteric nervous system. Coupling this model with our model of the neuro-vascular unit (including blood brain barrier) currently in progress, will bring us to our goal of a physiologically representative in vitro model of the gut-brain-microbiome axis. Alongside our in vitro work, I will show how our recent work on developing electronic probes to study the enteric nervous system. Transitioning from in vitro human and rat to in vivo rat models allows us to integrate electrophysiological recordings of neuronal activity with tissue impedance to really begin to unravel gut-brain axis signaling.

CV: Róisín M. Owens is Professor of Bioelectronics at the Dept. of Chemical Engineering and Biotechnology in the University of Cambridge and a Fellow of Newnham College. She received her BA in Natural Sciences (Mod. Biochemistry) at Trinity College Dublin, and her PhD in Biochemistry and Molecular Biology at Southampton University. She carried out two postdoc fellowships at Cornell University, on host-pathogen interactions of Mycobacterium tuberculosis in the dept. of Microbiology and Immunology with Prof. David Russell, and on rhinovirus therapeutics in the dept. of Biomedical Engineering with Prof. Moonsoo Jin. From 2009-2017 she was a group leader in the dept. of bioelectronics at Ecole des Mines de St. Etienne, on the microelectronics campus in Provence. Her current research centers on application of organic electronic materials for monitoring biological systems in vitro, with a specific interest in enhancing the biological complexity and adapting the electronics to be fit for purpose. She has received several awards including the European Research Council starting (2011), proof of concept grant (2014) and consolidator (2016) grants, a Marie Curie fellowship, and an EMBO fellowship. She currently serves as co-I and co-director for the EPSRC CDT in Sensor Technologies, renewed in 2019. She is a 2019 laureate of the Suffrage Science award. From 2014-2020, she was principle editor for biomaterials for MRS communications (Cambridge University Press), and she serves on the advisory board of Advanced BioSystems and Journal of Applied Polymer Science (Wiley). In 2020 she became Scientific Editor for Materials Horizons (RSC). She is author of 100+ publications and 2 patents and her work has been cited more than 6000 times.

Current and Future of AI in Clinical Medicine: Lessons Learned this Decade and Future Paradigm for Clinical Impact

Date: Thursday, September 29, 2022

Time: 9:15 – 10:00

Location: ERATO

Dr. Anthony Chang
Chief Intelligence and Innovation Officer (CIIO) and Medical Director of the Heart Failure Program at Children's Hospital of Orange County, AIMed Founder, USA

Abstract: Artificial intelligence has gradually been introduced and adopted in the clinical medicine realm, but the clinical impact has not been as big as it was hoped. Among the issues include: lack of continual clinician/data scientist synergy, inadequate data and IT infrastructure, failure to maintain AI models that have generalizability, inadequate education for clinicians and administrators, and too little appreciation for the complexities of clinical medicine and decision making. The future of clinical medicine needs to have much stronger clinician involvement and direction so the level of cognition will be much higher. This future paradigm will need to involve AI technologies such as reinforcement learning and digital twins.

CV: Dr. Chang attended Johns Hopkins University for his B.A. in molecular biology prior to entering Georgetown University School of Medicine for his M.D. He then completed his pediatric residency at Children's Hospital National Medical Center and his pediatric cardiology fellowship at the Children's Hospital of Philadelphia. He then accepted a position as attending cardiologist in the cardiovascular intensive care unit of Boston Children's Hospital and as assistant professor at Harvard Medical School. He has been the medical director of several pediatric cardiac intensive care programs (including Children's Hospital of Los Angeles, Miami Children's Hospital, and Texas Children's Hospital). He served as the medical director of the Heart Institute at Children's Hospital of Orange County. He is currently the Chief Intelligence and Innovation Officer (CIIO) and Medical Director of the Heart Failure Program at Children's Hospital of Orange County. He has also been named a Physician of Excellence by the Orange County Medical Association and Top Cardiologist, Top Doctor for many years as well as one of the nation's Top Innovators in Healthcare. He has completed a Masters in Business Administration (MBA) in Health Care Administration at the University of Miami School of Business and graduated with the McCaw Award of Academic Excellence. He also completed a Masters in Public Health (MPH) in Health Care Policy at the Jonathan Fielding School of Public Health of the University of California, Los Angeles and graduated with the Dean's Award for Academic Excellence. Finally, he graduated with his Masters of Science (MS) in Biomedical Data Science with a subarea focus in artificial intelligence from Stanford School of Medicine and has completed a certification on artificial Intelligence from MIT. He is a computer scientist-in-residence and a member of the Dean's Scientific Council at Chapman University. He has helped to build a successful cardiology practice as a startup company and was able to complete a deal on Wall Street. He is known for several innovations in pediatric cardiac care, including introducing the cardiac drug milrinone and co-designing (with Dr. Michael DeBakey) an axial-type ventricular assist device in children. He is a committee member of the National Institute of Health pediatric grant review committee. He is the editor of several textbooks in pediatric cardiology, including Pediatric Cardiac Intensive Care, Heart Failure in Children and Young Adults, and Pediatric Cardiology Board Review.

Building trustworthy AI systems with reliable components

Date: Thursday, September 29, 2022

Time: 14:15 – 15:00

Location: ERATO

Prof. Riccardo Bellazzi
University of Pavia, Italy

Abstract: AI medical systems, designed to support diagnosis, therapy planning and monitoring, have a long history, but recently they received a renewed strong attention due to the advancements in machine and deep learning and to the large and increasing availability of digital data. The need of protecting citizens, providing them with safeguards against misuse of AI approaches, and in particular of data-driven technologies, has pushed towards the implementation of “trustworthy” AI systems, lawful, ethical and robust. This talk will discuss how components, based on reliability principles, may provide the basis for the design and implementation of successful AI solutions. Finally, the talk will advocate that only a proper socio-technical approach will eventually provide trustworthy systems.

CV: Riccardo Bellazzi is Full Professor of Bioengineering and Biomedical Informatics at the University of Pavia. He is the Director of the Department of Electrical, Computer and Biomedical Engineering of the University of Pavia. Moreover, he leads the Laboratory of biomedical informatics at the hospital “Salvatore Maugeri” in Pavia. The scientific interests of Prof. Bellazzi are highly interdisciplinary and are aimed at applications of informatics to medicine and life sciences, comprising artificial intelligence, biomedical data mining, telemedicine, temporal data analysis, decision support, clinical research informatics. Prof. Bellazzi has a wide and internationally recognized research activity. In 2000 he founded the working group on “Intelligent Data Analysis and Data Mining” of the International Association of Medical Informatics (IMIA). In 2009 he became a Fellow of the American College of Medical Informatics for his international achievements. He is a Founding Fellow of the International Academy of Health Sciences Informatics (IAHSI), and he was Vice-President for Medinfo of IMIA in the period 2011-2014. He is and was involved in several EU-funded projects related to IT in medicine and bioinformatics. He is a member of the editorial board of the journals “Methods of Information in Medicine”, “Journal of the American Medical Informatics Association”, “International Journal of Biomedical Informatics”, “Journal of Diabetes Science and Technology “and former Associate Editor of the “Journal of Biomedical Informatics”. Prof. Bellazzi is author of more than 230 publications on international peer reviewed journals and of than 250 publications in proceedings of international conferences. Finally, he is co-founder of the academic spin-offs Biomeris, which implements software to support clinical research, and Engenome, which is specialized on the analysis of Next Generation Sequencing data with AI approaches.

AI-enabled Sensing and Interventions for Global Health

Date: Friday, September 30, 2022

Time: 8:30 – 9:15

Location: ERATO

Prof. Jeffrey Palmer
Massachusetts Institute of Technology Lincoln Laboratory, USA

Abstract: The challenges and opportunities to improve the global health cycle are at critical inflection points under the strain of a world-wide pandemic, international conflict, and large-scale environmental disasters. AI-enabled sensing, decision support, and actions can leverage the enormous data generated and consumed through the global health steps of monitoring, diagnosis, intervention, training, prevention, and informing the public. This presentation will discuss how body sensor networks and health informatics platforms can work in concert with population-level and environmental sensing to assess health threat phenomenology, exposure dosimetry, medical intervention efficacy. These advances can be used to scale interventions, guide health and emergency response policy, enhance training of healthcare providers and first responders, and more effectively engage the public.

CV: Dr. Jeffrey S. Palmer is the Assistant Head of the Biotechnology and Human Systems Division at MIT Lincoln Laboratory. He shares responsibility for research, development, evaluation, and technology transfer in chemical and biological defense, human health & performance, and global resilience to climate, conflict, and disaster threats. Previously, he was the leader of the Human Health & Performance Systems Group that focused on AI-enabled biomedical tools, human performance enhancement, objective neurocognitive analytics, and biosensing via wearable, ingestible, and implantable devices. He has served on editorial boards for journals in biomechanics, molecular science, biomedical informatics, and biosensors. He is a Senior Member of the IEEE, past chairman of the IEEE EMBS Technical Committee on Wearable Biomedical Sensors and Systems and on the editorial board for the IEEE OJEMB. He has served on international studies for enhancing health and performance. He currently serves on the faculty for the NIH RADx initiative and a NASEM standing committee. He holds a B.S. from New Mexico State Univ., an M.S. from Rensselaer Polytechnic Institute, and a Ph.D. (minor in bioengineering) from MIT, all in mechanical engineering.

Deep Learning based Medical Image Reconstruction

Date: Friday, September 30, 2022

Time: 9:15 – 10:00

Location: ERATO

Prof. Dinggang Shen
Shanghaitech University, China

Abstract: This talk will introduce various deep learning methods we developed for fast MR acquisition, low-dose CT reconstruction, and low-cost and low-dose PET acquisition. The implementation of these techniques in scanners for real clinical applications will be demonstrated. Also, comparisons with state-of-the-art acquisition methods will be discussed.

CV: Dinggang Shen is Jeffrey Houpt Distinguished Investigator, and a Professor of Radiology, Biomedical Research Imaging Center (BRIC), Computer Science, and Biomedical Engineering in the University of North Carolina at Chapel Hill (UNC-CH). He is currently directing the Center for Image Analysis and Informatics, the Image Display, Enhancement, and Analysis (IDEA) Lab in the Department of Radiology, and also the medical image analysis core in the BRIC. He was a tenure-track assistant professor in the University of Pennsylvanian (UPenn), and a faculty member in the Johns Hopkins University. Dr. Shen's research interests include medical image analysis, computer vision, and pattern recognition. He has published more than 900 papers in the international journals and conference proceedings, with H-index 84. He serves as an editorial board member for eight international journals. He has also served in the Board of Directors, The Medical Image Computing and Computer Assisted Intervention (MICCAI) Society, in 2012-2015, and will be General Chair for MICCAI 2019. He is Fellow of IEEE, Fellow of The American Institute for Medical and Biological Engineering (AIMBE), and also Fellow of The International Association for Pattern Recognition (IAPR).

Industrial Panel

Chair: Athos Antoniades, Stremble Ventures Ltd, Cyprus

Date: Wednesday, September 28, 2022

Time: 9:15 – 10:15

Location: ERATO

Athos Antoniades, Stremble Ventures Ltd, Cyprus

Anca Bucur, Philips Research, Netherlands

Sergio Guillen, TSB RTLS Systems (My Sphera), Spain

Nenad Filipovic, BIORC Ltd., Serbia

Career Development Panel

Chair: Metin Akay, EMBS President, University of Houston, USA

Date: Wednesday, September 28, 2022

Time: 13:30 -14:45

Location: PANDORA A'

Metin Akay, EMBS President, University of Houston, USA

George Matsopoulos, National Technical University of Athens, Greece

Jeff Armitstead, ResMed Ltd., Australia

Valeria De Luca, Novartis, Switzerland

Maria Eugenia (Xenia) BELTRÁN, Universidad Politécnica de Madrid, Spain

May Dongmei Wang, BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA

Stephen T. C. Wong, Houston Methodist Hospital - Weill Cornell Medicine, USA

Kathy Grise, IEEE Future Directions Senior Program Director

Digital Reality Panel

Chair: Kathy Grise, IEEE Future Directions Senior Program Director

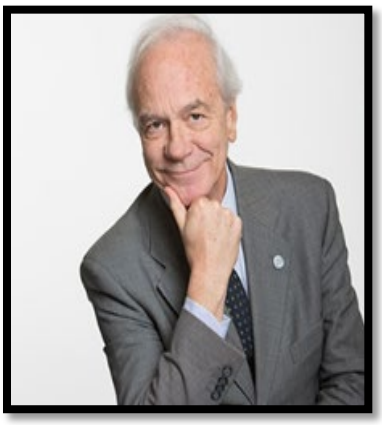
Date: Wednesday, September 28, 2022

Time: 15:30 – 17:00

Location: PANDORA C'

Kathy Grise, IEEE Future Directions Senior Program Director

Nicholas Napp, Founder, CEO Xmark Labs, USA



Roberto Saracco, University of Trento, Italy

May Dongmei Wang, BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA

Metin Akay, EMBS President, University of Houston, USA

European Health Data Space Panel

Chair: Christos N. Schizas, President of the Cyprus National eHealth Authority, Cyprus

Date: Thursday, September 29, 2022

Time: 13:15 – 14:15

Location: PANDORA A'

Christos N. Schizas, President of the Cyprus National eHealth Authority, Cyprus

Yiannos Tolias, Legal Officer, European Commission’s DG SANTE

Dimitris Koutsouris, Professor of Computer Engineering

Giuseppe Fico, Assistant Professor of Biomedical Engineering

Alexander Berler, Strategic Business Development Director at IHE Catalyst AISBL

Privacy Challenges in the Digital Health Transformation Panel

Chair: Neeli Prasad, Healthcare Subgroup, IEEE Digital Privacy Initiative, USA

Date: Friday, September 30, 2022

Time: 11:45 – 13:15

Location: PANDORA C'

Neeli Prasad, Healthcare Subgroup, IEEE Digital Privacy Initiative, USA

Dan Bogdanov, Cybernetica, Estonia

Agata Ferretti, ETH Zurich, Switzerland

Charalampos Z. Patrikakis, University of West Attica, Greece

Matthias Simon, University of Bielefeld Medical Center OWL, USA, Germany

Featured Virtual Talks

Designing Digital Tools for ADRDs that Double as Assessments and Interventions

Date: Thursday, September 29, 2022

Time: 15:00 – 16:30

Location: PANDORA C'

Prof. Diane Cook, Washington State University, USA

Abstract: The world's population is aging, and the increasing number of older adults with Alzheimer's disease and related dementias (ADRDs) is a challenge our society must address. New modes of technology offer unprecedented opportunities to address some of the needs that accompany cognitive decline by providing automated health assessment and memory interventions. In this work, we create EMMA, a memory management app, that combines the two capabilities. Through participatory design with older adults and caregivers, we design an app that is accessible and effective as a compensatory aid for older adults with memory decline. By collecting data from app usage in combination with sensor data, we extract digital markers that predict multiple clinical measures. We evaluate this app using data from 14 participants with mild cognitive impairment. We observed moderate to large correlations between predicted and ground-truth assessment scores for each clinical assessment.

CV: Diane Cook is Regents Professor and Huie-Rogers Chair in the School of Electrical Engineering and Computer Science at Washington State University, founding director of the WSU Center for Advanced Studies in Adaptive Systems (CASAS), and co-director of the WSU AI Laboratory. She is a Fellow of the IEEE and the National Academy of Inventors. Diane's work is featured in BBC, IEEE The Institute, IEEE Spectrum, Smithsonian, The White House Fact Sheet, Scientific American, the Wall Street Journal, AARP Magazine, HGTV, and ABC News. Her research aims to create smart environments that automate health monitoring and intervention, evaluated via the CASAS Smart Home in a Box installed in over 160 sites across 9 countries. Her research currently focuses on developing machine learning methods that map a human behaviorome as a foundation for constructing a digital twin. She also conducts multidisciplinary research to leverage digital twin technologies for automatically assessing, extending, and enhancing a person's functional independence.

Near-human Sensing in Fabric Smart Space

Date: Friday, September 30, 2022

Time: 10:15 – 11:45

Location: PANDORA C'

Prof. Min Chen, Huazhong University of Science and Technology, China

Abstract: In future network, the provisioning of ultra-low latency, non-intrusive and immersive service experience creates various challenges, among which near-human sensing is of great importance to obtain multi-modal information without disturbing user. This talk introduces the development of various functional fabrics, which have provided new thoughts for generating novel near-human services interconnected by fabric sensors, body area network, edge cloud and visualization system. In order to embrace digital intelligent world, this talk also presents the fabric smart space empowered by intelligent fabric agents, which gather multidimensional sensory data and interactive information via near-human sensing technologies. Finally, several examples with the use of fabric smart space are given in terms of sport, healthcare and medical scenarios.

CV: Min Chen is a full professor in School of Computer Science and Technology at Huazhong University of Science and Technology (HUST) since Feb. 2012. He is the director of Embedded and Pervasive Computing Lab, and the director of Data Engineering Institute at HUST.
He is the founding Chair of IEEE Computer Society Special Technical Communities on Big Data. He was an assistant professor in School of Computer Science and Engineering at Seoul National University before he joined HUST. He is the Chair of IEEE Globecom 2022 eHealth Symposium.
His Google Scholar Citations reached 36,000 with an h-index of 91. His top paper was cited 3,900 times. He was selected as Highly Cited Researcher from 2018 to 2021.
He got IEEE Communications Society Fred W. Ellersick Prize in 2017, and the IEEE Jack Neubauer Memorial Award in 2019. He is an IEEE Fellow for his contributions to data-driven communication, caching, and computing.

IEEE BHI-BSN 2022 Workshops

All workshops will be held on Tuesday, September 27, 2022.

Title: Physical based machine learning in bioengineering and bioinformatics

Organizers: **Nenad Filipovic,** Faculty of Engineering, BIOIRC Kragujevac, University of Kragujevac, Serbia

Short Description: Current treatment in the medicine still relies exclusively on diagnostic imaging data to define the present state of the patient, biomarkers and experience of the medical doctors to evaluate the efficacy of prior treatments for similar patients. Emerging technologies with applications of biomedical and health informatics are focused to precision medicine and preventive care. but may also involve registrants through a hands-on experience or demonstrations Physical based machine learning, computational methods, big data analytics, artificial intelligence, bioinformatics, give opportunity for a patient-specific model in order to improve the quality of prediction for the disease progression into life-threatening events that need to be treated accordingly. In this special Workshop authors will present physical based machine learning tools for disease prediction, and the integrative informatics; that can improve the predictive power of the patient specific model.

Title: Understanding Inner States of Humans using Measurements of “Invisibles” – ”Empatho-Kinaesthetic” Sensing

Organizers: Prof. Bjoern M. Eskofier, Machine Learning and Data Analytics (MaD) Lab, FAU, **Prof. Anne Koelewijn,** Junior Professorship for Computational Movement Science, FAU, **Prof. Martin Vossiek**, Institute of Microwaves and Photonics, FAU, Co-organizers: Misha Sadeghi, Falk Pulsmeye

Short Description: Every movement of the body of a living being is the result of mechanisms of action taking place inside of the body and interactions between them. The body’s motor functions are initiated and regulated by neuronal processes and, more complex movements, controlled by sensitive body perception and cognition. Depending on the physical constitution, state of health or stress, and movements, parameters of the (interaction) mechanisms change. We call this concept “empatho-kinaesthetic” sensing.

Title: The potential of enabling technologies in tailoring and adapting neuromotor and cognitive rehabilitation in children

Organizers: Dr Ilaria Bortone, Senior Postdoc Research Fellow, Institute of Clinical Physiology, National Research Council (IFC-CNR), Pisa, Italy, **Dr Lucia Billeci**, Full-term Researcher, Institute of Clinical Physiology, National Research Council (IFC-CNR), Pisa, Italy

Short Description: Rehabilitation is essential, along with prevention, promotion, treatment, and support, in ensuring healthy lives and promoting well-being for all at all ages. This becomes particularly true in the pediatric population, where neuromotor or neurocognitive impairments, causally and clinically heterogeneous, occur in a challenging developmental context. Wearables, sensing, immersive virtual environments and social robotics offer the opportunity and challenges to develop novel methods for implementation of advanced and adaptive therapies in terms of engagement, proposed tasks, data analysis and feasibility of the system in the clinical setting.

Title: Enhancing high value care system through knowledge extraction from health care data using process mining techniques

Organizers: Vicente Traver Salcedo, Universitat Politecnica de Valencia, **Paulo Carvalho,** University of Coimbra

Short Description: The use of big data technologies for inferring new evidence from patient information provides a great opportunity to support quality of care in a holistic way. However, the use of machine learning algorithms to create real scientific evidence in order to improve daily healthcare protocols has complex barriers to solve. One of the most common barriers is that most algorithms that create scientific evidence from big data are considered ‘black boxes’ by health experts, encouraging suspicion among physicians over the evidence inferred by their use. In this talk a paradigm for integrating health experts in the process of generating new evidences is presented. This interactive process mining paradigm combines the application of process mining technologies in healthcare using interactive machine learning paradigm for supporting health professionals in inferring new knowledge from past actions and providing accurate and personalized knowledge for future decisions and improve patients’ treatments and quality of life. In this tutorial, we will demonstrate the use of Interactive process mining techniques in real scenarios

IEEE BHI-BSN 2022 Workshops

All workshops will be held on Tuesday, September 27, 2022.

Title: Co-designing for gender equality: towards gender balance in scientific careers, decision making bodies and R&I content

Organizers: **Maria Fernanda Cabrera-Umpierrez,** Life Supporting Technologies – Universidad Politecnica de Madrid (Spain), **Yolanda Ursa**, INMARK (Spain)

Short Description: This Co-Design workshop aim is to identify key issues in aspects related to gender policies and develop potential solutions through a design thinking process in order to contribute to integrate the gender perspective in Science, Technology and Innovation. Participants will discuss opportunities in their country or institution and co-design potential solutions that can be implemented to foment gender equality in the future.

Title: Developing open, standard-based, interoperable Cancer Imaging Repositories in Europe: Issues, Experiences and Challenges

Organizers: **Prof. Manolis Tsiknakis,** FORTH-ICS & Hellenic Mediterranean University, **Prof. Karim Lekadir**, Universitat de Barcelona

Short Description: The AI4HI Network includes five large EU-funded projects on big data and AI in cancer imaging (CHAIMELEON, EUCANIMAGE, INCISIVE, ProCancer-I, PRIMAGE and has been organized into 8 working groups (Ethical and legal issues, Metadata interoperability, Data storage and management, Data annotation, AI development, AI validation, Clinical Working Group and Outreach Working Group), each consisting of 15 experts representing the five projects and a wide range of stakeholders, perspectives, approaches and disciplines. This workshop will focus on presenting the results delivered by these working groups analyzing the existing landscape, solutions and challenges based on a concrete set of clinical use cases related to a number of cancer types (lung, breast, liver, colorectal, prostate, brain, etc).

Title: Digital health and clinical trials

Organizers: Prof. Paolo Bonato, Harvard Medical School, USA, **Valeria De Luca,** Novartis, Europe

Short Description: During the last decade, we have witnessed a growing interest for the use of digital health solutions in clinical trials, with emphasis on the adoption of wearable sensors and systems to gather clinically relevant information outside of the clinic. Potential benefits of the technology include improvements in the quality of the data collected during the trial, a decrease in the sample size required to complete the trial, the detection of early signs of drugs' adverse effects, and improvements in adherence by study participants. In this workshop, we will discuss with experts from academia and the industry how digital health solutions should be designed to address the needs of clinical researchers and the pharmaceutical industry. Topics discussed during the workshop will include: 1) requirements recently introduced by funding agencies concerning the performance of clinical trials, 2) examples of trials that have leveraged the use of digital health solutions, 3) the growth of digital health units within pharmaceutical companies, 4) examples of platforms developed to facilitate the performance of clinical trials, and 5) recommendations concerning how to approach the development of digital health technologies.
Speakers: Magda Krakowiak (EiT Health), Steve Schachter (Harvard Medical School), Geoffrey Gill (Shimmer USA), Paul Wacnik (Pfizer), Valeria De Luca (Novartis), Christoph Kanzler (Biogen), Nele Peerenboom (VivoSense), Ashkan Vaziri (BioSensics), Dan Karlin (MindMed), Shaalan Beg and Marina Perrin (Science 37), Larry Liu and Tyler Pugsley (Medable), Andy Coravos (HumanFirst), Larsson Omberg (Sage Bionetwork), Jennifer Goldsack (Digital Medicine Society), and Fay Horak (Oregon Health & Science University).

Wednesday, September 28, 2022

8:30 – 19:45
Registration
Room: FOYER ERATO

8:30 – 9:15
Opening Keynote
Chair: Dimitrios I. Fotiadis, JBHI EiC, Univ. of Ioannina, FORTH, Greece
Room: ERATO

Indoor Radar Sensing of Elderly People: Overcoming the Barriers in Home Care Technology
Prof. George Karagiannides
ECE Department of Aristotle University of Thessaloniki, Greece

The use of new technologies in monitoring of elderly people has significantly grown in the last years. Although indoor radar monitoring is still in its early stage of development, it carries great potential to be one of the leading technologies in the future. In this presentation, the basics and the advantages of indoor radar sensing, compared to other existing technologies as cameras and wearable devices, will be provided and discussed.

9:15 – 10:15
Industrial Panel
Chair: Athos Antoniades, Stremble Ventures Ltd, Cyprus
Room: ERATO

Anca Bucur
Philips Research Netherlands

Sergio Guillen
TSB RTLS Systems (My Sphera), Spain

Nenad Filipovic
BIORC Ltd., Serbia

10:15 – 10:30
Coffee Break
Room: FOYER ERATO

10:30 – 12:00
BHI Session # 1 Biomedical Signal Processing and Sensor Informatics
Chair: Bjoern M. Eskofier, FAU, Germany; **George Matsopoulos,** National Technical University of Athens, **Greece**
Room: POLYMNIA

10:30
Transcutaneous Cervical Vagus Nerve Stimulation Reduces Respiratory Variability in the Context of Opioid Withdrawal
Asim H Gazi, Anna B Harrison and Tamara P Lambert (Georgia Institute of Technology, USA); Malik Obideen and Justine W Welsh (Emory University School of Medicine, USA); Viola Vaccarino and Amit J Shah (Rollins School of Public Health, USA); Sudie E Back (Medical University of South Carolina, USA); Christopher Rozell (Georgia Tech, USA); Douglas Bremner (Emory School of Medicine, USA); Omer T Inan (Georgia Institute of Technology, USA)

The United States opioid epidemic is a public health crisis, and the physiological effects of opioid withdrawal can be a major impediment to recovery from opioid use disorder (OUD). Prior work has demonstrated that transcutaneous cervical vagus nerve stimulation (tcVNS) can counteract some of opioid withdrawal's physiological effects by reducing heart rate and perceived symptoms. The purpose of this study was to assess the effects of tcVNS on respiratory manifestations of opioid withdrawal -- specifically, respiratory timings and their variability. Patients with OUD (N = 21) underwent acute opioid withdrawal over the course of a two-hour-long protocol. The protocol involved opioid cues to induce opioid craving and neutral conditions for control purposes. Patients were randomly assigned to receive double-blind active tcVNS (n = 10) or sham stimulation (n = 11) throughout the protocol. Respiratory effort and electrocardiogram-derived respiration signals were used to estimate inspiration time (T_i), expiration time (T_e), and respiration rate (RR), along with each measure's variability

quantified via interquartile range (IQR). Comparing the active and sham groups, active tcVNS significantly reduced IQR(T_i) -- a variability measure -- compared to sham stimulation (p = .02). Notably, IQR(T_i) was found to be positively associated with post-traumatic stress disorder symptoms in prior work. Therefore, a reduction suggests that tcVNS downregulates the respiratory stress response associated with opioid withdrawal. Although further investigations will be necessary to address study limitations (e.g., small sample size), these results promisingly suggest that tcVNS -- a non-pharmacologic, non-invasive, readily implemented neuromodulation approach -- can serve as a novel therapy to mitigate opioid withdrawal symptoms.

10:42

Feasibility of Remote Pulse Transit Time Estimation Using Narrow-band Multi-wavelength Camera Photoplethysmography

Gašper Slapničar (Jožef Stefan Institute & Jožef Stefan International Postgraduate School, Slovenia); Wenjin Wang (Southern University of Science and Technology, China); Mitja Lustrek (Jozef Stefan Institute, Slovenia)

Contact-free remote sensing gained much traction in the past decade. While such monitoring of some vitals (heart rate) is approaching clinical levels of performance, others remain difficult to estimate (blood pressure) while being very valuable. In this paper we investigated the feasibility of estimating pulse transit time (PTT) - a marker known to be highly correlated with blood pressure - in a remote way from a single measuring site, using just a single modified RGB camera. The replacement of infrared (IR) filter with a narrow band triple bandpass filter allowed us to remotely measure the PTT between traditional wavelengths (green) and infrared (NIR) using a regular RGB camera. We measured PTT leveraging the fact that different wavelengths penetrate to different skin depths. Use of such a filter minimizes the inter-channel influence and band overlap and leverages NIR information not traditionally available from consumer RGB cameras. This way we obtained slightly delayed photoplethysmograms corresponding to each wavelength and skin depth. In our initial experiments with 5 subjects we observed relatively consistent temporal delays between waveforms from different wavelengths (especially near-infrared and green) in accordance with expectations and related work. These early results show promising fundamentals for further research in remote multi-wavelength PTT and blood pressure estimation, while also highlighting important fundamental and technical challenges to be considered.

10:54

Unobtrusive In-Home Respiration Monitoring Using a Toilet Seat

Krittika Goyal, David Borkholder and Steven Day (Rochester Institute of Technology, USA)

Non-invasive monitoring of pulmonary health could revolutionize the care of health conditions ranging from COVID- 19 to asthma to heart failure, but current technologies face challenges that limit their feasibility and adoption. Here, we introduce a novel approach to monitor respiration by measuring changes in impedance from the back of the thigh. The integration of electrodes into a toilet seat ensures patient compliance with unobtrusive daily respiration monitoring benefitting from repeatable electrode placement on the skin. In this work, the feasibility of the thigh and the sensitivity of impedance to respiration have been investigated empirically by comparing thorax and thigh-thigh bioimpedance measurements to spirometer measurements, and computationally, using finite element modeling. Empirical results show a measurable peak-peak impedance (0.022 ohm to 0.290 ohm for normal breathing across 8 subjects) with respiration across thigh-thigh and a high correlation (0.85) between lung tidal volume and impedance change due to respiration. Thigh-thigh bioimpedance measurements were found to be able to distinguish between shallow, normal, and deep breathing. Further, day-to-day variability in the relationship between impedance and tidal volume was investigated. The results suggest that the novel approach can be used to detect respiration rate and tidal volume and could provide valuable insight into disease state for conditions ranging from COVID-19 to heart failure.

11:06

Enhancing Continuous Glucose Monitoring-based Eating Detection with Wearable Biomarkers

Sorush Omidvar (University of Georgia, USA); Ali Roghanizad and Lucy Chikwetu (Duke University, USA); Garrett Ash (Yale University, USA); Jessilyn Dunn (Duke University, USA); Bobak Jack Mortazavi (Texas A&M University & Center for Outcomes Research and Evaluation - Yale University, USA)

Proper diet monitoring is a cornerstone of preventing and treating Type 2 Diabetes. However, this usually relies on burdensome manual meal logging. Continuous glucose monitors (CGMs), which have recently gained popularity as a tool to help Type 2 Diabetics with their treatments, may allow for a burden-free, sensor-based approach to logging periods of eating through monitoring the glucose dynamics and attempting to identify periods of post-prandial glucose response. However, CGMs-alone may not be sufficient in properly detecting periods; periods such as those present in gastric emptying may result in false positives for eating detection, given the sharp rise in glucose response. This work seeks to augment CGM-captured signals with that of other wearable biomarkers, captured from smartwatches, to aid in the detection of eating periods. These signals have been shown to detect eating motions. We explore a hierarchical model approach to augmenting CGM-based eating detection with additional sensing modalities. We test our model data collected from healthy participants

eating in free-living conditions. We find that CGM-based eating detection can be improved by retrospectively reviewing wearable sensing data for confirmation, improving our model performance of eating detection, as measured by the area under the receiver operating characteristic curve, by 0.15 (from 0.64 to 0.79), and similarly across additional performance metrics.

11:18
Motor-imagery EEG signal decoding using multichannel-empirical wavelet transform for brain computer interfaces
Ilaria Siviero, Lorenza Brusini, Gloria Menegaz and Silvia Francesca Storti (University of Verona, Italy)

Motor-imagery (MI) electroencephalography (EEG) signal decomposition is an emerging technique for improving the performance of brain computer interfaces (BCIs). We proposed a multichannel-empirical wavelet transform (EWT) representation combined with a scattering convolutional network (SCN) to efficiently decode the brain activity and extract relevant wave patterns for MI-based BCI. Two different preprocessing steps were tested: the first (PM1) included a bandpass Butterworth filter (1-40 Hz) and the independent component analysis (ICA), the second one (PM2) consisted only of a bandpass Butterworth filter (8-30 Hz). A binary support vector machine (SVM) classifier was used and the performance was evaluated in terms of classification accuracy. The proposed framework was assessed using the BCI competition IV dataset IIa, which contains EEG from 9 healthy subjects. PM1 presented a maximum mean accuracy over all subjects of 82.05% in the classification of the tongue and the left-hand MI tasks. PM2 achieved an average accuracy over all subjects of 88.40% and a standard deviation of 3.01 outperforming other state of the art methods in classifying right-hand and left-hand MI tasks. Finally, we observed that the best channels, intended as the channels holding the highest discrimination power between two MI tasks, were highly subject-specific and thus enabling task-based channel selection is crucial.

11:30
Discussion

10:30 – 12:00
Special Session: Integrated AI and modelling for disease prediction
Chair: Nenad Filipovic, University of Kragujevac, Serbia
Room: KLEIO

10:30
Segmentation and Classification of Disc Hernia in Magnetic Resonance Images using Deep Learning
Tijana Sustersic (Faculty of Engineering, University of Kragujevac & Bioengineering Research and Development Center (BioIRC), Serbia); Vesna Ranković, Vojin Kovačević and Nenad Filipovic (University of Kragujevac, Serbia)

Localization of lumbar discs in magnetic resonance imaging (MRI) is a difficult task, mainly due to the disc variance in in size, shape, number, and appearance. This paper proposes a deep learning methodology for automatic segmentation and classification of disc herniation. The dataset used in this research included publicly available database Lumbar Spine MRI Dataset obtained from Mendeley Data, combined with images obtained from patients from the Clinical Centre of Kragujevac, Serbia. Total number of images was 1169 images in sagittal view and 557 images in axial view. The methodology includes several steps starting from segmentation of disc, bounding box cropping and enhancement of disc region, after which the classification based on convolutional neural network (CNNs) is performed (healthy, bulge, central, right or left herniation for axial view and healthy, L4/L5, L5/S1 level of herniation in sagittal view). Results show 0.87 accuracy for classification in axial view images and 0.91 accuracy for sagittal view images. The obtained results represent the advancement in comparison to the state-of-the-art results, where mostly binary classification (healthy or diseased disc) is investigated. Future research will focus on increasing the dataset size, investigation of other deep neural network architectures, as well as employing transfer learning in disc hernia classification.

10:42
Automated assessment of colorectal cancer based on histopathology images
Maria Venianaki (JADBio - Gnosis DA S.A., Greece); Georgios Papoutsoglou, Paulos Charonyktakis and Giorgos Borboudakis (JADBio, Greece)

Molecular cancer biomarkers can provide an excellent diagnostic tool for the early detection of colorectal cancer and lead to more targeted and cost-efficient therapies. There are several studies that have investigated the molecular features of colorectal cancer to provide insight into disease progression and understand better the pathogenesis of this type of cancer. In this work, we present a novel machine learning framework in order to predict seven distinct molecular and genetic features of colorectal cancer in a binary classification setting from histopathology images. The proposed methodology in this paper includes three stages: a) feature construction using pre-trained neural networks, b) modeling based on distance matrices and c) classification using machine learning algorithms.

The histology images used were derived from The Cancer Genome Atlas colon and rectal cancer (TCGA-CRC-DX) cohort, a publicly available dataset which has been widely used in other studies. We used 300 diagnostic slides of primary colorectal tumors from 298 patients. Four molecular features were explored, namely hypermutation (high vs low mutation density), microsatellite instability (highly microsatellite instable vs stable), chromosomal instability (chromosomal instability vs genomic stability), CpG island methylator phenotype (CIMP) (CIMP-high vs CIMP-low) and three genetic mutations, i.e. BRAF, KRAS and TP53 (mutant vs wild-type status).
The results show that the proposed methodology is promising for classification from histopathology images. Note that the framework is general and can be applied in any dataset with histopathology images and can also be combined with molecular data.

10:54
Comparative Analysis of Patch-based and Full Image Methodology of Carotid Artery Plaque Semantic Segmentation in Ultrasound images
Lazar Dašić (Bioengineering Research and Development Center (BioIRC), Serbia); Andjela Blagojevic (Faculty of Engineering, University of Kragujevac & Bioengineering Research and Development Center, Serbia); Tijana Sustersic (Faculty of Engineering, University of Kragujevac & Bioengineering Research and Development Center (BioIRC), Serbia); Nenad Filipovic (University of Kragujevac, Serbia)

Arterial stenosis, caused by plaque depositions within the coronary wall, can lead to stroke and even death. The main purpose of this study is to analyze two different techniques that adequately recognize and segment fibrous, calcified and lipid plaque component in the carotid wall. Correct identification of these plaque components plays key role in an evaluation of the risk of cardiovascular disease progression. Even though both methods use Convolutional Neural Network models in its core, the main difference is in the way training ultrasound imaging data is processed. U-net architecture was chosen as CNN model, since numerous previous research showed that U-net achieves respectable results for the segmentation problems on biomedical imaging data. Custom weighted loss function that combines categorical focal loss and dice loss was used. Results showed that full image segmentation attain better segmentation of the calcified plaque component, while patch-based segmentation (that splits ultrasound images into small pieces) attains better results for segmentation of fibrous and lipid plaque component. While both methods achieved good results in segmentation of background and fibrous classes, real problem was segmentation of lipid and calcified components. Unfortunately, it was showed that splitting images into patches that are too small, results in a loss of deeper features of the image.

11:06
Physics-informed Neural Network for Isotonic Muscle Contraction
Bogdan Milicevic (University of Kragujevac & Bioengineering Research and Development Center BioIRC, Serbia); Milos Ivanovic and Boban Stojanovic (University of Kragujevac, Faculty of Science, Serbia); Nenad Filipovic (University of Kragujevac, Serbia)

Biophysical muscle models, often called Huxley-type models, are based on the underlying physiology of muscles, making them suitable for modeling non-uniform and unsteady contractions. This kind of model can be computationally intensive, which makes usage of large-scale simulations more difficult. To enable more efficient usage of the Huxley muscle model, we create a physics-informed surrogate model, which behaves similarly to the original Huxley muscle model, but it requires significantly less computational power. Huxley muscle model is a biophysical muscle model, based on sliding filament and cross-bridge theory. The myosin filaments of muscle fibers slide past the actin filaments during muscle contraction. The actin and myosin form a protein complex by attachment of myosin head on the actin filament. Each of the attached heads contributes to the total force generated within the muscle fiber. A Huxley's muscle equation, used to describe the distribution of attached myosin heads to the actin-binding sites, is usually solved by the method of characteristics. Once this equation is solved we can calculate generated force and also stiffness in muscle fibers which can be further used in finite element analysis to perform simulations at the macro-level. In our paper, we present the alternative method to solve this partial differential equation and possibly accelerate multi-scale simulations.

11:18
Towards Automated Assessment of Drug Efficacy on Cardiomyopathic Human Heart Function
Momcilo Prodanovic (University of Kragujevac, Institute for Information Technologies, Serbia & FilamenTech, Inc., USA); Danica Prodanović (University of Kragujevac, Faculty of Science & Bioengineering Research and Development Center (BioIRC), Serbia); Boban Stojanovic (University of Kragujevac, Faculty of Science, Serbia); Nenad Filipovic (University of Kragujevac, Serbia); Srboljub M. Mijailovich (Illinois Institute of Technology, USA)

Structural and functional abnormalities of the ventricular myocardium commonly related to Hypertrophic and Dilated Cardiomyopathies (HCM and DCM) are caused by inherited mutations in sarcomeric proteins. Automating predictions of mutations and drugs effects on cardiac muscle function could enhance early diagnosis and evaluation of response to treatment in cardiomyopathies. However, providing information for Artificial Intelligence (AI) tools by integrating results from

multiple experiments is quite challenging because the stored information could be collected under different conditions and the acquired information by AI tools could be significantly inaccurate or even misleading. Recent advances in multiscale computational tools, coupled with multiple experiments, for translation of data from molecular interactions including the effect of small molecules (drugs) to the level of cardiac muscle fibers and tissues, might provide the most relevant and standardized information for the AI databases. Using MUSICO platform for precise modeling of protein-protein interactions and Ca2+ regulation in cardiac muscle cells, we examined the effects of drugs Disopyramide and Digoxin that could improve cardiac muscle contractility. Furthermore, coupling finite element solver Mexie with MUSICO, enables assessment of PV loops of healthy, HCM and DCM hearts as well as the efficacy of drugs on improving cardiac muscle and whole heart function.

11:30
Integrating deep learning and meshing techniques to perform 3D reconstruction of patient-specific carotid bifurcation with plaque classification
Tijana Djukic (Institute for Information Technologies, University of Kragujevac, Serbia); Smiljana Tomasevic (University of Kragujevac, Serbia); Branko Arsic (Faculty of Science, University of Kragujevac, Serbia); Branko Gakovic (Clinic for Vascular and Endovascular Surgery, Serbian Clinical Centre, Belgrade, Serbia); Nenad Filipovic (University of Kragujevac, Serbia)

One of the diseases in human cardiovascular system is carotid artery stenosis (CAS) and its early detection is very important in order to prevent potentially deteriorating consequences. Ultrasound (US) imaging is usually the initial recommended CAS diagnostic examination technique, because of a noninvasive procedure without ionizing radiation. This examination can identify atherosclerotic plaque components in order to pre-estimate the risk of cardiovascular disease and ensure appropriate preventive, therapeutic, or surgical treatment. However, conventional 2D US imaging has technical limitations in observing the complicated 3D shapes and asymmetric vasodilation of bifurcations. In this study an integrated approach is presented that is capable of performing 3D reconstruction of patient-specific carotid bifurcation from US images. Deep learning techniques are used to segment the regions of interest including lumen and arterial wall areas, as well as plaque types. Afterwards, meshing techniques are applied to create the 3D geometry and hexagonal mesh of finite elements. The characterization of carotid plaques in three dimensions could improve investigations of the changes of plaque morphology, geometry and its distribution and these can provide important information about the effects of anti-atherosclerotic therapies. The generated models can also be used to perform further numerical simulations, involving blood flow, stenting implantation or plaque progression.

11:42
Discussion

10:30 – 12:00
Virtual Session # 1 Big Data and AI
Chair: Maria Fernanda Cabrera, Tech Univ of Madrid, Spain**; Themistoklis Exarchos,** Ionian University, Greece
Room: PANDORA C'

10:30
Fine-grained Cross-Layer Attention Framework for Wound Stage Classification
Keval S Nagda and Narges Norouzi (University of California, Santa Cruz, USA); Michael J Briden (University of California Santa Cruz, USA)

Determining progress during wound healing is crucial for effective diagnosis and treatment. The wound healing process begins with the hemostasis phase, where the wound is quickly closed by clotting. In the second stage of wound healing, inflammation controls swelling and infection, making the wound appear red and reflective. During the proliferative stage, the wound decreases in size as new tissues are built, and the wound's area turns visibly pink. The wound shows the signs of complete healing in the maturation or the remodeling phase as new skin is developed. Thus, wound healing can be categorized into four distinct phases: hemostasis, inflammatory, proliferation, and maturation. Previous computer vision and machine learning works have solved this task using convolutional methods that pay attention to specific local regions of the image of the wound. Convolutional Neural Networks (CNN) are effective for image classification tasks since the middle layers capture spatial details while the top layers at the end learn global information from the images. This approach can be an issue while performing Fine-Grained Visual Categorization (FGVC) tasks since the convolution operations concentrate more on the local structure and avoid long-range dependencies. there is no long-range information sharing between different layers of CNNs. This paper explores an alternative, non-local attention approach and implements a cross-layer attention mechanism between different layers of a CNN that focuses on the areas of interest and considers related spatial regions of the wound. The proposed cross-layer mechanism includes two modules: Cross-Layer Context Attention (CLCA) and Cross-Layer Spatial Attention (CLSA). We apply a CLCA module to the intermediate layers. The idea is that the CLCA module improves the global context information on the feature maps from the middle layers. We use a CLSA module on the top

layer. The CLSA module enhances the ability to capture spatial attention of the feature maps from the top layer. A comparative study based on the experimental results and visual representations shows that adding cross-layer modules to mid-level and top-level layers enables better classification of wound healing stage and generalization.

10:42
Genomics transformer for diagnosing Parkinson's disease
Diego Machado Reyes (Rensselaer Polytechnic Institute, USA); Mansu Kim (Catholic University of Korea, Korea (South)); Hanqing Chao and Juergen Hahn (RPI, USA); Li Shen (University of Pennsylvania, USA); Pingkun Yan (RPI, USA)

Parkinson's disease (PD) is the second most common neurodegenerative disease and presents a complex etiology with genomic and environmental factors and no recognized cures. Genotype data, such as single nucleotide polymorphisms (SNPs), could be used as a prodromal factor for early detection of PD. However, the polygenic nature of PD presents a challenge as the complex relationships between SNPs towards disease development are difficult to model. Traditional assessment methods such as polygenic risk scores and machine learning approaches struggle to capture the complex interactions present in the genotype data, thus limiting their discriminative capabilities in diagnosis. On the other hand, deep learning models are better suited for this task. Nevertheless, they encounter difficulties of their own such as a lack of interpretability. To overcome these limitations, in this work, a novel transformer encoder-based model is introduced to classify PD patients from healthy controls based on their genotype. This method is designed to effectively model complex global feature interactions and enable increased interpretability through the learned attention scores. Results: The proposed framework outperformed traditional machine learning models and multilayer perceptron (MLP) baseline models. Moreover, visualization of the learned SNP-SNP associations provides not only interpretability to the model but also valuable insights into the biochemical pathways underlying PD development, which are corroborated by pathway enrichment analysis. Our results suggest novel SNP interactions to be further studied in wet lab and clinical settings.

10:54
Efficient Metric Learning with Graph Transformer for Accurate Colorectal Cancer Staging
Zongxiang Pei (Nanjing University of Aeronautics and Astronautics, China); Daoqiang Zhang (Nanjing University, China); Wei Shao (Nanjing University of Aeronautics and Astronautics, China)

Colorectal cancer (CRC) is the third leading cause of cancer death in men and the third leading cause of cancer death in women in United States. So far, the histopathological image remains the golden standard in staging CRC, and accurate staging CRC is important for timely therapy and possible delay of the disease. Existing studies often utilized the pre-trained deep models to extract features from histopathological images, which neglected to take the supervised metric information into consideration. In addition, most of the existing methods did not take advantages of the correlations among different samples for the downstream classification tasks. To address the aforementioned problems, in this paper, we propose an efficient Metric learning with Graph Transformer (MGT), which adopts efficient metric learning to help extract distinguished image features followed by applying graph transformer for CRC staging. The main advantage of the proposed graph transformer is that it can fully exploit the correlations among different patients, which results in better tumor staging performance. To evaluate the effectiveness of the proposed method, we conduct several experiments for CRC staging on public available dataset TCGA-CRC in The Cancer Genome Atlas (TCGA). The experimental results show that our method can consistently achieve superior classification performance than the comparing methods.

11:06
A CNN Model with Discretized Mobile Features for Depression Detection
Yueru Yan (Beijing Normal University, China); Mei Tu (Samsung Research China-Beijing, China); Hongbo Wen (Beijing Normal University, China)

Depression has been a serious mental illness for a long time, which significantly influence people' life quality. Meanwhile, as smartphone becomes an integral part of people's life, it creates the opportunity to analyze user's feelings through phone usage and sensor data. However, previous studies mainly adopt machine-learning methods for depression detection, ignoring the sequential patterns hidden in it. In this study, we aim to monitor the symptoms of depression through sequential mobile data collected from phone and its sensors. First, we establish a deep-learning model called Dep-caser to fully utilize the sequential information in mobile data. Next, we introduce a discretization method based on Information Value to deal with data sparsity and outliers. In total, we recruited 257 people to join the study and extracted five-day longitudinal data from their smartphones and electronic bands. We conduct two experiments to examine the effectiveness of Dep-caser and discretization method respectively. The results demonstrate that Dep-caser outperforms most of the machine learning methods and the discretization further improves the performance of the deep-learning model to achieve an overall accuracy of 0.83. All in all, our study shows the promising future to adopt deep-learning models with sequential phone usage and sensing data to detect depression.

11:18
Parallel Multi-scale convolution based prototypical network for few-shot ECG beats classification
Zicong Li (University of Manchester, United Kingdom (Great Britain)); Henggui Zhang (Schuster Building & The University of Manchester, United Kingdom (Great Britain))

The electrocardiogram (ECG) presents essential information of the electrical activity of the heart measured by electrodes placed on the body surface, forming an important approach to diagnosing cardiac arrhythmias. Although various deep-learning based models have been implemented for auto-classification of arrhythmias, limited clinical data still impedes the progress of the auto-diagnosis. This study presented a parallel multi-scale convolution based prototypical network (PM-CNN ProtoNet) for processing the few-shot learning tasks of ECG beats classification. One dimension ECG signals are segmented and transformed into spectrograms for obtaining representative features. As a feature extractor, the PM-CNN structure utilizes two-stream convolutional networks, capturing the robust feature information via different kernel sizes. Moreover, we employed a learnable parameter for multi-scaled feature fusion, preventing the excessive dimension caused by simple concatenation. By evaluating the proposed model on the MIT-BIH arrhythmia database, the PM-CNN ProtoNet achieves a satisfying accuracy of 91.6% in a 2-way 10 shot task. The comparative results between the PM-CNN ProtoNet and other state-of-art models also demonstrate the efficiency of our proposed model. In conclusion, the PM-CNN structure can improve the classification performance of the prototypical network in few-shot learning tasks while having the potential for auto-classification under a small amount of medical data.

11:30
TrustSleepNet: A Trustable Deep Multimodal Network for Sleep Stage Classification
Guanjie Huang (Meta & Penn State University, USA); Fenglong Ma (Pennsylvania State University, USA)

Correctly classifying different sleep stages is a critical and prerequisite step in diagnosing sleep-related issues. In practice, the clinical experts must manually review the polysomnography (PSG) recordings to classify sleep stages. Such a procedure is time-consuming, laborious, and potentially prone to human subjective errors. Deep learning-based methods have been successfully adopted for automatically classifying sleep stages in recent years. However, they cannot simply say ``I do not know'' when they are uncertain in their predictions, which may easily create significant risk in clinical applications, despite their good performance. To address this issue, we propose a deep model, named TrustSleepNet, which contains evidential learning and cross-modality attention modules. Evidential learning predicts the probability density of the classes, which can learn an uncertainty score and make the prediction trustable in real-world clinical applications. Knowing how uncertain the prediction is, the clinical experts can trust the results with low uncertainty score and set the ones with high uncertainty score aside for manual inspection. Cross-modality attention adaptively fuses multimodal PSG data by enhancing the significant ones and suppressing irrelevant ones. Experimental results demonstrate that TrustSleepNet outperforms state-of-the-art benchmark methods, including four machine learning methods and three deep learning methods, and the uncertainty score makes the prediction more trustable and reliable.

11:42
ST-GNN for EEG Motor Imagery Classification
B S Vivek and A Adarsh (TCS Research, India); J Gubbi (TCS Research and Innovation, India); Kartik Muralidharan (Tata Consultancy Services, India); Ramesh Kumar Ramakrishnan (TATA Consultancy Services, India); Arpan Pal (Tata Consultancy Services, India)

Brain-computer interface (BCI) systems play an important role in medical applications such as stroke rehabilitation and neural prosthesis. These systems aim to decode the neural activity of the human brain measured using an Electroencephalogram (EEG). In this work, we consider the task of EEG-based motor imagery (intent) classification. Motor imagery (MI) refers to the imagination of the limb movement in the brain without actual action. Classification of motor imagery forms the basis for BCI-based prosthetic control. Existing approaches either use handcrafted features or features extracted from a deep neural network to interpret EEG-based MI. However, majority of the existing works fail to harness the functional connectivity within the brain that is captured using multiple EEG channels. In our work, we represent the input EEG signal as a graph where the nodes represent the EEG channels. The proposed approach uses a graph representation with a trainable weighted adjacency matrix to learn the optimal connectivity between nodes. Spatio-temporal features of the EEG signal are extracted via the proposed model that consists of a temporal convolution module and a graph convolution network. Experimental results and ablation study highlight the effectiveness of the proposed approach on the PhysioNet EEG motor movement and imagery dataset (EEG-MMIDB).

11:54
Discussion

12:00 – 13:30
BSN Session # 1 Intelligent Wearable Sensing Technology
Chair: Addythia Saphala, FAU, Germany;Sunghoon **Ivan Lee,** University of Massachusetts Amherst, USA
Room: POLYMNIA

12:00 SixthSense: Smart Integrated Extreme Environment Health Monitor with Sensory Feedback for Enhanced Situation Awareness
Rita Paradiso (Smartex, Italy); Goran Bijelic (Tecnalia Research and Innovation, Spain); Nerea Briz Iceta (Tecnalia Research and Innovation Spain, Spain); Milos Kostic (Tecnalia Serbia, Serbia); Matija Štrbac (Tecnalia Serbia ltd, Italy); Giovanni Magenes (University of Pavia, Italy); Ana Belén Carballo Leyenda (University of Léon, Spain); Lucas Paletta (JOANNEUM RESEARCH Forschungsgesellschaft mbH, Austria); Aleksandar Vujic (TeleGroup, Serbia); Andreas Morschhauser (Chemnitz University of Technology, Germany); Čedomir Stefanović (Aalborg University, Denmark)

Natural disasters occurring in inaccessible rural areas are on the rise, leading to the multiplication of first responders' missions. However, engagement in fighting wildfires or participating in rescue missions includes risks for the well-being of the engaged first responders. Consequently, a system that monitors their actions and provides real-time and actionable information without obstructing their operational capacity is needed. The EU-funded SIXTHSENSE project aims to improve the efficiency and safety of first responders' engagement in difficult environments by optimizing on-site team coordination and mission implementation. The project proposes an innovative wearable health monitoring system based on multimodal biosensor data that enables first responders to detect risk factors early on and allows real-time monitoring of all deployed responders. This paper is an introduction to the overall concept of the project, to the methodology and the system architecture, moreover details on Alpha version of SixthSense prototype are presented.

12:10
Automatic ECG signal quality assessment in Mountain Rescuers through the computation of Sample Entropy
Edoardo Spairani (University of Pavia, Italy); Ana Belén Carballo Leyenda (University of Léon, Spain); Gianluca De Toma (Smartex s r l, Italy); José Rodriguez-Marroyo (University of Léon, Spain); Giovanni Magenes (University of Pavia, Italy)

In the present study we propose a novel method to automatically assess the quality of ECG signals collected through a wearable device in typical mountain rescuers activities. ECGs signals have been obtained during sessions of programmed field tests at the Bormio Ski Resort (Valtellina, Lombardy, Italy) in the month of March. Here, following the defined protocol, a group of 15 mountain rescuers has carried out daily rescuers' activities, while wearing wearable textile system by Smartex Srl. The test protocol was designed to simulate the real physiological demands of mountain rescuers during their emergency deployments. Among the activities performed rescuers had to walk up and down hill in snow-covered trails, carrying stretchers onto which simulated victims were located etc... To infer the quality of ECG signals recorded we developed an algorithm for the automatic evaluation of collected signal deterioration. This method is based on the analysis of regularity of ECGs' P-QRS-T complexes pattern. To estimate the maintenance of typical ECGs pattern shape, approximate entropy (ApEn) was computed in moving fixed-length windows sliding along the signal, obtained after applying wavelet transform of the row ECG. The ApEn indices series was then thresholded to spot ECG points where P-QRS-T complexes were more or less easy to identify, respect to points where signal quality was completely deteriorated. Moreover, we evaluated signal quality maintenance while performing low and high intensity activities.

12:20
Comparison of Surface Models and Skeletal Models for Inertial Sensor Data Synthesis
Lena Uhlenberg (FAU Erlangen Nürnberg, Germany); Oliver Amft (Friedrich-Alexander Universität (FAU) Erlangen-Nürnberg, Germany)

We present a modelling and simulation framework to synthesise body-worn inertial sensor data based on personalised human body surface and biomechanical models. Anthropometric data and reference images were used to create personalised body surface mesh models. The mesh armature was aligned using motion capture reference pose and afterwards mesh and armature were parented. In addition, skeletal models were created using an established musculoskeletal dynamic modelling framework. Four activities of daily living (ADL), including upper and lower limbs were simulated with surface and skeletal models using motion capture data as stimuli. Acceleration and angular velocity data were simulated for 12 body areas of surface models and 8 body areas of skeletal models. We compared simulated inertial sensor data of both models against physical IMU measurements that were obtained simultaneously with video motion capture. Results showed average errors of 27 °/s vs. 31 °/s and 1.74m/s2 vs. 3.3 m/s2 for surface and skeletal models, respectively. Mean correlation coefficients of body surface models ranged between 0.2 - 0.9 for simulated angular velocity and between 0.1 - 0.8 for simulated acceleration when compared to physical IMU data. The proposed surface modelling consistently showed similar or lower error compared to established skeletal modelling across ADLs and study participants. Body surface models can offer a more realistic representation compared to skeletal models for simulation-based analysis and optimisation of wearable inertial sensor systems.

12:30
Contactless SpO2 Detection from Face Using Consumer Camera
Li Zhu and Korosh Vatanparvar (Samsung Research America, USA); Migyeong Gwak (University of California, Los Angeles, USA); Jilong Kuang and Alex Gao (Samsung Research America, USA)

We describe a novel computational framework for contactless oxygen saturation (SpO2) detection using videos recorded from the human face with smartphone cameras and ambient light. For contact pulse oximeter, a ratio of ratios (RoR) metric derived from selected region of interest (ROI) combined with linear regression modeling is the standard approach. However, when used upon contactless remote PPG (rPPG), the assumptions of this standard approach do not hold automatically: 1) the rPPG signal is usually derived from the face area where the light reflection may not be uniform due to variation in skin tissue composition and/or lighting conditions (e.g., shadowed vs. non-shadowed), 2) for most consumer-level cameras under ambient light, the rPPG signal is converted from light reflection associated with wide-band spectra, which creates complicated nonlinearity for SpO2 mappings. We propose a computational framework to overcome these challenges by 1) determining and dynamically tracking the ROIs according to both spatial and color proximity and calculate the RoRs based on selected individual ROIs which have homogeneous skin reflections, and 2) using a nonlinear machine learning model to mapping the SpO2 levels from RoRs derived from two different color combinations. We validated the framework with 30 healthy participants during various breathing tasks and achieved 1.24% root mean square error for across-subjects model and 1.06% for within-subject models, which surpassed the FDA-recognized ISO 81060-2-61:2017 standard.

12:40
A Novel Active Human Echolocation Device
Benny Lo (Imperial College, United Kingdom (Great Britain)); Saeed Akbarzadeh (Fudan University, China); Xiao Gu and Zhipeng Wu (Imperial College London, United Kingdom (Great Britain))

Some animals, like bats and dolphins, can echolocate themselves and navigate through complete darkness. They can generate ultrasonic signals and locate themselves based on the echo bounced back from the surrounding objects/structures. As human, we lack such abilities to echolocate ourselves, and we mainly rely on our vision to guide and navigate. However, recently, some visually impaired people have trained and learned the skills to echo locate themselves demonstrating that we can too echo locate ourselves with our own hearing. Based on this principal, we propose a novel wearable device that can aid both sighted and visually impaired people in acquiring the echolocation skills. As our hearing is tuned to filter out echos, the proposed device is designed with an ultrasound transmitter with a carrier frequency of 40 kHz and modulated with a signal with 2kHz frequency to generate a click sound that could be heard by the user for echolocation. Hence, the brain experienced far less confusion while attempting to comprehend the surrounding world and isolate the aspects necessary to acquire the abilities. To assess the ability of user to acquiring the echolocation skills, a healthy subject study was conducted where six training sessions that we conducted, and EEG (electroencephalogram) signal of the subjects were collected while they were blindfolded and using the proposed device to echolocate. From the results, we have shown that there was a significant correlation between their echolocation training and the intensified activations of the visual cortex area demonstrating the subjects were able to use the echoed signal to 'visualize' the surrounding environment. It also shows the subjects' ability to learn and echolocate themselves quickly in a room fitted with a random objects.

12:50
App for Physical Fitness Improvement based on Physical Activity Guidelines and Self-Testing Tools
Giannis-Panagiotis Botilias (University of Ioannina, Greece); Chrysostomos Stylios (PLATANI, Greece & Industrial Systems Institute, Athena RC, Greece)

Leading a sedentary lifestyle is becoming a significant public health issue, but a way of dealing with this issue is Physical Activity (PA). Regular PA is proven to help prevent and manage chronic diseases, maintain healthy body weight, and improve fitness. However, starting any PA after a long sedentary lifestyle carries risks of injuries, and a smoother transition with appropriate fitness programs is required. The rapidly growing number of smartphone users has given birth to broad-spectrum apps that use built-in sensors and collect data to provide insights about health and fitness. This work presents a fitness mobile application developed following the World Health Organization (WHO) guidelines for the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) self-screening tool utilizing built-in mobile sensors.

13:00
Discussion

12:00 – 13:30
Special Session Advanced AIoT systems for non-communicable diseases
Chair: Ming Huang, Nara Institute of Science and Technology, Japan; **Toshiyo Tamura,** Waseda University, Japan; **Xin Zhu**, The University of Aizu, Japan
Room: KLEIO

12:00
An IoT system for heat stroke prevention
Toshiyo Tamura (Waseda University, Future Robotics Organization); Ming Huang (Nara Institute of Science and Technology, Japan)

To prevent a heat stroke, the IoT system has been attempted. The wearable sensors were used to monitor both environmental conditions such as ambient temperature, humidity and radiation, and physical information such as heart rate, deep body temperature (DBT) and physical activity of clients, especially workers.. All data was collected and transferred to the cloud system. In the cloud system, automated decision making was performed to alarm the working conditions of clients. The wearable devices were mostly used as commercially available ones, and DBT was obtained from our developed dual- heat-flow thermometer. From the slope of DBT values with heart rate and physical activity. Pre-examination gave the threshold of DBT as 0.25C per 5 min and an alarming time was 5 min before reaching 38.0 C. The heart rate and physical activities were used as references. The WBGT which was specified as a heat illness was calculated. he threshold was over 28.5 C of web bulb was converted to output of humidity sensor. This is the last criteria of the warning. In a preliminary study, we performed two workers during day activities. The result indicated the slope of DBT change was an important part of the alarming time and stopped the work before WBGT warning.

12:12
Capacitive Sheeting Electrode System for Behavioral and Physiological Signals Monitoring in Bed
Akinori Ueno (Tokyo Denki University, Japan)

Home monitoring requires measuring the physiological and behavioral signals without impairing a subject's everyday life. This research presents an integrated and capacitive (i.e. noncontact) approach for obtaining simultaneous physiological and behavioral signals of recumbent humans in beds. In the proposed approach, a fabric-sheet unified sensing electrode (FUSE) obtains physiological signals by recording the electrocardiogram (ECG), chest and abdominal respiratory movements (RMs), and ballistocardiogram (BCG). The FUSE also measures the behavioral signals of body proximity (BPx) to detect bed-exiting/bed-entering motion and to discriminate lateral/supine lying postures. A prototype system with FUSE was validated in a short-term experiment and 6-h overnight measurements on two different groups composed of seven lying subjects. The results confirmed that the approach senses each signal independently and records the ECG, RMs, BCG, and BPx signals simultaneously. The mean sensitivities of the R and T waves of the ECG during sleep were 86.1% and 88.0%, respectively, whereas those of the chest and abdominal RMs were 90.7% and 90.1%, respectively. Although our prototype system has room for improvement, the results suggest that our approach enables the unconstrained, nocturnal monitoring of the physiological and behavioral signals in recumbent humans. The at-home monitoring of the physiological and behavioral signals is expected to contribute to early detection of non-communicable diseases and to cost-effective personalized healthcare in the future. This noncontact and easy-to-install system for in-bed measurements can facilitate a new era of home monitoring.

12:24
Monitoring of Diet and Physical Activity with Automatic Ingestion Monitor
Edward Sazonov (The University of Alabama, USA)

The Automatic Ingestion Monitor (AIM) is a passive food intake sensor requiring no self-report of eating episodes, just compliance with wearing the device. The current version of the AIM (v2, or AIM-2) includes an optical mastication sensor, an accelerometer, an egocentric camera, and USB and Bluetooth connectivity. Lightweight machine learning methods running on the device detect eating in real-time and capture images of foods and beverages being consumed. Post-processing of the AIM-2 data on a dedicated AI-IoT server further refines the eating episode detections, determines compliance with device wear, and recognizes the physical activities. This talk will present our ongoing work on using the AIM-2 for monitoring of energy intake, diet, physical activity, and energy expenditure.

12:36

Segmentation of femur from MRI images using PP-LiteSeg

Boyuan Peng, Yiyang Liu and Xin Zhu (University of Aizu, Japan); Shouhei Ikeda and Saburo Tsunoda (Aizu Medical Center, Japan)

Recently, the incidence of tumors around the world is increasing annually. In addition to the well-known solid tumors such as liver cancer, stomach cancer, and lung cancer, a variety of hematological malignancies such as lymphoma, leukemia and multiple myeloma have increasing incidences around the world.
Lymphomas are malignant tumors that originate in lymph nodes or lymphoid tissues. Lymphomas are mainly classified as non-Hodgkin's lymphoma and Hodgkin's lymphoma. A common symptom of both types of lymphoma is painless swelling of one or more lymph glands. Hodgkin's lymphoma is more common in the neck, armpits, and chest, while non-Hodgkin's lymphoma is usually found in lymph nodes throughout the body.
Currently, clinical practice relies on routine site bone marrow biopsy to diagnose lymphoma. However, biopsy is an invasive operation with sampling errors. MRI can compensate for the deficiency of biopsy and improve the detection rate of lymphoma. In addition, MRI may have predictive value for the prognosis of lymphoma patients.
However, using MRI images to analyze hematological malignancies is not only time-consuming and labor-intensive but also requires extensive experience. Diagnosis is essential for effective treatment of Hematological malignancies. With the rapid development of artificial intelligence, deep learning has been widely used in computer-aided detection and analysis. Accurate segmentation of femur from MRI images is crucial to the analysis of femoral marrow. Yun et al. proposed a fully automated method for femoral segmentation using pelvic CT, and their method was accurate and improved the subsequent measurement of fracture determination. Yue et al. analyzed the role of whole-body MRI versus PET/CT in the diagnosis and prognosis of bone marrow infiltration in lymphoma. In our previous work, we also proposed a method for the automatic segmentation of femur. PP-LiteSeg is a novel lightweight model for the real-time semantic segmentation task. PP-LiteSeg incorporates an attention mechanism module that generates attention weights and fuses input features with the weights.
In this research, we proposed a new method based on PP-LiteSeg for femur segmentation in MRI images from patients with hematological malignancies. In addition, we compared the segmentation results of PP-LiteSeg with those of traditional CNN models.

12:48

Gender Difference in Prognosis of Patients with Heart Failure: A Propensity Score Matching Analysis

Xue Zhou and Xin Zhu (University of Aizu, Japan); Keijiro Nakamura (Toho University Ohashi Medical Center, Japan); Ming Huang (Nara Institute of Science and Technology, Japan)

Heart failure (HF) has been a global health concern with high prevalence, mortality and costs. A reliable prognostic prediction for HF was essential. Despite advances in predicting adverse outcomes in patients with HF, limited studies considered or specifically explored the effect of gender differences on prognosis. In this study, we estimated the gender differences in prognosis of patients with HF based on a propensity score matched cohort. Missing data were handled by a multiple imputation method using regression with predictive mean matching. Thereafter, propensity score matching (PSM) was performed with a single hidden layer neural network in a 1:1 matching (male vs. female). Totally, 730 patients with HF were enrolled in this study, (male: 399; female: 331). After PSM analysis, 364 patients were matched (male: 182; female: 182) and important prognostic factors including age, echocardiographic variables, and variables related to kidney function were balanced between female and male groups. This study demonstrated that female gender had better overall survival than that of male (hazard ratio of all-cause mortality between female and male: 0.593; 95% confidence interval(CI), 0.353-0.996, p = 0.048) but prognosis conditions involving cardiovascular survival and HF-related readmission had no significant difference between male and female patients (cardiovascular mortality: hazard ratio: 0.669; 95%CI, 0.311-1.443, p = 0.306; HF-related readmission: hazard ratio:0.828; 95%CI, 0.549-1.250, p = 0.370).

13:00

Integrating Wearable and IoT Sensing with Edge and Cloud Computing in LifeChamps to Support Cancer Champions

Farhad Abtahi (Karolinska Institutet & KTH Royal Institute of Technology, Sweden); Fernando Seoane (Karolinska Institutet & Karolinska University Hospital, Sweden); Antonios Billis and Paraskevas Lagakis (Aristotle University of Thessaloniki, Greece); Dany Saphiro (Dell Technologies, Israel); Panagiotis P. Bamidis (Aristotle University of Thessaloniki, Greece)

LifeChamps aims to address the inherent complexity caused by cancer treatments and to act in the monitoring of health status and improvement of quality of life in a significant manner by using emerging technologies in the fields of Big Data, Data Analytics and Artificial Intelligence. LifeChamps is providing support to middle aged and older (pre-frail and frail) cancer patients, as well as their caregivers and healthcare professionals, with an integrated Big Data-driven solution capable to improve their Quality of Life (QoL) via a timely and more accurate clinical decision support at the point of care. Its Artificial Intelligence (AI) and analytics engine, running both at the cloud and at the mobile edge, can determine accurately which

factors affect the oncological patients' QoL the most, during and after their treatment. Furthermore, complemented by a health coach system LifeChamps offers personalized healthcare services to these patients and their caregivers.

13:13
Discussion

12:00 – 13:30
Virtual Session # 2 Recent Developments in Health Technology
Chair: Chairs: Dimitrios Koutsouris, National Technical University of Athens, Greece; **Antonis Sakellarios,** University of Ioannina, Greece
Room: PANDORA C'

12:00
Stratification and Survival Prediction for Amyotrophic Lateral Sclerosis Patients
Yixiao Huang, Xiaoli Wu and Rosa H. M. Chan (City University of Hong Kong, China)

Survival analysis is widely used in modelling the relationship between clinical features and survival outcomes, which can help designing ALS trials and developing better treatment for ALS patients. However, the power of conventional survival analysis may be limited when the subgroups with different survival distributions exist in the population. Integrating clustering information into survival analysis is a possible solution. Besides, previous studies on clustering ALS data seldom took both clinical features and survival information into consideration. Pooled Resource Open-Access ALS Clinical Trials (PRO-ACT) Database is the largest ALS dataset containing over than 10700 patient records.
In this paper, we applied a deep probabilistic method that jointly accounts for clustering and survival objectives. Utilizing clinical features and survival time, the model is able to infer the hidden clusters and conduct cluster-specific survival analysis. We demonstrated that the model identifies meaningful subgroups and yields promising performance over baseline methods in survival time prediction. Using a SHAP explainer, we identified clinically meaningful predictors that are beneficial to develop precision medicine. Due to a large proportion of missing data in the database, we showed that different choices of imputation methods are crucial for analysing ALS data and found that probabilistic principal component analysis (PPCA) gives the best performance.

12:10
One-side Virtual Histological Staining Model for Complex Human Samples
Lulin Shi, Ivy Wong, Claudia Lo and Terence Wong (The Hong Kong University of Science and Technology, Hong Kong)

Virtual histological staining technique with a label-free auto-fluorescence image as an input is a challenging scientific pursuit to visualize complicated biological structures with distinct features. Recently, most of the related methods follow the two-side image translation architecture (cycleGAN) to get rid of paired data restriction, which is necessary for unprocessed and thick tissue virtual histological staining style transformation. However, the associated cycle consistency loss will inevitably lead to huge calculation consumption and cannot address the problem of incorrect translation among intracellular and extracellular components, which we termed as incorrect staining issue. In this paper, we propose a novel and computational efficient one-side image translation framework to transfer unstained auto-fluorescence images into virtual hematoxylin- and eosin-stained counterparts for both thin and thick human samples. To address the incorrect nuclear staining issue, we design a region classification loss to incorporate partial supervision information. We focus on the virtual staining on complex human samples, including both thin human lung cancer samples and thick samples. Experimental data on the samples with complicated cellular structures are used to demonstrate that our method is computationally efficient while achieving a comparable transformation performance over the two-side framework. With the proposed framework, stained images from unstained samples scans can be obtained within minutes without high-cost equipment and laborious sample preparation procedures, providing an efficient alternative scheme for fast histopathology, revolutionizing the histology realm.

12:20
A Customized Artificial Ear Based on Vibrotactile Feedback: A Pilot Study
Yicheng Yang and Weibang Bai (Imperial College London, United Kingdom (Great Britain)); Benny Lo (Imperial College, United Kingdom (Great Britain))

Hearing aid devices have been around for decades, while most of them focus on sound amplification and SNR improvement. This paper proposes an artificial ear based on the vibrotactile feedback. The speech signal is converted into the vibrotactile devices placed around the subject's ear through the speech recognition algorithm and pattern coding method. Preliminary experiments on the prototype consisting of six motors which has shown that the recognition accuracy of letters and daily sentences reached 90%. The learning time of interpreting the vibrotactile signals could be less than four times that in realtime conversation, proving the feasibility of the proposed device for real-life application.

12:30
An Experimental Study of Digital Communication System with Human Body as Communication Channel
Chengyi Zhang, Qingyun Jin and Mohan Zhao (Tongji University, China); Dingguo Zhang (University of Bath, United Kingdom (Great Britain)); Lin Lin (Tongji University, China)

For a long time, people have carried out various studies on human body communication (HBC) in order to establish a suitable communication link through human body. However, in the galvanic coupled method of HBC, the high current intensity is rarely used to implement the communication link. In the medical field, functional electrical stimulation (FES) is often used to send high intensity electrical pulses to make muscles contract, and this contraction phenomenon will generate surface electromyography (sEMG) signals on the surface of human skins. According to this principle and the galvanic coupling method of HBC, we propose a new digital communication system based on FES and sEMG signal detection with human body as communication channel in this paper. We modulate the transmitted signal into electrical stimulation to stimulate the muscles and detect the sEMG signal caused by it to achieve a complete communication process. The framework of the entire communication system is proposed. Its error performance for different stimulation parameters is tested and evaluated by experiments. Using FES and sEMG signal detection, our work makes an exploration of HBC at high current intensity. This work is expected to be applied to the HBC design combined with electrical stimulation in medical field.

12:40
Bio-Electrical Impedance Analysis for Wrist-Wearable Devices
Artem Nikishov and Konstantin Pavlov (Samsung Research Russia, Russia); Namseok Chang and Jaehyuck Park (Samsung Electronics, Korea (South)); Justin Younghyun Kim (Samsung, Korea (South)); Wonseok Lee (Samsung Electronics, Korea (South))

In the recent years, there has been an astonishing growth of consumer interest in personal healthcare. In this work we described results of the bio-electrical impedance analysis (BIA) algorithm implementation that does not require information about parasitic impedances values in a smartwatch structure, and skin contact impedances values. Only voltages and currents directly measured by BIA device are taken into consideration. It makes BIA process independent of complex hardware of smartwatches (including small size of the electrodes) and avoids additional factory mode calibrations in case of the minor structural changes. The applicability and accuracy of the method has been verified at circuit simulation for pre-commercial smartwatch prototype which has two electrodes embedded in control buttons with an ~0.3 cm2 area of each and two electrodes embedded into the bottom side with an ~1.5 cm2 area of each. The bio-electrical impedance errors were analyzed at variation of the parasitic capacitance between contact electrodes and BIA analog-front-end circuit and at variation of skin contact impedance magnitude up to 15 kOhm per 1 cm2 of the electrode area at 50 kHz of signal frequency. Such high magnitude of skin contact impedance covers the most extreme cases at low humidity, very dry or damaged skin, too weak or too hard touches by user.

12:50
Sweat Loss Estimation Solution for Smartwatch
Konstantin Pavlov, Elena Volkova and Georgii Megre (Samsung Research Russia, Russia); Wonseok Lee (Samsung Electronics, Korea (South)); Justin Younghyun Kim (Samsung, Korea (South)); Evgenii Nikolaev and Alexey Perchik (Samsung Research Russia, Russia); Namseok Chang and Jaehyuck Park (Samsung Electronics, Korea (South)); Vladimir Tsepulin (Samsung Research Russia, Russia)

This study aimed to develop the new fitness function for wearable devices, namely - Sweat loss estimation during running activity. Machine learning model (polynomial Kernel Ridge Regression) was trained and validated with large and diverse dataset. Totally 568 human subjects participated in 748 running tests. Sweat loss contributing factors such as users' anthropometric parameters, distance, ambient temperature and humidity were distributed in the wide range of values. The performance of fully automatic sweat loss estimation algorithm provides average root mean square error (RMSE) = 236 ml; more important health-related parameter body weight percentage RMSE (RMSEBWP) = 0.33% and coefficient of determination (R2) = 0.79. To the authors' knowledge the algorithm provides the highest performance among existing solutions or ever described in literature. The described method of sweat loss estimation is based on sensors that are currently available in the most smartwatches and fitness trackers. Although we used indirect estimation (no direct measurements of sweat amount) the approach showed a high performance. It was shown that multiple factors influence sweating during the running exercise and only a part of factors can be used for smartwatch algorithm. A set of measures to overcome an uncertainty of unknown factors were implemented: dataset with a variety of external conditions and user parameters, improved running distance estimation, data augmentation technique and sweat loss ML model optimization.

13:00
Discussion

13:30 – 14:45
Lunch
Room: PANDORA A'

13:30 – 14:45
Career Development Panel
Chair: Metin Akay, EMBS President, University of Houston, USA
Room: PANDORA C'

George Matsopoulos
National Technical University of Athens, Greece

14:45 – 15:30
Keynote Lecture
Chair: May D. Wang, BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA
Room: ERATO

Harnessing ultrasound for modulation of the central and peripheral nervous system
Prof. Elisa Konofagou
Columbia University, USA

Focused ultrasound (FUS) neuromodulation has previously been proposed as a promising technique to drive neuronal activity and has been shown throughout a breadth of applications including in mice, rats, non-human primates and humans as a novel technique for the noninvasive manipulation of neuronal activity using ultrasound. Our group and others have demonstrated excitation of both the central (CNS) and peripheral nervous system (PNS). In the CNS, motor- and cognitive-related brain regions of mice were induced by targeting specific brain structures. Higher acoustic pressures increased the success rate. Pupil dilation was observed when neuromodulating regions in the brain covering the superior colliculus and other anxiety-related structures such as hippocampus and locus coeruleus. In the PNS, we showed for the first time stimulation of the sciatic nerve with FUS eliciting a physiological motor response was recorded in vivo. Clipping the sciatic nerve downstream of stimulation eliminated EMG activity during FUS stimulation. Peak-to-peak EMG responses and latencies were comparable to conventional electrical stimulation methods. Histology along with behavioral and thermal testing did not indicate damage to the nerve or surrounding regions. Finally, underlying mechanisms on the Piezo2 channel and clinical studies on pain mitigation will be shown. Our studies demonstrate the capability of FUS to modulate target specific regions in both the brain and the periphery with several potential clinical applications.

15:30 – 17:00
BHI Session #2 Big Data and AI (I)
Chair: Jie Liang, University of Illinois at Chicago, USA; **Fahad Saeed,** Florida International University, USA
Room: POLYMNIA

15:30
A Multimodal Approach for Dementia Detection from Spontaneous Speech with Tensor Fusion Layer
Loukas Ilias, Dimitris Askounis and John Psarras (National Technical University of Athens, Greece)

Alzheimer's disease (AD) is a progressive neurological disorder, meaning that the symptoms develop gradually throughout the years. It is also the main cause of dementia, which affects memory, thinking skills, and mental abilities. Nowadays, researchers have moved their interest towards AD detection from spontaneous speech, since it constitutes a time-effective procedure. However, existing state-of-the-art works proposing multimodal approaches do not take into consideration the inter- and intra-modal interactions and propose early and late fusion approaches. To tackle these limitations, we propose deep neural networks, which can be trained in an end-to-end trainable way and capture the inter- and intra-modal interactions. Firstly, each audio file is converted to an image consisting of three channels, i.e., log- Mel spectrogram, delta, and delta-delta. Next, each transcript is passed through a BERT model followed by a gated self-attention layer. Similarly, each image is passed through a Swin Transformer followed by an independent gated self-attention layer. Acoustic features are extracted also from each audio file. Finally, the representation vectors from the different modalities are fed to a tensor fusion layer for capturing the inter-modal interactions. Extensive experiments conducted on the ADReSS Challenge dataset indicate that our introduced approaches obtain valuable advantages over existing research initiatives reaching Accuracy and F1-score up to 86.25% and 85.48% respectively.

15:42
Analysis of ensemble-combination strategies for improving inter-database generalization of deep-learning-based automatic sleep staging
Adriana Anido-Alonso and Diego Alvarez-Estevez (University of A Coruña, Spain)

Deep learning has demonstrated its usefulness in reaching top-level performance on a number of application domains. However, the achievement of robust prediction capabilities on multi-database scenarios referring to a common task is still a broad of concern. The problem arises associated with different sources of variability modulating the respective database generative processes. Hence, even though great performance can be obtained during validation on a local (source) dataset, maintenance of prediction capabilities on external databases, or target domains, is usually problematic. Such scenario has been studied in the past by the authors in the context of inter-database generalization in the domain of sleep medicine. In this work we build up over past work and explore the use of different local deep-learning model's combination strategies to analyze their effects on the resulting inter-database generalization performance. More specifically, we investigate the use of three different ensemble combination strategies, namely max-voting, output averaging, and weighted Nelder-Mead output combination, and compare them to the more classical database-aggregation approach. We compare the performance resulting from each of these strategies using six independent, heterogeneous and open sleep staging databases. Based on the results of our experimentation we analyze and discuss the advantages and disadvantages of each of the examined approaches.

15:54
Towards Graph Representation Learning Based Surgical Workflow Anticipation
Xiatian Zhang, Noura Al Moubayed and Hubert P. H. Shum (Durham University, United Kingdom (Great Britain))

Surgical workflow anticipation can give predictions on what steps to conduct or what instruments to use next, which is an essential part of the computer-assisted intervention system for surgery, e.g. workflow reasoning in robotic surgery. However, current approaches are limited to their insufficient expressive power for relationships between instruments. Hence, we propose a graph representation learning framework to comprehensively represent instrument motions in the surgical workflow anticipation problem. In our proposed graph representation, we maps the bounding box information of instruments to the graph nodes in the consecutive frames and build inter-frame/inter-instrument graph edges to represent the trajectory and interaction of the instruments over time. This design enhances the ability of our network on modeling both the spatial and temporal patterns of surgical instruments and their interactions. In addition, we design a multi-horizon learning strategy to balance the understanding of various horizons indifferent anticipation tasks, which significantly improves the model performance in anticipation with various horizons. Experiments on the Cholec80 dataset demonstrate the performance of our proposed method can exceed the state-of-the-art method based on richer backbones, especially in instrument anticipation (1.27 v.s. 1.48 for inMAE; 1.48 v.s. 2.68 for eMAE). To the best of our knowledge, we are the first to introduce a spatial-temporal graph representation into surgical workflow anticipation.

16:06
quEEGNet: Quantum AI for Biosignal Processing
Toshiaki Koike-Akino (Mitsubishi Electric Research Laboratories (MERL), USA); Ye Wang (Mitsubishi Electric Research Laboratories, USA)

The great advancement of artificial intelligence (AI) techniques based on deep neural networks (DNN) has enabled practical development of human-machine interfaces (HMI) including brain-computer interfaces (BCI) through the analysis of the user's physiological data, such as electroencephalogram (EEG) and electromyogram (EMG). However, such biosignals are highly prone to variation depending on the biological states of each subject. Hence, frequent calibration is often required in typical HMI systems. Toward resolving this issue, subject-invariant methods, employing domain generalization and transfer learning, have been proposed to reduce user calibration for HMI systems.
In this paper, we introduce an emerging quantum machine learning (QML) framework to assist classical deep learning methods for biosignal processing applications. Specifically, we propose a hybrid quantum-classical neural network model that integrates a variational quantum circuit (VQC) into a deep neural network (DNN) for electroencephalogram (EEG), electromyogram (EMG), and electrocorticogram (ECoG) analysis. The proposed concept is referred to as quantum EEGNet (quEEGNet). We demonstrate that the proposed quantum neural network (QNN) achieves state-of-the-art performance while the number of trainable parameters is kept small for VQC. To the best of our knowledge, this is the very first paper discussing quantum AI applied to HMI and BCI systems, envisioning the future era of quantum supremacy.

16:18
Classification of Video Capsule Endoscopy Images Using Visual Transformers
Daniel Lopes Soares Lima (Federal University of Maranhão, Brazil); Alexandre CP Pessoa (Universidade Federal do

Maranhão, Brazil); Anselmo de Paiva (Federal University of Maranhão, Brazil); António Cunha (Universidade de Trás-os-Montes e Alto Douro & INESC/TEC, Portugal); Geraldo Braz and João Almeida (Federal University of Maranhão, Brazil)

Cancers related to the gastrointestinal tract have a high incidence rate in the population, with a high mortality rate. Videos obtained through endoscopic capsules are essential for evaluating anomalies that can progress to cancer. However, due to their duration, which can reach 10 hours, they demand great attention from the medical specialist in their analysis. Machine learning techniques have been successfully applied in developing computer-aided diagnostic systems since the 1990s, where Convolutional Neural Networks (CNNs) have become very successful for pattern recognition in images. CNNs use convolutions to extract features from the analyzed data, operating in a fixed-size window and thus having problems capturing pixel-level relationships considering the spatial and temporal domains. Otherwise, transformers use attention mechanisms, where data is structured in a vector space that can aggregate information from adjacent data to determine meaning in a given context. This work proposes a computational method for analyzing images extracted from videos obtained by endoscopic capsules, using a transformer-based model that helps diagnose of gastrointestinal tract abnormalities. Preliminary results are promising. The classification task of 11 classes evaluated on the publicly available Kvasir-Capsule dataset yielded an average value of 99.70% of accuracy, 99.64% of precision, 99.86% of sensitivity, and 99.54% of f1-score.

16:30
How Generalizable and Interpretable are Speech-Based COVID-19 Detection Systems?: A Comparative Analysis and New System Proposal
Yi Zhu (INRS, Canada); Alex Mariakakis (University of Toronto, USA); Eyal de Lara (University of Toronto, Canada); Tiago Falk (INRS-EMT, Canada)

Recent work has shown the potential of using speech signals for remote detection of coronavirus disease 2019 (COVID-19). Due to the limited amount of available data, however, existing systems have been typically evaluated within the same dataset. Hence, it is not clear whether systems can be generalized to unseen speech signals and if they indeed capture COVID-19 acoustic biomarkers or only dataset-specific nuances. In this paper, we start by evaluating the robustness of systems proposed in the literature, including two based on hand-crafted features and two on deep neural network architectures. In particular, these systems are tested across two international COVID-19 detection challenge datasets (COMPARE and DICOVA2). Experiments show that the performance of the explored systems degraded to chance levels when tested on unseen data, especially those based on deep neural networks. To increase the generalizability of existing systems, we propose a new set of acoustic biomarkers based on speech modulation spectrograms. The new biomarkers, when used to train a simple linear classifier, showed substantial improvements in cross-dataset testing performance. Further interpretation of the biomarkers provides a better understanding of the acoustic properties of COVID-19 speech. The generalizability and interpretability of the selected biomarkers allow for the development of a more reliable and lower-cost COVID-19 detection system.

16:42
Discussion

15:30 – 17:00
Special Session: Radar-Based Activity Recognition and Health Monitoring
Chair: Sevgi Z Zubeyde Gurbuz, University of Alabama, USA
Room: KLEIO

15:30
Radar Monitoring of Patients in a Psychiatric Hospital
Marjorie Skubic (University of Missouri, USA); Nuerzati Resuli (GlobalFoundries, USA)

The noninvasive monitoring of patients in a psychiatric hospital presents unique challenges due to safety and privacy concerns. Because patients may be at risk of harming themselves or others, it is common for clinical staff to perform safety checks on patients every 15 minutes during the day and night. Cameras are not permitted in patient rooms due to privacy concerns. Wearable sensors and bed sensors are not allowed due to safety concerns. Here, we present one approach using a radar system embedded in the ceiling over the bed, to avoid patient contact with wires and sensors. The most urgent aim is to recognize when patients are in bed but not breathing. The first step is to determine when the bed is empty vs. when a patient is in bed (independent of respiration). The approach is tested in a psychiatric hospital with seven patients for a total of 12 nights, spanning 135 hours. Ground truth is determined with nurses' notes and a depth sensor embedded in the ceiling over the bed. The classification accuracy of an empty bed vs. a patient in bed is 99% across all nights. We also show how bed restlessness can be quantified, to provide a measure of sleep quality.

15:42
Realistic Micro-Doppler Database Generation Through Neural Style Transfer Framework
Shelly Vishwakarma (University College London, United Kingdom (Great Britain))

Real-time monitoring of humans can assist professionals in providing healthy living enabling technologies to ensure the health, safety, and well-being of people of all age groups. This work presents an application of opportunistic Radio frequency (RF) sensing system for monitoring human activities directly related to healthcare. In order to further enhance the human activity recognition performance of the existing sensing systems, we propose a style-transfer neural framework to generate a realistic synthetic micro-Doppler signature dataset to be used for augmenting the limited measurement dataset. The proposed network extracts environmental effects such as noise, multipath, and occlusions effects directly from the measurement data and transfers these features to our clean simulated signatures. This results in more realistic-looking signatures qualitatively and quantitatively. We use these enhanced signatures to augment our measurement data and observe an improvement in the classification performance by 5\% compared to no augmentation case. Overall, the paper demonstrates the feasibility of generating realistic simulated spectrograms and opens up opportunities for understanding the natural phenomena directly from the measurement data. Furthermore, since these signatures can effectively mimic realistic signatures, they can be used to augment the training dataset and effectively enhance the sensing performance of the existing sensing systems for real-world applications such as e-healthcare and ambient assisted living.

15:54
Gait Parameter Estimation and Activity Recognition from Continuous RF Data Streams
Sevgi Z Gurbuz (The University of Alabama, USA)

The detection and rapid response to critical health events, such as falls, stroke, seizure and heart attack are critical to ensuring positive outcomes, longevity, and quality of life, especially in older adults. Each year roughly 1,000 older adults suffer fall-related fatalities in Assisted Living Facilities (ALFs), where patients are more closely observed, while mobility limitations affect more than one third of adults over age 70 and a majority of adults over 85 years of age and is most often the first sign of functional decline. Human activity recognition (HAR) and gait analysis are important functions that support ageing-in-place and remote health monitoring. Although there have been many works investigating HAR with radar based on single-activity snapshots in time, few works address recognition in continuous streams of RF data, where in daily life many different activities are conducted. This work proposes a novel variable window averaging method to segment RF data streams containing a mixture of large-scale gross motor activities as well as fine-grain hand gestures, a physics-aware generative adversarial network (PhGAN) to recognize daily activities, and a new technique to estimate step-time variability from RF data. Our results show that extraction of motion detected intervals and GAN-synthesized samples during training boosts HAR accuracy, while the estimation variance of time-step variability from radar compares well with that obtained from a Vicon motion capture system.

16:06
Stabilizing Skeletal Pose Estimation using mmWave Radar via Dynamic Model and Filtering (one page paper)
Shuting Hu and Arindam Sengupta (The University of Arizona, USA); Siyang Cao (University of Arizona, USA)

In this paper, we illustrate a method to stabilize the position estimation of human skeleton using mmWave radar. In our previous study, an optimized CNN architecture was used to extract the positions of human skeleton accurately. However, the position estimation of the joints vibrates over time. In the field of digital signal processing, filters are used to remove unwanted parts of signal and widely applied in noise reduction, radar, audio and video processing, etc. In this paper, three types of filters i.e. Elliptic, Savitzky-Golay, and Whittaker-Eilers are discussed and applied to both positions and angles of the human skeleton. This paper further presents a humanoid robotics dynamic model, specifically forward kinematics, to recalculate joint positions with improved stability. We define the root joint, a world coordinate system, and "T" pose, to get the subsequent joints' rotation matrix using kinematics chain of the skeleton, then compute the Euler angles. After the filtering, we compare the effect of different filters using a method of Standard Deviation (SD) of the angle slope. In addition, we analyze the change of localization accuracy after recalculating the positions using forward kinematics based on the current angle, root position, and bone length information. The data collection and experimental evaluation have shown a motion stability improvement of 54.62% compared to the CNN predicted value.

16:18
An EEG-based Method for Drowsiness Level Estimation
David O'Callaghan (Xperi Corporation, Ireland); Cian Ryan (Xperi, Ireland); Ashkan Parsi (Xperi Corporation, Ireland); Joseph Lemley (Xperi Corporation & National University of Ireland, Galway, Ireland)

Obtaining accurate estimates of a driver's level of drowsiness to help develop non-invasive methods for drowsiness detection is a challenging and open research problem. Many approaches to drowsiness or sleepiness estimation are

supervised machine learning ones that require accurate labels for their sensor data to train a model. In this work, we present a method to annotate time-series data with a driver's estimated level of drowsiness using characteristics from the electroencephalogram (EEG). We describe a novel scoring algorithm that assigns a value between one and ten to segments of EEG data corresponding to a driver's predicted response on the Karolinska Sleepiness Scale (KSS). The parameters of the scoring algorithm are tuned using a metaheuristic optimization algorithm called Late-Acceptance Hill-Climbing and a loss function that utilizes the driver's own KSS ratings. We present promising qualitative results for our method to estimate a person's level of drowsiness on a more granular scale than traditional survey methods like KSS. Furthermore, the approach can be extended beyond drowsiness estimation to any task involving the need to make use of EEG data between event markers or annotations. In addition, we describe the data acquisition process that was employed in this work along the with database created.

16:30
Designing Wearable Multi Sensory e-Textile System with IoT Functions for Respiration Monitoring
Gozde Cay (Baylor College of Medicine, USA); Dhaval Solanki, Md Abdullah Al Rumon, Vignesh Ravichandran and Kunal Mankodiya (University of Rhode Island, USA)

The aim of this project is designing a textile-based monitoring system based on IoT functions to monitor the respiration rate from chest movements wirelessly. This monitoring system includes a chest belt integrated with textile pressure sensors, an embedded system to collect data from the pressure sensors and an edge computing device to process and visualize the data.

16:42
Discussion

15:30 – 17:00
Digital Reality Panel (Sponsored by IEEE Future Directions DRI)
Chair: Kathy Grise, IEEE Future Directions Senior Program Director
Room: PANDORA C'

Nicholas Napp
Founder, CEO Xmark Labs, USA

Roberto Saracco
University of Trento, Italy

May Dongmei Wang
BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA

Metin Akay
EMBS President, University of Houston, USA

17:00 – 17:15
Coffee Break
Room: FOYER ERATO

17:15 – 18:45
Poster Session # 1 & Reception Posters Finger Food
Room: FOYER ERATO

Screen 1

17:15
Mathematical Modeling and Growth Model Analysis for Preventing the Cancer Cell Development
Dimitrios G Boucharas (Biomedical Research Institute - FORTH, Greece); Chryssa Anastasiadou (Hellenic Agricultural Organization, Greece); Spyridon Karkabounas (University of Ioannina, Greece); Efthimia Antonopoulou (Aristotle University of Thessaloniki, Greece); George Manis (University of Ioannina, Greece)

Cancer, one of the leading causes of morbidity across the globe, accounts for more than ten million deaths in 2020. The tremendous effort employed by the scientific community improves the efficiency of chemotherapy treatments, while the work in preventing cancer is comparably limited. This study attempts to mathematically model the cancer cell growth. Cancer was chemically induced to Naval Medical Research Institute inbred mice utilizing a fully carcinogenic agent. Specific organic

compounds from the polyamine and thiol families were mixed with the agent to observe if the former can cease or delay the oncogenesis incidence by neutralizing the carcinogenic agent. As a result, a series of records containing the tumor size and the corresponding examination date was accumulated. A plethora of complex mathematical functions was recruited to evaluate the constructed curve in terms of the best fit to the series of data points. The developed models were explored based on their ability to predict future values, while the importance of the model parameters was exploited in a devised classification problem. The results presented herein are encouraging and can potentially expand the scope of this research into other research areas such as the development of effective nutritional supplements able to inhibit carcinogenesis.

17:25

A hybrid approach based on dynamic trajectories to predict mortality in COVID-19 patients upon steroids administration

Vasileios C. Pezoulas (University of Ioannina, Greece); Eugenia Mylona (Unit of Medical Technology and Intelligent Information Systems, University of Ioannina & FORTH-IMBB, Greece); Costas Papaloukas (University of Ioannina, Greece); Angelos Liontos (School of Medicine, University of Ioannina, Ioannina, Greece); Dimitrios I. Biros, Orestis I. Milionis, Chris Kyriakopoulos, Kostantinos Kostikas and Haralampos Milionis (School of Medicine, University of Ioannina, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Since the World Health Organization (WHO) has declared Artificial Intelligence (AI) as a powerful tool in the fight against COVID-19, multiple studies have been launched aiming to shed light into risk factors for ICU admission and mortality. None of the existing studies, however, have captured the dynamic trajectories of hospitalized COVID-19 patients who receive steroids nor have explored trajectory-based mortality indicators. In this work, we present a novel, hybrid approach to address this need. Latent Growth Mixture Modelling (LGMM) was used to analyze the trajectories of patients who received steroids. The patients were then grouped into clusters based on the similarity of their dynamic trajectories. State-of-the art machine learning classifiers are trained on the original dataset with and without dynamic trajectories to assess whether their inclusion can enhance the prediction of mortality. Our results highlight the importance of trajectories for predicting mortality in patients who receive steroids yielding 4% and 5% increase in the sensitivity (0.84) and specificity (0.85). The FiO2 and percentage of neutrophils at day 5, along with the percentage of lymphocytes at day 7, were identified as the main causes for mortality in patients who receive steroids, where the SatO2 levels showed significant alterations in the dynamic trajectories.

17:35

Can Free Drawing Anticipate Handwriting Difficulties? A Longitudinal Study

Linda G. Dui, Simone Toffoli and Christopher Speziale (Politecnico di Milano, Italy); Cristiano Termine (University of Insubria, Italy); Matteo Matteucci and Simona Ferrante (Politecnico di Milano, Italy)

Handwriting difficulties need to be addressed early to avoid several problems to children, both at school and in everyday life, but dysgraphia diagnosis cannot be performed before handwriting maturation. To solve this issue, we hypothesize that the analysis of drawings produced in a pre-literacy stage can predict handwriting problems that will occur years later. We designed a three-year longitudinal study from the last year of kindergarten to the end of second grade with two aims: (1) to longitudinally assess the evolution of drawing features, and (2) to understand if the features collected at pre-literacy can predict future handwriting problems. Hence, features were tested for statistically significant variation among the five time points available to assess their longitudinal evolution in time. Moreover, we trained machine learning models to select the most important features collected at pre-literacy and to assess their predictive capabilities, with dysgraphia risk assessed at the end of second grade. 202 children completed the longitudinal study. We found that 81% of the feature was sensitive to longitudinal maturation, and that it is possible to predict the difficulties with a weighted area under the precision-recall curve of 0.72. This is a step forward towards an early intervention for handwriting problems.

17:45

What PLS can still do for Imaging Genetics in Alzheimer's disease

Federica Cruciani (University of Verona, Italy); André Altmann (University College London, United Kingdom (Great Britain)); Marco Lorenzi (Inria Sophia Antipolis, France); Gloria Menegaz and Ilaria Boscolo Galazzo (University of Verona, Italy)
In this work we exploited Partial Least Squares (PLS) model for analyzing the genetic underpinning of grey matter atrophy in Alzheimer's Disease (AD).

To this end, 42 features derived from T1-weighted Magnetic Resonance Imaging, including cortical thicknesses and subcortical volumes were considered to describe the imaging phenotype, while the genotype information consisted of 14 recently proposed AD related Polygenic Risk Scores (PRS), calculated by including Single Nucleotide Polymorphism passing different significance thresholds. The PLS model was applied on a large study cohort obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database including both healthy individuals and AD patients, and validated on an independent ADNI Mild Cognitive Impairment (MCI) cohort, including Early (EMCI) and Late MCI (LMCI).
The experimental results confirm the existence of a joint dynamics between brain atrophy and genotype data in AD, while providing important generalization results when tested on a clinically heterogeneous cohort. In particular, less AD specific

PRS scores were negatively correlated with cortical thicknesses, while highly AD specific PRSs showed a peculiar correlation pattern among specific subcortical volumes and cortical thicknesses. While the first outcome is in line with the well known neurodegeneration process in AD, the second could be revealing of different AD subtypes.

17:55

Classification of Sleep Apnea via SpO2 in a Simulated Smartwatch Environment

Brendan Lyden (Munster Technological University, Ireland); Zachary Dair (Munster Technological University & Advance CRT, Ireland); Ruairi O'Reilly (Munster Technological University, Ireland)

Sleep apnea is one of the most common sleep disorders. To diagnose sleep apnea, a patient must undertake a polysomnography where multiple physiological signals are recorded in a specialised sleep laboratory. Reducing the number of physiological signals necessary for a diagnosis and enabling data monitoring in a distributed fashion would assist in the detection of sleep apnea. Smartwatches are becoming more advanced, with the current generation capable of deriving blood oxygen saturation, which can indicate sleep apnea. This work evaluates the efficacy of sleep apnea classifiers in a simulated smartwatch environment. Results demonstrate that SpO2 is a performant signal for classifying sleep apnea. Naive Bayes trained with features extracted from a Long Short Term Memory Network is capable of classifying sleep apnea with an accuracy of 97.04%, outperforming state-of-the-art approaches. Classification within the simulated smartwatch environment demonstrates robustness up to a signal-to-noise ratio of 50 dB and maintains high levels of accuracy at sampling frequencies above 25 Hz. The results are encouraging as to the role smartwatches could play in aiding sleep apnea detection. Sleep apnea is a potentially dangerous and debilitating sleep disorder characterised by a temporary stoppage or reduction of breathing during sleep. There are three different types of sleep apnea, Obstructive Sleep Apnea (OSA), Central Sleep Apnea (CSA) and Mixed Sleep Apnea (MSA).

18:05

Machine Learning Models to Predict Myocardial Infarction Within 10-Years Follow-up of Cardiovascular Disease Progression

Konstantina-Helen Tsarapatsani (National Technical University of Athens, Greece); Antonis Sakellarios and Vasileios C. Pezoulas (University of Ioannina, Greece); Vassilios Tsakanikas (Unit of Medical Technology and Intelligent Information Systems, Greece); George Matsopoulos (National Technical University of Athens, Greece); Winfried März and Marcus Kleber (Mannheim Medical Faculty, University of Heidelberg, Germany); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

The early prevention of myocardial infarction (MI), a complication of cardiovascular disease (CVD), is an urgent need for the timely provision of medical intervention and the reduction of cardiovascular mortality. The performance of machine learning (ML) has proven useful in aiding the early diagnosis of this disease. In this work, we utilize clinical cardiovascular disease risk factors and biochemical data, employing machine learning models i.e. Random Forest (RF), Extreme Grading Boosting (XGBoost) and Adaptive Boosting (AdaBoost), to predict the 10-year risk of myocardial infarction in patients with 10-years follow-up for CVD. We used the cohort of the Ludwigshafen Risk and Cardiovascular Health (LURIC) study, while 3267 patients were included in the analysis (1361 suffered from MI). We calculated the performance of machine learning models, more specifically the mean values of Accuracy (ACC), Sensitivity, Specificity and the area under the receiver operating characteristic curve (AUC) of each model. We also plotted the corresponding receiver operating characteristic curve for each model. The findings of the analysis reveal that the Extreme Gradient Boosting model detects MI with the highest accuracy (74.27 %). Moreover, explainable artificial intelligence was applied, especially the Shapley values were calculated to identify the most important features and interpret the results with XGBoost.

18:15

A 21-hub-gene Signature in Multiple Sclerosis Identified using Machine Learning Techniques

Ekaterini S Bei, Stavroula Tsakaneli and Michalis Zervakis (Technical University of Crete, Greece)

Multiple sclerosis (MS) is a chronic inflammatory demyelinating disease that affects approximately 2.8 million persons globally. While there is currently no cure for this neurodegenerative disease, MS has become a highly manageable disease through treatment options like disease-modifying medications, that can help to control the symptoms and slow disease progression. Among them, interferon beta (IFNβ) therapy is a first-line treatment for MS but has shown to be only partially effective. Thus, it is important to identify biomarkers that aid in early identification of IFNβ responders. In this study, based on gene expression profiles from untreated and interferon treated patients from a publicly available dataset, we performed differential expression analysis and Pigengene network association (weighted correlation network analysis (WGCNA) and Bayesian networks modeling) in order to construct a high-confidence protein-protein (PPI) interaction network. Subsequently, aiming to find the most significant clustering modules, we applied a number of topological analysis methods (cytoHubba plugin) followed by MCODE clustering algorithm. Our approach resulted in highly connected hub genes generating a reliable 21-hub-gene-gene signature that could predict the response of interferon beta (IFNβ) therapy in

patients with MS. The 21-hub-gene signature showed high classification performance (Accuracy = 91,49%, Sensitivity = 94.55%, Specificity = 87.15%) demonstrating potential clinical benefit.

18:25

HSmartBPM: A modular web platform for tailored management of hypertension

Nikolaos Siopis (Centre for Research and Technology Hellas & University of Western Macedonia, Greece); Anastasios Alexiadis and Georgios Gerovasilis (Centre for Research and Technology Hellas, Greece); Andreas Triantafyllidis (Information Technologies Institute, Centre for Research and Technology Hellas, Greece); Konstantinos Votis (Information Technologies Institute, Centre For Research and Technology Hellas, Greece); Dimitrios Tzovaras (Centre for Research and Technology Hellas, Greece)

Hypertension is a serious disorder which contributes to an increased risk of cardiovascular disease and death. Achieving control of blood pressure is critical for minimizing cardiovascular risk. The patient's active participation in hypertension management is critical for enhancing self-care. Digital health systems dealing with the complexity of long-term hypertension self-management and remote medical management have been scarce. HSmartBPM provides a modular web platform for tailored management of hypertension. It aspires to create a user-centered environment to optimize hypertension care delivery, imposing minimum burden on healthcare professionals and patients. The HSmartBPM components include a virtual agent for patient guidance, a Decision Support System (DSS) for individualized monitoring of health parameters, with the ability to trigger alerts, risk prediction for cardiovascular disease, and shared care plan activities (including questionnaires, prescribed medication, educational material, nutrition) for patient treatment, with the ability to keep track of adherence, as well as automatic measurement collection from connected smart medical devices (e.g. blood pressure monitors, oximeters, body composition scales) contributing to a personalized approach for the therapeutic management of hypertension. Overall, the HSmartBPM solution aims to assist both patients and healthcare professionals with the everyday management of hypertension through the provision of an intelligent and tailored system.

Screen 2

17:15

Can Multi-channel Heart Sounds Analysis improve Murmur Detection?

Diogo Marcelo Nogueira (University of Porto & INESC TEC, Portugal); Jorge Oliveira (Rua de Casal Maria, 90, Portugal); Carlos A Ferreira (Porto Polytechnic Institute, Portugal); Miguel Coimbra (University of Porto, Portugal); Alipio Jorge (University of Porto - INESC TEC, Portugal)

Cardiac auscultation is still the most cost-effective screening procedure for cardiovascular diseases. The development of computer assisted methods can empower a large variety of health professionals and thus enable mass cardiac health low-cost screening. The procedure for correct cardiac auscultation includes listening to the heart sounds of the four main auscultation spots. Until recently, attempts to develop automatic heart sound analysis methods that explore the multi-channel richness of a real auscultation, were very difficult due to the lack of adequate public datasets. In this work, we use the CirCor Dataset which is characterized by the existence of more than one heart sound per patient (each patient has heart sounds collected at different auscultation spots). Using this dataset, we evaluate and quantify the comparative impact of using a single or a multi-channel approach. A single channel approach uses the sound from a single auscultation spot, whereas a multi-channel approach uses four auscultation spots in an asynchronous way. From the different classifiers tested, models that use four auscultation spots achieved a higher overall performance than those that search for abnormalities in a single heart sound spot. Our best result is a multi-channel SVM that analyzes four auscultation spots, with an overall performance of 87,4%. This opens the path to future research using a multi-channel approach.

17:25

Influence of Sensor Position and Body Movements on Radar-Based Heart Rate Monitoring

Liv Herzer, Annika Muecke and Robert Richer (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Nils C. Albrecht and Markus Heyder (Hamburg University of Technology, Germany); Katharina M Jaeger and Veronika Koenig (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Alexander Koelpin (Hamburg University of Technology & Chair for Electronics and Sensor Systems, Germany); Nicolas Rohleder (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany); Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

Cardiac parameters are important indicators for health assessment. Radar-based monitoring with microwave interferometric sensors (MIS) is a promising alternative to conventional measurement methods, as it enables completely contactless cardiac function diagnostics. In this study, we evaluated the effects of sensor positioning and movement on the accuracy of radar-based heart rate measurements with MIS. For this purpose, we recruited 29 participants which performed semi-standardized movements, a reading task, and a standardized laboratory stress test in a seated position. Furthermore, we compared three different sensor positions (dorsal, upper pectoral, and lower pectoral) to a gold standard 1-channel wearable ECG sensor node. The dorsal positioning achieved the best results with a mean error (ME) of 0.2±5.4 bpm and a mean

absolute error (MAE) of 3.5±4.1 bpm for no movement and also turned out to be most robust against motion artifacts with an overall ME of 0.1±14.1 bpm (MAE: 9.5±10.4 bpm). No correlation was found between movement intensity and measurement error. Instead, movement type and direction were identified as primary impact factors. This study provides a valuable contribution towards the applicability of radar-based vital sign monitoring with MIS in real-world scenarios. However, further research is needed to sufficiently prevent and compensate for movement artifacts.

17:35

Machine Learning-based Detection of In-Utero Fetal Presentation from Non-Invasive Fetal ECG

Katharina M Jaeger, Michael Nissen, Robert Richer and Simone Rahm (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Adriana Titzmann (Erlangen University Hospital, Germany); Peter Fasching (University Hospital Erlangen, Germany); Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Heike Leutheuser (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany)

Preterm births account for more than 10 % of all newborns. An adverse fetal presentation is a risk factor for intrapartum and neonatal mortality. To date, no technology enables a longitudinal, ubiquitous, and unobtrusive monitoring of fetal presentation. This study presents a first approach to fetal orientation detection based on non-invasive fetal electrocardiography (NI-fECG) using the non-invasive multimodal foetal ECG-Doppler data set for antenatal cardiology research. The data set contains 60 recordings from 39 pregnant women (21 - 27 weeks), including NI-fECG and ultrasound position ground truth. We evaluated both handcrafted and generic features for five different classifiers (k-Nearest-Neighbor, Support Vector Classification, Decision Tree Classifier, AdaBoost Classifier, and Multilayer Perceptron) using cross-validation on subject splits on a cleaned subset. Best results for the distinction between vertex (head down) and breech (head up) were achieved using an AdaBoost classifier with a balanced accuracy of 86.5 ± 15.0 %. With this work, we take a first step toward longitudinal fetal presentation monitoring, which contributes to a better understanding of reduced fetal movements and extends the potential applications of NI-fECG in prenatal care. In future work, we will expand our classification system to detect more detailed fetal presentations using a newly created data set.

17:45

Investigating Graph-based Features for Speech Emotion Recognition

Anastasia Vasileios Pentari (Foundation for Research and Technology-Hellas & CSD-University of Crete, Greece); George P. Kafentzis (University of Crete, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece)

During the last decades, automatic speech emotion recognition (SER) has gained an increased interest by the research community. Specifically, SER aims to recognize the emotional state of a speaker directly from a speech recording. The most prominent approaches in the literature include feature extraction of speech signals in time and/or frequency domain that are successively applied as input into a classification scheme. In this paper, we propose to exploit graph theory and structures as alternative forms of speech representations. We suggest applying the so-called Visibility Graph (VG) theory to represent speech data using an adjacency matrix and extract well-known graph-based features from the latter. Finally, these features are fed into a Support Vector Machine (SVM) classifier in a leave-one-speaker-out, multi-class fashion. Our proposed feature set is compared with a well-known acoustic feature set named the Geneva Minimalistic Acoustic Parameter Set (GeMAPS). We test both approaches on two publicly available speech datasets: SAVEE and EMOVO. The experimental results show that the proposed graph-based features provide better results, namely a classification accuracy of 70% and 98%, respectively, yielding an increase by 29.2% and 60.6%, respectively, when compared to GeMAPS. As an extension of work we aim to investigate different datasets and different languages.

17:55

Continuous Human Activity Recognition and Step-Time Variability Analysis with FMCW Radar

Sevgi Z Gurbuz (The University of Alabama); Mohammad Mahbubur Rahman, Emre Kurtoglu and Dario Martelli (The University of Alabama, USA)

Human activity recognition (HAR) and gait analysis are important functions that support ageing-in-place and remote health monitoring. Although there have been many works investigating HAR with radar based on single-activity snapshots in time, few works address recognition in continuous streams of RF data, where in daily life many different activities are conducted. This work proposes a novel variable window averaging method to segment RF data streams containing a mixture of large-scale gross motor activities as well as fine-grain hand gestures, a physics-aware generative adversarial network (PhGAN) to recognize daily activities, and a new technique to estimate step-time variability from RF data. This paper proposes new techniques to segment, recognize and analyze streams of real-world human movements for the purposes of gait analysis, and in particular, estimating step-time variability, a critical parameter that is indicative of fall risk. Our results show that first extracting motion intervals from the power burst curve has benefits to computation time and accuracy, while use of physics-based synthesis of signatures with GANs can boost classification accuracy. Multi-channel radars offer greater accuracy in estimation of time-step variable in comparison to use of just a single-channel radar. The radar-extracted estimates of time-

step variability compare well with that extracted from the Vicon system. The results show the potential for using radar not just for fall detection, but also for gait analysis and fall risk assessment in the home.

18:05

Estimating Post-Stroke Upper-Limb Impairment from Four Activities of Daily Living using a Single Wrist-Worn Inertial Sensor

Brandon Oubre (University of Massachusetts Amherst, USA); Sunghoon Ivan Lee (University of Massachusetts, USA)

Upper-limb hemiparesis resulting from stroke is a common cause of long-term disability. Wearable inertial sensors offer a potential means of developing assessments of motor impairment severity that are more objective, ecologically valid, and that can be administered frequently than traditional clinical motor scales. Our recent work proposed a method for unobtrusively estimating upper-limb impairment severity by analyzing submovements extracted from the performance of large, continuous, random movements. Here, we validate that similar analytic methods are able to estimate upper-limb impairment severity from the performance of activities of daily living (ADLs) using only the data obtained from a single wrist-worn inertial sensor. Twenty stroke survivors were equipped with an nine-axis inertial sensor on the stroke-affected wrist and performed four ADLs that involved upper-limb movements and required manipulation of the environment. A random forest model trained on the kinematic features of submovements extracted from ADL performance was able to estimate the upper extremity portion of the Fugl-Meyer Assessment with a normalized root mean square error of 17.0% and R^2=0.75. These results support the potential for a technology that can assess stroke survivors' real-world upper-limb motor performance in a seamless, minimally-obtrusive manner, though additional development and validation are needed to achieve this vision.

18:15

Comparison of PPG and BCG Features for Camera-based Blood Pressure Estimation by Ice Water Stimulation

Guanghang Liao and Caifeng Shan (Shandong University of Science and Technology, China); Wenjin Wang (Southern University of Science and Technology, China)

Non-invasive Blood Pressure (BP) measurement is highly demanded for pervasive healthcare with the development of Internet of Things, sensors and mobile technology. Camera based Photoplethysmography (camera-PPG) has been applied for non-contact BP estimation. Most camera-PPG based approaches calculate the Pulse Transmission Time between different peripheral sites like face and palm for BP calibration, which require more than one body part to be simultaneously measured and thus introduce inconvenience to real applications. In this study, we investigate the feasibility of measuring BP from a single body site using either the forehead PPG signals or neck ballistocardiographic (BCG) motion signals. Two morphological features (K-value and Augmentation Index) that have clinical meanings for BP monitoring have been compared. The study was conducted in the ice water stimulation experiment involving 16 healthy subjects. The results show that the neck can be an attractive site for BP estimation as the neck-BCG signals show more distinct features (e.g. dicrotic wave) that have stronger correlations with BP than the forehead-PPG signals, and it eliminates the privacy issue of imaging a face. Both the K value and Augmentation Index can well track the changes of BP. The conclusions drawn from this study inspire the selection of physiological site and features for non-contact BP estimation

18:25

Energy Estimation of Sleep Monitoring Algorithms for Application Specific Integrated Circuit Implementation

Chakaveh Ahmadizadeh, Sajjad Gholami and Reza Ranjandish (Switzerland)

Sleep monitoring is crucial for a variety of health issues. The emergence of wearable technologies allows access to valuable sleep data to a wide range of users. For such wearable technologies to be unobtrusive and practical for daily living, their size and weight need to be minimized. Consequently, the work presented in this paper is with the ultimate goal of the implementation of a wireless wearable sleep monitoring device using Application Specific Integrated Circuits (ASICs). Sophisticated machine learning algorithms are commonly used for sleep stage classification, however, the high computational cost of some of these algorithms leads to high electrical power consumption and the need for large and heavy batteries. This paper investigated the energy consumption of four of the commonly used classification algorithms used for sleep monitoring, i.e. k-nearest neighbor, neural network, logistic regression, and random forest, based on the low-level counts of arithmetic and relational operations and simulated energy consumed by required operations for an ASIC hardware implementation. The method used in this paper ensures software-implementation independence of the estimated results by investigating low-level operations. Based on the assessments performed on a publicly available sleep dataset, results showed that the logistic regression and neural network classification algorithms were able to perform with considerably lower energy consumption when ASIC implementation is considered.

Screen 3

17:15
Towards Continuous Acute Pain Detection using Deep Learning and Electrodermal Activity
Javier O Pinzon-Arenas (Universidad Militar Nueva Granada, Colombia); Hugo Posada-Quintero (University of Connecticut, USA)

Measuring pain objectively, namely, based on physiological signals instead of self-reported measures, would be highly valuable for people with chronic pain. The subjectivity of the gold standard to quantify pain, which is based upon subjects' self-reported assessment using numerical or visual scales, makes pain management extremely complicated and, in many cases, has led to opioid abuse. Electrodermal activity (EDA) is a highly sensitive measure of sympathetic activity and has been increasingly used to objectively assess pain. In this study, we evaluated convolutional neural networks (CNN) and long short-term memory (LSTM) architectures for the task of detecting pain continuously. Additionally, we tested the use of the time-frequency spectrum of the phasic component of the electrodermal activity, as feature for this task. We used a merged database composed of thirty-six healthy subjects that underwent heat pain stimuli by means of a thermal grill. The LSTM models obtained better performance than the CNN ones by more of 3% in the F1-Score. Moreover, the best performance was achieved by a stacked bi- and uni-directional LSTM architecture, with 75.3% F1-Score, even showing its capability detecting the onset and end of the pain response. Continuous objective pain detection using deep learning can contribute to reduce the consequences of subjectiveness of current pain assessment methods, and the continuous monitoring of the patient pain state.

17:25
Explainable Machine Learning for Vitamin A Deficiency Classification in Schoolchildren
Jayroop Ramesh and Donthi Sankalpa (American University of Sharjah, United Arab Emirates); Amar Khamis (Mohammed Bin Rashid University of Medicine and Health Sciences, United Arab Emirates); Assim Sagahyroon and Fadi Aloul (American University of Sharjah, United Arab Emirates)

Vitamin A deficiency is one of the leading causes of visual impairment globally. While blood tests are common approaches in developed countries, various socioeconomic and public perspectives render this a challenge in developing countries. In Africa and Southeast Asia, the alarming rise of preventable childhood blindness and delayed growth rates has been dubbed as an "epidemic". With the proliferation of machine learning in clinical support systems and the relative availability of electronic health records, there is the potential promise of early detection, and curbing ocular complication progression. In this work, different machine learning methods are applied to a sparse dataset of ocular symptomatology and diagnoses acquired from Maradi, Nigeria collected during routine eye examinations conducted within a school setting. The goal is to develop a screening system for Vitamin A deficiency in children without requiring retinol serum blood tests, but rather by utilizing existing health records. The SVC model achieved the best scores of accuracy: 75.7%, sensitivity:83.7%, and specificity: 74.9%. Additionally, Shapley values are employed to provide post-hoc clinical explainability (XAI) in terms of relative feature contributions with each classification decision. This is a vital step towards augmenting domain expert reasoning, and ensuring clinical consistency of shallow machine learning models.

17:35
DeepMuCS: A Framework for Co-culture Microscopic Image Analysis: From Generation to Segmentation
Nabeel Khalid, Mohammadmahdi Koochali, Vikas Rajashekar and Mohsin Munir (German Research Center for Artificial Intelligence, Germany); Christoffer Edlund (Sartorius Corporate Research, Sweden); Timothy Jackson (Sartorius, BioAnalytics, United Kingdom (Great Britain)); Johan Trygg and Rickard Sjögren (Sartorius Corporate Research, Sweden); Andreas Dengel (Deutsche Forschungszentrum für Künstliche Intelligenz GmbH, Germany); Sheraz Ahmed (German Research Center for Artificial Intelligence, Germany)

Discrimination between cell types in the co-culture environment with multiple cell lines can assist in examining the interaction between different cell populations. Identifying different cell cultures in addition to cell segmentation in co-culture is essential for understanding the cellular mechanisms associated with disease states. In drug development, biologists are more interested in co-culture models because they replicate the tumor environment in vivo better than the monoculture models. Additionally, they have a measurable effect on cancer cell response to treatment. Co-culture models are critical for designing a drug with maximum efficacy on cancer while minimizing harm to the rest of the body. In the past, there existed minimal progress related to cell-type aware segmentation in the monoculture and no development whatsoever for the co-culture. The introduction of the LIVECell dataset has allowed us to perform experiments for cell-type-aware segmentation. However, it is composed of microscopic images in a monoculture environment. This paper presents a framework for co-culture microscopic image data generation, where each image can contain multiple cell cultures. The framework also presents a pipeline for culture-dependent cell segmentation in co-culture microscopic images. The extensive evaluation revealed that it is possible to achieve cell-type aware segmentation in co-culture microscopic images with good precision.

17:45

Pneumonia and COVID-19 Detection in Chest X-rays Using Faster Region-Based Convolutional Neural Networks (Faster R-CNN)

Hanan J Farhat (University of Saint Joseph of Beirut & Beirut International University, Lebanon); Georges Sakr (Virgilsystems Inc., Canada); Rima Kilany (Saint-Jospeh University, France)

Purpose: The arising of SARS-CoV-2 or 2019 novel coronavirus in December 2019 have prioritized research on pulmonary diseases diagnosis and prognosis, especially using artificial intelligence (AI) and Deep Learning (DL). Polymerase Chain Reaction (PCR) is the most widely used technique to detect SARS-CoV-2, with a 0.12\% false negative rate. While 75\% of the hospitalized cases develop pneumonia caused by the virus, patients can still develop bacterial pneumonia. COVID-19 pneumonia can be diagnosed based on clinical data and Computed Tomography (CT scan). However, Chest X-rays are faster, cheaper, emit less radiations, and can be performed on bed-side. In this article, we extend the application of VGG-16 based Faster Region-Based Convolutional Neural Network (Faster R-CNN) to the detection of Pneumonia and COVID-19 in Chest X-rays.
Methods: The Faster R-CNN algorithm was trained using several public datasets of total images count ranging from 2122 to 18455 Chest X-rays. The datasets were composed of different combinations of Chest X-rays labeled with Pneumonia, COVID-19 or Normal labels. Internal and external testing were applied, in addition to comparison to a healthcare representative and to related work findings. The impact of several hyper-parameters such as objectness threshold, epochs count and length was evaluated.
Results: Our results comply with the state of the art of Faster-RCNN in pneumonia detection as the best accuracy achieved is 65\%. For COVID-19 detection, Faster R-CNN achieved a 90\% validation accuracy but decreased dramatically when testing internally. For the optimal hyper-parameters, they were found to be 250 epochs with 250 epoch length. And for the objectiveness threshold, 80\% was the best tested value if the truthiness of either pneumonic or normal Chest X-rays.
Conclusion: Faster R-CNN's performance in the detection of Pneumonia and COVID-19 Pneumonia from Chest X-rays as a standalone model is not sufficient. Further research at the level of the model's backbone classifier, the training and testing datasets' content and the images' quality may assist in improving the model's generalizability.

17:55

Data augmentation in semi-supervised adversarial domain adaptation for EEG-based sleep staging

Elisabeth Heremans (KU Leuven, Belgium); Trui Osselaer (ETH Zurich, Belgium); Nick Seeuws (KU Leuven, Belgium); Huy Phan (Queen Mary University of London, United Kingdom (Great Britain)); Dries Testelmans and Maarten De Vos (KU Leuven, Belgium)

The upcoming era of wearable health monitoring devices has created a need for automated signal processing algorithms that can be trained with a minimal amount of labeled data. In order to achieve better predictions with few training data, transfer learning techniques like adversarial domain adaptation can be used to combine information of different datasets. In our previous work, we developed a semi-supervised adversarial domain adaptation framework for this purpose. We applied our method to remote sleep monitoring, by performing sleep staging on single-channel wearable EEG signals. In this work, we propose data augmentation to help in tackling this challenge. A combination of different data augmentation techniques is applied to modify labeled EEG signals. This effectively improves the robustness of the sleep staging model to these modifications. By using an artificially increased amount of labeled data, the semi-supervised adversarial domain adaptation method improves its performance on the wearable EEG data. The accuracy is increased consistently by 0.6% to 1.4% relative to the results without data augmentation. As both adversarial domain adaptation and data augmentation are strategies to deal with the scarceness of data, we conclude that these methods are complementary, and that they can effectively be combined to surpass their individual performance.

18:05

Clustering Egocentric Images in Passive Dietary Monitoring with Self-Supervised Learning

Jiachuan Peng, Peilun Shi, Jianing Qiu and Xinwei Ju (Imperial College London, United Kingdom (Great Britain)); Frank Po Wen Lo (Imperial College London & ICL, United Kingdom (Great Britain)); Xiao Gu (Imperial College London, United Kingdom (Great Britain)); Benny Lo (Imperial College, United Kingdom (Great Britain))

In our recent dietary assessment field studies on passive dietary monitoring in Ghana, we have collected over 250k in-the-wild images. The dataset is an ongoing effort to facilitate accurate measurement of individual food and nutrient intake in low and middle income countries with passive monitoring camera technologies. The current dataset involves 20 households (74 subjects) from both the rural and urban regions of Ghana, and two different types of wearable cameras were used in the studies. Once initiated, wearable cameras continuously capture subjects' activities, which yields massive amount of data to be cleaned and annotated before analysis being conducted. To ease the data post-processing and annotation tasks, we propose a novel self-supervised learning framework, which combines masked autoencoder with contrastive learning, to cluster the large volume of egocentric images into separate events. Each event consists of a sequence of temporally continuous and contextually similar images, in which a subject performs a few or some actions and activities. By clustering

images into separate events, annotators and dietitians can examine and analyze the data more efficiently and facilitate the subsequent dietary assessment processes. Validated on a held-out test set with ground truth labels, the proposed framework outperforms baselines in terms of clustering quality and classification accuracy.

18:15

Performance vs. Privacy: Evaluating the Performance of Predicting Second Primary Cancer in Lung Cancer Survivors with Privacy-preserving Approaches

Jui-Fu Hong (National Central University, Taiwan); Yi-Ju Tseng (National Yang Ming Chiao Tung University, Taiwan & Boston Childrens Hospital, USA)

Deep learning has been widely used in the medical field to support medical decision making. Simultaneously, with the rise of data privacy protection, accessing clinical records across different institutions has become a possible challenge. Several approaches, such as federated and transfer learning, have been proposed to train models without accessing all the records from each institution, but the performance of these privacy-preserved models may not be as good as centralized approaches, which aggregate all records to build a centralized model. To explore the potential of privacy-preserving second primary cancer (SPC) prediction of lung cancer survivors using real-world data, we evaluated the performance of federated learning, transfer learning, learning with a single institution, and traditional centralized learning. We trained machine learning models using data from four hospitals and compared the model performances of learning from a single institution, centralized learning, federated learning, and transfer learning. The results show that federated learning outperformed other learning strategies in three of the four sites (AUROC from 0.733 to 0.777). However, only Site 6 showed that federated learning significantly outperformed all the other learning strategies ($P < 0.05$). In summary, federated learning can develop a unified model for the multiple institutions while maintaining data security.

Screen 4

17:15

Explainable Deep Learning for Insight into Schizophrenia

Charles A Ellis (Tri-institutional Center for Translational Research in Neuroimaging and Data Science, USA); Abhinav Sattiraju (Center for Translational Research in Neuroimaging and Data Science, USA); Robyn Miller (Tri-institutional Center for Translational Research in Neuroimaging and Data Science, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Schizophrenia (SZ) has diverse clinical symptoms, which makes diagnosis challenging. Recent attempts at deep learning-based automated diagnosis have not involved explainability, which misses an opportunity to use the automated feature extraction capabilities of deep learning to identify biomarkers of clinical utility. Here, we use explainable deep learning to identify key EEG frequency bands of SZ

17:25

Identifying Heterogeneous Subgroup of Systemic Connective Tissue Diseases via Cluster Analysis with Immunomarkers

Chia-Wei Chang (National Yang Ming Chiao Tung University, Taiwan); Hsin-Yao Wang (Chang Gung Memorial Hospital at Linkou, Taiwan); Wei-Lin Lo (Chang Gung Memorial Hospital at Keelung, Taiwan); Wei-Ting Lin and Jia-Ruei Yu (Chang Gung Memorial Hospital at Linkou, Taiwan); Yi-Ju Tseng (National Yang Ming Chiao Tung University, Taiwan & Boston Childrens Hospital, USA)

Highly complex nature of systemic connective tissue diseases (SCTDs) has obstructed the precise management of SCTDs. To identify the heterogeneity in SCTDs, we conducted a cluster analysis using a method that jointed multiple correspondence analysis and k-means on immunomarkers, and determined the heterogeneity of clusters by the differences in clinical manifestations. None of the six clusters comprised a single SCTD. They exhibited pronounced differences in clinical expression, indicating that clustering results can provide additional information to discern the heterogeneity in prognosis. In conclusion, the data-driven classification for SCTDs potentially provides a more objective and precise diagnosis basis, leading to appropriate therapeutic measures.

17:35

Predicting Intradialytic Hypotension in Patients Receiving Hemodialysis Treatment with A Bagging Method

Chien-Liang Liu, Min-Hsuan Lee, Shan-Ni Hsueh and Chia-Chen Chung (National Yang Ming Chiao Tung University, Taiwan); Chun-Ju Lin, Po-Han Chang, An-Chun Luo, Hsuan-Chi Weng, Yu-Hsien Lee and Ming-Ji Dai (Industrial Technology Research Institute, Taiwan); Min-Juei Tsai (Chang-Hua Hospital, Ministry of Health and Welfare, Changhua, Taiwan)

This work aims to predict intradialytic hypotension for those patients who receive hemodialysis treatment. The data is collected from monitoring devices, so the problem addressed in this work is an extremely imbalanced dataset. We use the bagging technique to develop the model, in which we apply undersampling to the majority class to generate many balanced datasets. Each dataset is trained by an XGBoost, and the final prediction outcome is the majority vote of all XGBoost models.We conduct experiments on a real dataset and compare our proposed method with many alternatives. The experimental results show that our proposed method can outperform other comparison methods.

17:45

Nerve Conduction Studies for Carpal Tunnel Syndrome Diagnosis using STFT-Based Spectrogram and Deep 2D Convolutional Neural Network

Dimitrios Bakalis and George Manis (University of Ioannina, Greece); Konstantinos Tsamis (University Hospital of Ioannina, Greece)

The classification of nerve conduction studies (NCS) is very important for the automatic diagnosis of nerve diseases. Recent literature has revealed a long discussion about the importance and necessity of NCS in carpal tunnel syndrome (CTS) management. Traditionally the classification procedure is divided into three steps, including the step of electrodiagnostic feature extraction for the median nerve mononeuropathy, the step of decision making about CTS and the step of pattern classification. Owing to recent advances in artificial intelligence, it has been demonstrated that deep neural networks can carry out the task of feature extraction directly from the data and recognize neurological instabilities better than professional physicians. This paper proposes a deep two-dimensional convolutional neural network (CONV2D) capable of diagnosing CTS utilizing the nerve signals. The time domain signals of NCS, belonging into categories patient and control, were first transformed into time-frequency spectrograms utilizing the short-time Fourier transformation (STFT). Subsequently, the spectrograms were fed as an input to the CONV2D to be identified and finally classified. The study included NCS recordings from volunteers, examined prospectively, to create a database for the training and testing purposes. The classification results showed that the deep model can outperform, both in execution time and accuracy, the use of typical machine learning models utilizing the manually extracted features, as it has been done in previous studies. Therefore, it is validated that the proposed architecture is reliable enough to be employed in decision making, excluding human errors.

17:55

Activity and Age Classification from Handwritten Samples Acquired with a Smart Ink Pen

Simone Toffoli, Eugenio Lomurno and Francesca Lunardini (Politecnico di Milano, Italy); Carmen Galán de Isla and Pilar Cáceres (FundeSalud - Foundation for Research and Training of Health Professionals of Extremadura, Spain); Milad Malavolti, Matteo Matteucci and Simona Ferrante (Politecnico di Milano, Italy)

The early identification of the decline associated with aging would be beneficial for improving the elders' quality of life. Such a goal could be achieved by monitoring the elders' performances in daily life activities in the home setting, with the use of Internet-of-Things solutions. Handwriting represents a suitable activity for the purpose. It is mastered by most adults and the complex mechanisms behind its execution have been demonstrated to deteriorate to some extent with aging. However, transparency in the acquisition, data reliability and validity represent critical points in the unsupervised scenario. This work is aimed at assessing whether handwriting indicators are effective in discriminating writing from drawing and young from elder writers. Writing and drawing samples were acquired in 21 young and 9 elder subjects, employing a smart ink pen. The device is used as a normal pen, but the embedded motion and force sensors allow to record quantitative information regarding the execution. Indicators were extracted from the pen data and evaluated with classification algorithms and model explanation techniques in the two discrimination tasks. The results were promising, achieving 93.33% and 90% test accuracy in the activity and age discrimination, respectively, with the theoretical background supported by the adopted explanation techniques. These findings suggest that the considered set of indicators is suitable for the remote monitoring of handwriting.

18:05

Medication and Adverse Drug Events Information Extraction in Discharge Summaries to Enrich Discharge Medication Instructions

Christine Kakalou (Centre for Research and Technology Hellas & National and Kapodistrian University of Athens, Greece); Pantelis Natsiavas (Centre for Research and Technology-Hellas (CERTH), Greece); Theodore Dalamagas (ATHENA Research Center, Greece); Manolis Koubarakis (University of Athens, Greece)

Improved readability of Electronic Health Records (EHR) free-text could support better patient information provision and prevent confusion when EHR information are openly available. An informed domain-specific Information Extraction approach is introduced ultimately aiming to enrich discharge summaries with patient-friendly language. An evaluation of the initial step to extract medications and their respective Adverse Drug Events are presented.

18:15
MCMC Methods for Estimation of Thoracic Fluid Levels using UWB Radar
Burak Civek and Emre Ertin (The Ohio State University, USA)

Non-invasive monitoring of internal tissue properties can provide valuable information about the progression of life-threatening diseases. UWB radar sensors allow serial measurements in ambulatory setting to assist management of chronic conditions. In this paper, we formulate the EM inverse scattering problem as a blind deconvolution problem and simultaneously estimate both the transmitted waveform and the dielectric properties of internal tissues to assess thoracic fluid levels. We propose a novel adaptive MCMC method which combines the Slice sampling and Hamiltonian Monte Carlo approaches, with a Parallel Tempering implementation to escape local minima. The Bayesian formulation allows quantitative uncertainty measures in the form of credibility intervals. We investigate the performance of the proposed estimation method using numerical simulations and measured data from multilayer phantoms.

Screen 5

17:15
Fine-tuned feature selection to improve prostate segmentation via a fully connected meta-learner architecture
Dimitris Zaridis (University of Ioannina, Greece); Eugenia Mylona (Unit of Medical Technology and Intelligent Information Systems, University of Ioannina & FORTH-IMBB, Greece); Nikolaos Tachos (Unit of Medical Technology and Intelligent Information Systems, Greece); Kostas Marias (FORTH, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Precise delineation of the prostate gland on MRI is the cornerstone for accurate prostate cancer diagnosis, detection, characterization, and treatment. The present work proposes a meta-learner deep learning (DL) network that combines the complexity of 3 well-established DL models and fine tune them in order to improve the segmentation of the prostate compared to the base learners. The backbone of the meta-learner consist the original U-net, Dense2U-net and Bridged U-net models. A model was added on top of the three base networks that has four convolutions with different receptor fields. The meta-learner outperformed the base-learners in 4 out of 5 performance metrics. The median Dice Score for the meta-learner was 89% while for the second-best model it was 83%. Except for Hausdorff distance, where the meta-learner and Dense2U-net performed equally well, the improvement achieved in terms of average sensitivity, balanced accuracy, dice score and rand error, compared to the best performing base-learner, was 6%, 3%, 5% and 4%, respectively.

17:25
Multimodal generative imaging genomics framework: facilitating analysis in the case of missing modalities
Giorgio Dolci (TReNDS, Georgia State University, USA); Md Abdur Rahaman (Georgia Institute of Technology, USA & Tri-Institutional Center for Translational Research in Neuroimaging and Data Science (TReNDS), USA); Jiayu Chen (TReNDS, Georgia State University, USA); Kuaikuai Duan (University of California San Diego, USA); Zening Fu and Anees Abrol (TReNDS, Georgia State University, USA); Gloria Menegaz (University of Verona, Italy); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

We present a deep multimodal generative framework which uses functional and structural neuroimaging and genomics modalities to predict Alzheimer's disease. The model has the capability to impute missing modalities via generative models transferring the knowledge from other active data sources. In this way we are able to perform prediction even if some subjects have missing modalities.

17:35
Distributions of Explanations for Neuroimaging Classification
Charles A Ellis and Robyn Miller (Tri-institutional Center for Translational Research in Neuroimaging and Data Science, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Recent studies involving explainability for neuroimaging deep learning classification have only provided point estimates of explanations. Having a distribution of explanations could increase the reliability of those explanations. Here, we demonstrate a novel method that combines Monte Carlo batch normalization with layer-wise relevance propagation to enable this capability within the context of fMRI functional network connectivity classification.

17:45
ProCAncer-I: An platform integrating imaging data and AI models, supporting precision care through prostate cancer's continuum
Haridimos Kondylakis (Computational Biomedicine Laboratory, FORTH-ICS, Greece); Stelios Sfakianakis (FORTH, Greece); Varvara Kalokyri (FORTH-ICS, Greece); Nikolaos Tachos (Unit of Medical Technology and Intelligent Information

Systems, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece); Kostas Marias (FORTH, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece)

Prostate cancer incidence has doubled in Europe between 1995 and 2018, surpassing both lung and colorectal cancer incidence. As such, it is a major health challenge, necessitating precision care through the whole disease continuum. The ProCAncer-I EU project aspires to create the largest interoperable, high-quality mpMRI (multi-parametric Magnetic Resonance Imaging) dataset worldwide comprising more than 11.000 retrospective and more than 6.000 prospective mpMRI examinations for the study of prostate cancer. This paper presents the technological infrastructure developed to that purpose and the first results after the first implementation period of the project.

17:55
A Critical Appraisal of Data Augmentation Methods for Imaging-Based Medical Diagnosis Applications
Tara M Pattilachan (University of Central Florida, USA); Ugur Demir, Elif Keles and Debesh Jha (Northwestern University, USA); Derk Klatte, Megan Engels, Sanne Hoogenboom and Candice Bolan (Mayo Clinic, USA); Michael Wallace (Mayo Clinic, United Arab Emirates); Ulas Bagci (Northwestern University, USA)

Current data augmentation techniques and transformations are well suited for improving the size and quality of natural image datasets but are not yet optimized for medical imaging. We hypothesize that sub-optimal data augmentations can easily distort or occlude medical images, leading to false positives or negatives during patient diagnosis, prediction, or therapy/surgery evaluation. In our experimental results, we found that utilizing commonly used intensity-based data augmentation distorts the MRI scans and leads to texture information loss, thus negatively affecting the overall performance of classification. Additionally, we observed that commonly used data augmentation methods cannot be used with a plug-and-play approach in medical imaging, and requires manual tuning and adjustment.

18:05
Neonatal Patient Segmentation using Depth Encoding
Yasmina Souley Dosso (Carleton University, Canada); Kim Greenwood (Children's Hospital of Eastern Ontario, Canada); JoAnn Harrold (The Children's Hospital of Eastern Ontario, CHEO, Ottawa, Canada); James R Green (Carleton University, Canada)

Patient segmentation is an important step in neonatal monitoring for subsequent applications. Many studies have faced difficulty in obtaining a clear delineation between the patient and the background. This study demonstrates how depth information can effectively enhance the RGB image for neonatal patient segmentation, especially when the delineation is unclear due to patient coverage.

18:15
Fuzzy Ensemble of Efficient-Nets for Skin Cancer Classification
Dibyendu Das (Ramakrishna Mission Vivekananda Educational and Research Institute, India); Nikhilanand Arya (Indian Institute of Technology Patna, India); Sriparna Saha (IIT Patna & Department of CSE, India)

Skin cancer is deadly among all cancer types, and its increasing cases in the last decade have put tremendous stress on dermatologists. With the advancement in medical imaging techniques and involvement of artificial intelligence in healthcare, we have proposed a novel Choquet Fuzzy Ensemble of Efficient-Nets for multi-class skin cancer classification. This architecture classifies dermoscopic images into eight different skin cancer types. It outperforms the existing state-of-the-art while handling the high-class imbalance using a novel reward function technique.

18:25
Flash Artefact Removal from Power Doppler Ultrasound
Yi Yin, Mohammadreza Soltaninejad and Sally L. Collins (University of Oxford, United Kingdom (Great Britain))

Flash artefact in power Doppler (PD) ultrasound is induced by tissue motion during the imaging procedure. It can be difficult to avoid, especially in pregnancy when there is an active fetus. This artefact produces an abrupt increase of the PD signal seen as a ‘flash', this aberrant signal adversely affects the quantitative assessment of blood flow. We proposed to use a U-Net convolutional neural network to remove the flash artefact from three-dimensional PD ultrasound volumes. A loss function was proposed to compute the pixel-wise signal difference, structural difference and signal intensity distribution difference between the flash scan section image and a neighbored noiseless scan section which is considered as ground-truth. Promising preliminary results were obtained from a dataset of PD ultrasound volumes and synthetic images.

Screen 6

17:15
BEBOP: Bidirectional dEep Brain cOnnectivity maPping
Riccardo Asnaghi (Politecnico di Milano, Italy); Letizia Clementi (Politecnico di Milano & CHDS, Center for Health Data Science, Human Technopole, Italy); Marco D Santambrogio (Politecnico di Milano & MIT, Italy)

Functional connectivity mapping provides information about correlated brain areas, useful for many applications such as on mental disorders. Thereby this work aims to improve this mapping by using deep metric learning considering the directionality of information flow and time-domain features. To deal with the computational cost of a complete pairwise combination network, we trained a network able to recognize similar signals and, after training, feed it with all combinations of signals from each brain area. The labels of similarity or dissimilarity are determined by agglomerative clustering using the Jensen-Shannon Distance (JSD) as a metric. To validate our approach we employed a resting-state eye-open functional Magnetic Resonance Imaging (fMRI) datasets from ADHD and healthy subjects. ADHD affects children and adolescents worldwide ranges from 5% to 7%. Previous works highlighted that mental illnesses can alter network pathways in the brain. A better understanding and mapping of the functional connectivity between cerebral areas could lead to a better understanding of these disorders, provide new insights, and allow for a faster and more objective diagnosis. After obtaining the maps from each subject, and noticing the difference, we perform a feature importance selection using logistic regression. The ten most promising areas were extracted, such as the frontal cortex and the limbic system. These results are in complete agreement with previous literature. It is well known that the frontal cortex and the limbic system are mainly involved in attention and impulsivity.

17:25
Development of an Inertial Sensor-Based Exergame for Combined Cognitive and Physical Training
Fabio Egle, Felix Kluge and Daniel Schoene (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany); Linda Becker (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Anne D. Koelewijn (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany)

Mild cognitive impairment (MCI) is a condition where older people have experienced cognitive decline, which can then transition to dementia. Hence, it is important to prevent further health decline. Therefore, we have developed an exergame that aims to prevent cognitive and physical decline in older people with MCI. The exergame uses inertial measurement units, worn on the user's wrists and feet, to record their movements. The user steps in place to move through the game environment and interacts with different obstacles through movement. We performed an experiment to evaluate the technical game performance, exercise intensity, and game usability and enjoyment. We found that our movement detection algorithms were able to detect 90\% of all movements after one attempt, on average between 1.7-3.5 seconds. While our young participants' heart rates did not reach moderate exercise intensity while playing the game, we expect that the activity is suitable for the target population. Furthermore, young participants' user feedback from questionnaires regarding usability and enjoyment was positive.

17:35
ADARP: A Multi Modal Dataset for Stress and Alcohol Relapse Quantification in Real Life Setting
Ramesh Kumar Sah, Michael McDonell, Patricia Pendry and Sara Parent (Washington State University, USA); Hassan Ghasemzadeh (Arizona State University, USA); Michael Cleveland (Washington State University, USA)

Stress detection and classification from wearable sensor data is an emerging area of research with significant implications for individuals' physical and mental health. In this work, we introduce a new dataset, ADARP, which contains physiological data and self-report outcomes collected in real-world ambulatory settings involving individuals diagnosed with alcohol use disorders. We describe the user study, present details of the dataset, establish the significant correlation between physiological data and self-reported outcomes, demonstrate stress classification, and make our dataset public to facilitate research.

17:45
Enhancement of Remote PPG and Heart Rate Estimation with Optimal Signal Quality Index
Jiyang Li (SUNY University at Buffalo, USA); Korosh Vatanparvar, Li Zhu, Jilong Kuang and Alex Gao (Samsung Research America, USA)

With the popularity of non-invasive vital signs detection, remote photoplethysmography (rPPG) is drawing attention in the community. Remote PPG, or rPPG signals are extracted by a contactless manner that is more prone to artifacts than PPG signals collected by wearable sensors. To develop a robust and accurate pipeline to estimate heart rate (HR) from rPPG signals, we propose a novel real-time dynamic ROI tracking algorithm that is applicable to slight motions and light changes. Furthermore, we develop and include a signal quality index (SQI) to improve the HR estimation accuracy. Studies have

explored optimal SQIs for PPG signals, but not for remote PPG signals. In this paper, we select and test six SQIs: Perfusion, Kurtosis, Skewness, Zero-crossing, Entropy, and signal-to-noise ratio (SNR) on 124 rPPG sessions from 30 participants wearing masks. Based on the mean absolute error (MAE) of HR estimation, the optimal SQI is selected and validated by Mann-Whitney U test (MWU). Lastly, we show that the HR estimation accuracy is improved by 29% after removing outliers decided by the optimal SQI, and the best result achieves the MAE of 2.308 bpm.

17:55

Deep learning semantic segmentation for indoor terrain extraction: Toward better informing free-living wearable gait assessment

Jason Moore and Sam Stuart (Northumbria University, United Kingdom (Great Britain)); Richard Walker (Northumbria Healthcare NHS Foundation Trust, United Kingdom (Great Britain)); Peter McMeekin and Fraser Young (Northumbria University, United Kingdom (Great Britain)); Alan Godfrey (Northumbria University at Newcastle, Newcastle upon Tyne, United Kingdom (Great Britain))

Contemporary approaches to gait assessment use wearable devices within free-living environments to capture habitual information, which is more informative compared to data capture in the lab. Wearables range from inertial to camera-based technologies but pragmatic challenges such as analysis of big data from heterogenous environments exist. For example, wearable camera data often requires manual time-consuming subjective contextualization, such as labelling of terrain type. There is a need for the application of automated approaches such as those suggested by artificial intelligence (AI) based methods. This pilot study investigates multiple segmentation models and proposes use of the PSPNet deep learning network to automate a binary indoor floor segmentation mask for use with wearable camera-based data (i.e., video frames). To inform the development of the AI method, a unique approach of mining heterogenous data from a video sharing platform (YouTube) was adopted to provide independent training data. The dataset contains 1973 image frames and accompanying segmentation masks. When trained on the dataset the proposed model achieved an Instance over Union score of 0.73 over 25 epochs in complex environments. The proposed method will inform future work within the field of habitual free-living gait assessment to provide automated contextual information when used in conjunction with wearable inertial derived gait characteristics.

18:05

Explainable machine learning analysis of longitudinal mental health trajectories after breast cancer diagnosis

Eugenia Mylona (Unit of Medical Technology and Intelligent Information Systems, University of Ioannina & FORTH-IMBB, Greece); Konstadina Kourou (Institute of Molecular Biology and Biotechnology, FORTH-IMBB, Greece); Georgios C. Manikis (Foundation for Research and Technology, Greece); Haridimos Kondylakis (Computational Biomedicine Laboratory, FORTH-ICS, Greece); Evangelos Karademas (University of Crete, Greece); Kostas Marias (FORTH, Greece); Ketti Mazzocco (University of Milan, Greece); Paula Poikonen-Saksela (Helsinki University Hospital, Finland); Ruth Pat-Horenczyk (The Hebrew University of Jerusalem, Greece); Berta Sousa (Champalimaud Research and Clinical Centre, Portugal); Panagiotis Simos (School of Medicine, University of Crete, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Mental health impairment after breast cancer diagnosis may persist for months or years. The present work leverages on novel machine learning techniques to identify distinct trajectories of mental health progression in a 18-month period following BC diagnosis and develop an explainable predictive model of mental health progression using a large list of clinical, sociodemographic and psychological variables. The modeling process was conducted in two phases. The first modeling step included an unsupervised clustering to define the number of trajectory clusters, by means of a longitudinal K-means algorithm. In the second modeling step an explainable ML framework was developed, on the basis of Extreme Gradient Boosting (XGBoost) model and SHAP values, in order to identify the most prominent variables that can discriminate between good and unfavorable mental health progression and to explain how they contribute to model's decisions. The trajectory analysis revealed 5 distinct trajectory groups with the majority of patients following stable good (57%) or improving (21%) trends, while for others mental health levels either deteriorated (12%) or remained at unsatisfactory levels (11%). The model's performance for classifying patient mental health into good and unfavorable progression achieved an AUC of 0.82 ± 0.04. The top ranking predictors driving the classification task were the higher number of sick leave days, aggressive cancer type (triple-negative) and higher levels of negative affect, anxious preoccupation, helplessness, arm and breast symptoms, as well as lower values of optimism, social and emotional support and lower age.

18:15

The Stroop Competition: A Social-Evaluative Stroop Test for Acute Stress Induction

Victoria Mueller, Robert Richer, Lea Henrich, Leonie Berger, Antonia Gelardi, Katharina M Jaeger and Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Nicolas Rohleder (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany)

The Stroop test is one of the most widely used protocols to induce cognitive stress and reliably activates the sympathetic nervous system (SNS). However, it only moderately activates the hypothalamic-pituitary-adrenal (HPA) axis, the stress axis responsible for cortisol secretion. In other well-known stress protocols, such as the cold pressor test, adding social-evaluative elements to the regular procedure has proven to cause increased HPA axis activation. For this reason, we introduce the "Stroop Competition", a novel stress protocol based on the established Stroop test that adds social-evaluative feedback by conducting the test against a fake opponent with subsequent performance evaluation. We investigated the stress response of 22 participants performing either the "Stroop Competition" (Competition group) or the regular Stroop test (Control group) three consecutive times. Stress responses were assessed using ECG recordings to extract heart rate (HR) and heart rate variability (HRV) and saliva samples to extract salivary alpha-amylase (sAA) and cortisol. In the Competition group, participants experienced higher SNS activation indicated by significantly higher HR and lower HRV levels as well as higher sAA response to the stressor compared to the Control group. Additionally, overall cortisol levels were significantly higher in the Competition group supporting higher HPA axis activity. The findings of our pilot study confirm our hypothesis that adding social-evaluative elements to the Stroop test causes a more effective activation of both the SNS and HPA axis. We are convinced that our novel "Stroop Competition" protocol will provide a valuable addition to the already existing stress protocols in biopsychological research.

18:25

Cognitive-emotional Stress and Risk Stratification of Situational Awareness in Immersive First Responder Training

Lucas Paletta, Martin Pszeida, Michael Schneeberger and Amir Dini (JOANNEUM RESEARCH Forschungsgesellschaft mbH, Austria); Lilian Reim and K. Wolfgang Kallus (Institut Begleitforschung Psychologisches Qualitätsmanagement, Austria)

First responders engage in highly stressful situations at the emergency site. Staying cognitively under control under these circumstances is a necessary condition to perform efficient decision making for the purpose of own health and to pursue mission objectives.
VR-based training in disaster preparedness has been increasingly recognized as an important additional modality to traditional real-life skill training [3]. The increased realism in the practice enables first responders to reinforce their individual performance, in particular, to execute tasks appropriately under stress and apply decision making under conditions close to reality. Mills et al. [4] estimated that a mass casualty triage training of paramedic students in a real-world simulation is about 13 times more expensive than in VR, while the simulation efficacy has been found near identical. Recent research [5] has even indicated superior performance in simple search tasks following VR and AR training of first responders as opposed to traditional classroom and real world training. The use of wearable sensor-based monitoring systems offers life-saving opportunities for advanced health care solutions for stress analysis.
We are aiming at developing biosensor-based decision support for risk stratification on cognitive readiness of first responders at the mission site. In a first development stage, an exploratory pilot study was performed to test a formalized reporting schema applying equivalent stress in real, non-immersive and fully immersive training environments. Wearable psychophysiological measurement technology was applied to estimate the cognitive-emotional stress level under both training conditions. In this work we particularly focus on the potential of predicting the risk level for failures in situation awareness from digital analysis of cognitive-emotional stress. The results provide statistically significant indications for risk stratification of cognitive readiness based on situation awareness theory.

Screen 7

17:15

An implementation of an AI-assisted sonification algorithm for neonatal EEG seizure detection on an edge device

Feargal O'Sullivan, Emanuel M. Popovici and Sergi Gomez-Quintana (University College Cork, Ireland); Andriy Temko (University College Cork & Irish Centre for Fetal and Neonatal Translational Research, Ireland)

Seizure detection is a challenging problem for neonates where the brain is at the early stages of development. Early detection of neonatal seizures is an essential yet difficult clinical task. Failure to detect such events within an optimal time window may lead to reduced efficiency of the treatment and ultimately can lead to increased mortality and morbidity. Electroencephalography (EEG) analysis is the gold standard for detecting anomalies in the brain, with visual analysis of EEG recordings being the most common tool for monitoring and detecting abnormal brain function. There is a severe shortage of specialized medical professionals for EEG analysis, especially in disadvantaged communities. Machine learning (ML) techniques have been successfully deployed to compensate for the lack of expertise 24/7. These techniques are particularly interesting as they allow real-time online analysis of EEG, providing instantaneous feedback to the medical practitioner. AI-assisted sonification adds additional explainability to any such automated methodology. This empowers the medical professional (regardless of the individuals level of expertise in EEG analysis) to make accurate decisions quickly to maximise the quality of care provided to patients. A derived lightweight algorithm designed for resource constrained implementation scenarios is also evaluated and presented suggesting suitability for further ultra low power, mobile and wearables implementations.

17:25
Feature Variance in Affective ECG & PPG
Zachary Dair (Munster Technological University & Advance CRT, Ireland); Samantha Dockray (University College Cork, Ireland); Ruairi O'Reilly (Munster Technological University, Ireland)

Momentary assessments of human physiology provide insights into individuals' affective states. This approach has been widely adopted in the field of Psychophysiology. However, identifying the causality of physiological changes from psychological states is challenging due to data availability, the cost of labelling data and the expert nature of the task. Wearable devices are a means of acquiring data at scale and are a necessary precursor to enable generalisable models for automating the classification of momentary assessments via techniques such as machine learning. This work focuses on addressing technical limitations associated with acquiring data from wearables, namely, (i) the variance in features extracted between Electrocardiography and Photoplethysmography, (ii) the disparity in feature importance when classifying affective states, (iii) the disparity in feature importance between affective states themselves. It is envisaged addressing these limitations would provide a more transparent understanding of the impacts on momentary assessments of affective state, caused by varying data acquisition methods.

17:35
SPERTL: Epileptic Seizure Prediction using EEG with ResNets and Transfer Learning
Umair Mohammad and Fahad Saeed (Florida International University, USA)

Epilepsy is a chronic condition that causes repeat unprovoked seizures and many epileptics either develop resistance to medications and/or are not suitable candidates for surgical solutions. Hence, these recurring unpredictable seizures can have a severely negative impact on quality of life including an elevated risk of injury, social stigmatization, inability to take part in essential activities such as driving and possibly reduced access to healthcare. A predictive system that informs patients and caregivers about a potential upcoming seizure ahead of time is not only desirable but an urgent necessity for patients or caregivers. In this paper, we contribute by designing and developing patient-specific epileptic seizure (ES) prediction models using only electroencephalography (EEG) data with residual neural networks (ResNets) and transfer learning (TL) - (SPERTL). We train our proposed model on EEG data from 20 patients with a seizure prediction horizon (SPH) of 5 minutes and use the validation data to plot precision-recall curves for selecting the best thresholds. Testing on unseen data shows our model outperforms the state-of-the-art methods by achieving the highest average sensitivity of 88.1%, specificity of 92.3%, and accuracy of 92.3%. Our results also demonstrate the proposed model is less susceptible to false positives while maintaining a high positive prediction rate.

17:45
Development of FPGA based Lossless Compressor Circuit for Compression of EEG Signals
Md Mushfiqur Rahman Chowdhury (Indian Institute of Technology Mandi, India); Shubhajit Roy Chowdhury (School of Computing and Electrical Engineering, IIT Mandi, India)

This research presents about a Bio-Signal Compressing circuit where the design is Field Programmable Gate Array (FPGA) based and performs effective lossless data compression for single and multi-channel EEG data. As, EEG data consumes a massive amount of storage and each portion of the signal are very significant, these data recordings must be stored and circulated for diagnosis of any particular patient. That's why lossless data compressing sensors and circuits come into picture. The designed circuit implements an efficient algorithm resulting in high compression ratio. The circuit provides fast and accurate data recovery while enabling effective signal capture at sub-Nyquist rates. This FPGA-based solution uses the hardware resources effectively while achieving high-speed signal recovery. The main goal of this design is to develop real-time architecture that will give us live EEG data which will be sent to a doctor wirelessly and further which may monitor signal abnormalities in EEG when a seizure occurs. In the whole process, the EEG signal is fed to an algorithm based on the combination of modified multivariate auto regression method and data entropy prediction algorithm. In this project the Multivariate Auto-Regression (MVAR) algorithm has been refined by using least square matrix instead of using co-efficient matrix for prediction of electrode signals. The prediction algorithm also includes the application of low pass FIR Filter, which has been used to predict the future values and error of the electrodes available. The predicted signals and error signals have been used for compression purpose as they have lower empirical entropy compared to the source signals. The algorithm has been implemented in hardware using Verilog HDL and the system has been implemented on a Xilinx Zynq Ultrascale MPSoC ZCU 104 FPGA board. The resulting compression ratio (CR) of the proposed method is 76.2% on average, is some cases, it goes up to 99% for few channels, which is more than any other state of the art algorithms. In this research work, we have implemented FIR filter as a EEG data compressor and data predictor circuit, the MVAR model has also been implemented in hardware for the first time ever. The device is implementable in ASIC (Application Specific Integrated Circuit), after the ASIC implementation, the chip can be used as an implantable design too. The future task is to do live EEG data acquisition and compression by using this hardware implementation. The circuit which has been designed

works for 22 channels. The same design can be replicated to create the circuit design for compressing 128 channels or 256 channels EEG data.

17:55

The influence of sensor placement on the shoe on the performance of CNN-based gait analysis algorithms

Arne Küderle (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany); Nils Roth (University of Erlangen-Nuremberg, Germany); Leo Schwinn and Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

Past research has shown that the attachment position of inertial measurement units on the foot influence the accuracy of spatial gait parameters extracted via double integration. Recently, neuronal networks have been proposed as an alternative to integration-based methods. In this study we show that these methods are sensitive to the placement of the sensor unit, too. This motivates further investigations into the origins of these errors and the search for new methods to enable robust gait analysis in unsupervised environments.

18:05

A modular BLE-based body area network for first responders real-time monitoring in life-threatening scenarios

Giulia Sedda (Via Marengo, 2 & University of Cagliari, Italy); Giulia Baldazzi (University of Cagliari); Salvatore Spanu, Andrea Spanu, Piero Cosseddu, Annalisa Bonfiglio and Danilo Pani (University of Cagliari, Italy)

In this work, we present a prototype of a sensorized technical underwear able to detect physiological and biomechanical parameters of a first responder involved in search-and-rescue operations. The underwear implements a body sensor network of BLE nodes communicating with an Android smartphone, which features high modularity that allows the sensing of what is really needed in every life-threatening scenario. I. INTRODUCTION First responders involved in difficult search-and-rescue operations are subject to hazardous conditions. The development of smart garments with physiological sensing capabilities, able to be integrated in a broader monitoring system, is then of paramount importance for their safety. As part of the H2020 Search & Rescue European Project (https://search-and-re-rescue.eu/), we designed, developed, and tested on the field a modular wearable system for rescuers operating in critical emergency contexts, such as searching people trapped under the rubble. The system is able to collect physiological and biomechanical parameters measured by the attached sensor nodes and send them to the control center in real time. II. SYSTEM ARCHITECTURE The developed smart underwear is functionalized with different custom-designed sensor nodes, which are equipped with a Bluetooth low-energy (BLE) radio module, to communicate with the rescuer's Android smartphone. Nodes collect the signals from organic-electronic sensors obtained by directly functionalizing the smart underwear with conductive polymers and by integrating a thin strain organic semiconductor-based strain sensor in it. They allow monitoring the ECG, EMG, and knee joint angles of the first responder during the search and rescue operations, thus constituting an application-specific BLE body area network (see Fig. 1). Sensor nodes provide acquisition and basic processing features, by exploiting a CC2640R2F MCU. The smart underwear is worn under the rescuer's uniform and may integrate additional sensors. It is composed of a T-shirt and leggings made of highly breathable, stretchable, resistant, and comfortable polyester fabric. In some areas (see Fig. 1), the fabrics is functionalized by conductive inks based on poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT-PSS), to form electrodes able to detect cardiac and muscle biopotentials [1]. An organic semiconductor-based strain sensor [2] is integrated in the popliteal fossa area. Overall, up to four nodes can be present on the underwear to sense and transmit the physiological and biomechanical data. The smartphone, by running a custom Android app, uses the information of the integrated GPS module to send the geolocated data to the command center, which collects and processes them in real time. At present, the smart underwear was successfully tested in two of the seven use cases envisaged in the project. The app is being extended to include the acquisition of signals coming from further sensors embedded in the external uniform.

18:15

A deep learning-based algorithm to track the recovery of motor function in stroke survivors undergoing rehabilitation interventions

Federico Parisi (Harvard Medical School, USA & Spaulding Rehabilitation Hospital, USA); Eléonore Duroyon (ETH, USA); Catherine Adans-Dester (Spaulding Rehabilitation Hospital, USA); Benito L Pugliese, Eric Fabara and Paolo Bonato (Harvard Medical School, USA)

In this study, we explored the suitability of deep learning-based video analysis techniques to derive the kinematics of motor tasks performed by stroke survivors and estimate clinical scores used to track the recovery of motor function in response to rehabilitation interventions. Results obtained using the proposed approach were compared with those derived using previously developed machine learning algorithms for the analysis of data collected using wearable inertial sensors. The video analysis-based approach provided estimates of the clinical scores that were highly correlated (r2=0.75) with those generated by rehabilitation specialists. These results were comparable with those derived from wearable inertial sensor data (r2=0.79).

18:25

A Study on Pulse Transit Time Between Bio-impedance and Multi-wavelength Photoplethysmography sensors for Wearable Blood Pressure Monitoring

Zijun Liu (City University of Hong Kong, Hong Kong); Nan Ji (Hong Kong Centre for Cerebro-Cardiovascular Health Engineering, Hong Kong); Ting Xiang (City University of Hong Kong, Hong Kong); Yuanting Zhang (Hong Kong Centre for Cerebro-Cardiovascular Health Engineering (COCHE), Hong Kong)

Common pulse transit time (PTT)/pulse wave velocity (PWV) methods such as 2-site Photoplethysmography (PPG) can only provide a single type of waveform that lacks information diversity. In this study, we developed a dule-modal signal measurement system consisting of Impedance Plethysmography (IPG) and Multiwavelength Photo- plethysmography (MWPPG). The proposed IPG-MWPPG system was implemented and tested on wrist positions of normal human subjects. The preliminary results of this study showed that PTTs obtained between the peaks of IPG and corresponding MWPPG yielded PWV values within their physiological ranges reported previously. Thus, the IPG-MWPPG modality system could potentially be used for the unobtrusive monitoring of multiple physiological parameters including PWV, SpO2 and cuffless blood pressure in the future.

Screen 8

17:15

An Electromyography-Driven Soft Robotic and Ergonomic (SRE) Glove Design to Facilitate Hand Rehabilitation after Stroke

Xiangqian Shi (The Chinese University of Hong Kong, Hong Kong); Joanne Yip (The Hong Kong Polytechnic University, Hong Kong); Raymond Kai-Yu Tong, Jing Shu and Junming Wang (The Chinese University of Hong Kong, Hong Kong)

Background: Arm-hand disabilities are commonly observed after stroke. More than 50% of stroke survivors feel difficulty controlling their hands, resulting in limitations in performing activities of daily living (ADL) and decreased quality of life (QOL). Soft robots, made from various deformable materials, have shown excellent biomimetic properties in assisting ADL due to their inherent compliance and versatility. We designed the soft robotic and ergonomic (SRE) glove consisting of five Soft-Elastic Composite Actuators (SECA) that can easily fit on the back of the finger and actively assist the finger flexion and extension. Each SECA consisted of two separate segments centered on the corresponding finger joints, the proximal interphalangeal (PIP) and metacarpophalangeal (MCP) joints. SRE glove is fluidically controlled. On pressurization, the two segments of SECA will actively bend the PIP and MCP joints along the sagittal plane. Spasticity commonly occurs after stroke, which severely affects the finger extension. Thus, on depressurization, the bottom torque-compensating layer will provide an extra extension toque to help stroke survivors against finger spasticity and further extend their joints. To further explore the rehabilitation effects of SRE glove combined with the Electromyography (EMG)-driven approach, 20 sessions of one-hour SRE glove-assisted hand training were conducted on chronic stroke survivors.

Objectives: We investigated the effects of the EMG-driven SRE glove that could actively flex and extend the fingers in chronic stroke subjects with different levels of spasticity.

Methods: Sixteen chronic stroke subjects (n = 16) were recruited to conduct 20 sessions of one-hour SRE glove-assisted hand training within seven consecutive weeks. The SRE glove was actively triggered by the EMG signals from the extensor digitorum (ED, for hand opening) and flexor digitorum (FD, for hand closing). Subjects are instructed to sit in front of the table and continuously conduct the hand opening and closing. Stroke subjects repeated the task in equal quantities for 10 minutes, and then they were allowed to have a short break (5 minutes). Training effect was evaluated before and after training and three months later. Improvement of subjects was evaluated by the following outcomes: Action Research Arm Test (ARAT), Fugl-Meyer Assessment for Upper Extremity (FMA-UE), Box-and-Block test (BBT), Modified Ashworth Scale(MAS), and maximum voluntary grip strength.

Results: For all the recruited subjects (n = 16), significant improvement ($p<0.05$) in upper limb function was generally observed in ARAT with increased means of 2.44 (post 20-session) and 2.19 (3-month follow-up), FMAUE with increased means of 3.31 (Post) and 2.25 (3-month), BBT with increased means of 1.81 (Post) and 1.06 (3-month), and maximum voluntary grip strength with increased means of 2.14 kg (Post) and 1.08 kg (3-month). No significant change was observed regarding spasticity with the MAS. Conclusion: EMG-driven rehabilitation training using the SRE glove could benefit the functional recovery of the upper limb in chronic stroke. The SRE glove has the potential to be used in home-based rehabilitation to increase the duration and intensity of the training, thus further improving rehabilitation outcomes.

17:25

Sensitive and accurate biosensors for the rapid detection of acute myocardial infarction biomarkers

Walaa Khushaim and Veerappan Mani (King Abdullah University of Science and Technology, Saudi Arabia); José De Oliveira Filho (KAUST, Saudi Arabia)

Cardiovascular disease (CVD) is the leading cause of death worldwide. More than 85% of CVD-related deaths are due to acute myocardial infarction (AMI) commonly known as heart attack, which is a consequence of coronary artery disease. Affordable and early AMI diagnosis has the potential to save millions of lives each year; however, the clinical conventional methods are still ineffective. Quantitative measurements of blood cardiac biomarkers, which exist at low levels at the onset of AMI, are required for early diagnosis and even prevention of AMI. In this study, a diagnostic tool was developed for a low-cost, rapid and sensitive detection of cardiac troponin I (cTnI), the "gold standard" biomarker in AMI diagnosis. An electrochemical sensing technique based on laser-scribed graphene electrodes (LSGEs) modified with nanosheet materials to enhance sensing performance towards cTnI was explored. Porous carbon nitride (PCN) with improved porosity and electronic structure was used as the active nanosheet material. A two-step chemical method was used to synthesize PCN with and without functionalized Au nanoparticles. When compared to bare LSGE, the modification of the electrode surface with PCN materials had a substantially improved impact on the surface area, aptamer immobilization, and electrochemical biosensing potential. However, nano-gold decorated PCN nanosheets outperformed PCN alone and displayed a detection limit of 0.01 pg/mL. Furthermore, a point-of-care platform was created by integrating a PCN-Au aptasensor with a miniaturized potentiostat, which can detect picomolar cTnI levels in serum sample. The LSGE/PCN-Au aptasensor paves the way for developing an inexpensive sensitive cardiac biomarker sensor for point-of-care monitoring systems.

17:35

Comparing True and Reconstructed 3D Landmarks for Detection of Speech and Orofacial Impairments Associated with Amyotrophic Lateral Sclerosis (ALS)

Leif Simmatis (University of Toronto & University Health Network, Canada); Yana Yunusova (University of Toronto, Canada); Diego Guarin (University of Florida); Babak Taati (University Health Network, Canada)

Markerless orofacial assessment using deep learning and 2D cameras overcomes many of the limitations associated with sensor-based laboratory techniques and has potentially high clinical utility. Here, we compared detection of speech and orofacial impairments in amyotrophic lateral sclerosis (ALS) using (1) 3D facial landmarks reconstructed from 2D video, and (2) true 3D facial landmarks obtained using a depth camera. Both methods detected impairments associated with ALS, but true-3D performed moderately better. This tradeoff may be worth the considerably greater availability of 2D cameras for clinical applications. Keywords- Amyotrophic lateral sclerosis (ALS), markerless facial tracking, motor speech assessment I. BACKGROUND Speech and orofacial motor control is frequently impaired in individuals with neurological diseases such as amyotrophic lateral sclerosis (ALS), and these deficits are associated with poor clinical outcomes [1]. Markerless facial landmark tracking in combination with 3D cameras overcomes many limitations associated with traditional clinical approaches (subjectivity) and sensor-based systems (cost/complexity). 3D movements are important for speech [2]; but 3D cameras remain relatively inaccessible for clinical use. Potentially, 2D cameras with deep learning-based 3D facial reconstruction could capture relevant movement characteristics without the need for specialized 3D cameras. To establish this, we compared true and reconstructed-3D (rec-3D from here onwards) facial tracking methods in a clinically-relevant context - distinguishing people with ALS from healthy individuals. We quantified (1) correlation between true- and rec-3D facial kinematics, and (2) the classification performance (balanced accuracy) distinguishing individuals with ALS from healthy individuals. II. METHODS 15 individuals with ALS and 24 healthy control participants completed 3 orofacial/speech tasks: OPEN (open/close mouth 5x), SPREAD (spread cheeks laterally and return to rest 5x), and BBP (repeat "buy Bobby a puppy" 5x). Videos were captured using an Intel RealSense SR300 3D camera (50 frames per second). The Facial Alignment Network (FAN) [3], finetuned previously using clinical data, and depth data from the camera captured "true"-3D landmarks. 3D Dense Facial Alignment (V2) (3DDFA) [4] was used to reconstruct 3D landmarks from RealSense colour videos. Kinematic features of range of motion (ROM), speed, and symmetry were calculated from landmark trajectories. Correlations between true- and rec-3D features were calculated (Spearman ρ; threshold ≥|0.50|). Classification as ALS/control was done using a support vector machine (SVM) with Mann-Whitney U-test feature selection. Model performance was reported using balanced accuracy (suitable for imbalanced datasets - referred to as "acc"). Aggregate voting was based on majority vote per-person for all 3 tasks. III. RESULTS AND DISCUSSION We observed task-dependent differences in correlations between features and classifier performance. Approx. 30% of BBP and OPEN features had ρ ≥|0.50|, whereas in SPREAD, no features met this threshold. With regards to classification, we observed consistent results between true- and rec-3D cases, except for BBP (see Table 1). Potentially, discrepancies arose because FAN was finetuned whereas 3DDFA was not. Comparable classification performances in the aggregated-vote case supports a potential clinical use of 3D reconstruction technologies.

17:45

Wearable-Based Intelligent Emotional Well-Being Monitoring in Older Adults during Daily Life Activities

Eduardo Gutierrez Maestro, Tiago Rodrigues de Almeida and Oscar Mozos (Örebro University, Sweden)

We are experiencing unprecedented social and demographical changes. The world's population is expected to increase to 9.7 billion by 2050 with 2 billion being people aged 60 or above, according to the United Nations. Older adults wish to stay in their homes for as long as possible in order to enjoy an active and healthy ageing life. However, older adults living alone

are more likely to experience poor mental health, including depression, anxiety or low self-esteem. Although there is an increasing acknowledgment of the important role of mental health in the daily life of people, it still has relatively low priority in older adults, it has been poorly covered by existing health monitoring systems, and it is often considered a forgotten matter. Therefore, there is an urgent need for new and innovative forms to support the emotional well-being of older adults. Healthcare systems based on remote sensing technologies are becoming an alternative method in order to cover future demands on remote and personalised medicine. In this paper, we present an AI-based system to monitor the emotional well-being of older adults during their daily life. Our system is composed of the wearable watch-alike Empatica E4 that collects several physiological and activity signals during daily activities of the participants. Those signals are processed and converted into feature vectors that are classified into one of the affective concepts presented in "A circumplex model of affect" by J. A. Russel. Our feature vectors are selected from a pool of standard time-based features used in time analysis. To collect ground truth data from older adults, we provide an app for the smartphone that implements an ecological momentary assessment (EMA) tool for rapid and low obtrusive input by the used. The results in this paper show an improvement on the classification results in comparison to previous works using the same dataset, showing that our set of standard time-based features are suitable for emotional well-being intelligent monitoring and inference.

17:55

Self-Adaptive Epileptic Spike Detection Mechanism

Peihao Li and Maria Castillo (KAUST, France); Taous-Meriem Laleg-Kirati (King Abdullah University of Sciences and Engineering (KAUST), Saudi Arabia); Majed Al-Hameed (King Fahad Medical City, Saudi Arabia); Vahe Poghosyan (KFMC, Saudi Arabia)

In this paper, we propose a new Self-Adaptive Epileptic Spike Detection (SAM-ED) algorithm based on the fractal dimension. It takes prerecorded multi-channel magnetoencephalography(MEG) data file as input and labels the occurrences of epileptic spikes in windows. The performance is evaluated in terms of sensitivity and specificity over the whole data range. SAM-ED is able to demonstrate higher sensitivity while maintaining specificity as high as possible when testing real patient's data. We anticipate that this proposed model will find use case in clinical applications by providing comparable diagnostic performance against training based approaches and by providing generality to different types of bio signals. With zero prior knowledge required, simply by setting the idea specificity of SAM-ED at 70%, it shows high sensitivity (close to 100%), while maintaining an relatively low false detection rate between 20-36\%. Physicians can always trade-off between sensitivity and specificity by decreasing or increasing the desired specificity. Results obtained are suggesting that SAM-ED is able to adapt automatically to any types of input data for epilepsy spikes detection. By properly selecting a desired specificity value, SAM-ED can outperform other methods by showing much higher sensitivity. Furthermore, compared to tedious debugging existing in other spike detection algorithms, SAM-ED is more user friendly especially for clinicians and physicians in this field with a single parameter to adjust the sensitivity and specificity trade-offs. It is concluded that SAM-ED is reliable, robust and universal with potentials contributing to real practices.

18:05

A deep learning-based algorithm to estimate the knee flexion-extension angle using a sleeve with optical sensors

Federico Parisi (Harvard Medical School, USA & Spaulding Rehabilitation Hospital, USA); Juliette R Bromet (ETH Zurich, Switzerland); Benito L Pugliese (Harvard Medical School, USA); Alessandra Angelucci (Politecnico di Milano, Italy); Eric Fabara (Harvard Medical School, USA); Stefano Sapienza (Politecnico di Torino, Italy); Monica Mura (Politecnico di Torino, USA); Andrea Aliverti (Politecnico di Milano, Italy); Danilo Demarchi (Politecnico di Torino, Italy); Paolo Bonato (Harvard Medical School, USA)

We present a deep-learning based algorithm designed to estimate the knee flexion-extension angle from data collected using a sleeve with optical sensors. We collected data from 31 healthy volunteers walking on a treadmill at three different speeds. The knee flexion-extension angle estimated using the proposed algorithm was compared with the estimates derived by means of a camera-based motion capture system. The root-mean-square error of the estimates derived using the knee sleeve system was equal to 5.79±1.83 degrees, showing that the developed system has the potential to accurately estimate the knee flexion-extension angle.

18:15

Feasibility Study on the Mental Stress Relieving Effect of the tDCS Fusion Headband Device

Young Chang Jo, Hyuck Ki Hong, Chan Hee Jeong, Won Hee Hwang and Yeon Shik Choi (KETI, Korea (South))

In this paper, the feasibility of the newly proposed tDCS, PPG, EEG fusion device for stress relief effect was studied by collecting and analyzing PPG signals before and after tDCS stimulation. The significant parameters for stress evaluation used in this study consisted of SDNN and RMSSD in the time domain and LF, HF, and LF/HF in the frequency domain. And alpha band energy change of EEG was also studied. In case of mental stress, autonomic nervous system imbalance is caused, in particular, LF increases and HF decreases. Therefore, the value of LF/HF increases under stress, so it is necessary to carefully look at the changes in LF/HF before and after tDCS stimulation. It was confirmed that the LF/HF value decreased after tDCS stimulation to 1.318. During stress, LF increases and HF decreases, so the value appears

larger than in the relaxed state. In this experiment, the LF/HF value in the stressed state was about 0.13 higher. Therefore, it can be judged that the stress level is somewhat decreased through tDCS stimulation. Experimental results show the stress index, LF/HF ratio, improved by about 0.13 after tDCS stimulation. As a result of analyzing the EEG Power Spectrum Density before stimulation (Stress) and after tDCS electrical stimulation, it was confirmed that there was a large change in the alpha wave (8~12Hz). In general, the alpha wave is an EEG that appears in an awakened state, and it is known as an EEG that becomes more active in a relatively relaxed state among the awakened state. As the alpha wave increases after tDCS stimulation, the post stimulation state can be interpreted as a less stressed state compared to the stressed state.

18:25

Benchmarking of Sleep/Wake Detection Algorithms on a Large Cohort using Actigraphy, HRV, and Respiration Information

Daniel Krauss and Robert Richer (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Arne Küderle (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany); Janina Beilner (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Nicolas Rohleder (Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany); Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

Insufficient sleep quality is directly linked to a series of physical and physiological diseases. Therefore, reliable sleep monitoring is essential for the prevention, diagnosis, and treatment of such. As sleep laboratories are very cost- and resource-prohibitive, wearable sensors are a promising alternative for unobtrusive sleep monitoring at home. During sleep, body movements decrease compared to a wakeful state. In addition, cardiac and respiratory activity changes during sleep. Current systems are mostly based on wrist movement, typically assessed using actigraphy (ACT), for unobtrusive sleep/wake detection. However, movement-based systems tend to overestimate sleep due to a lack of movement shortly before falling asleep or in short periods of wakefulness. Previous research showed promising improvements in sleep/wake detection by combining ACT with cardiac and respiratory information such as heart rate variability (HRV) and respiration rate variability (RRV). However, this was only evaluated on small cohorts and not in large-scale studies. For that reason, this work aims to systematically compare ACT-based sleep detection with multimodal approaches combining ACT and HRV by benchmarking different state-of-the-art machine- and deep learning algorithms on a large-scale dataset. In particular, we investigate whether the classification performance can be further improved by including respiratory information into machine learning models. The data used in this work were collected in a sleep study of 2,237 participants, which contains ACT and polysomnography (PSG). PSG was used as ground truth for sleep/wake phases as well as to extract HRV and RRV from electrocardiography and respiratory induction plethysmography respectively. In total, 370 ACT features and 30 HRV features were extracted according to Zhai et al. In addition, 62 RRV features were extracted using the Neurokit2 library. To find the best set of hyperparameters, a grid search with embedded 5-fold cross-validation was performed over a defined search space. Our results show that including RRV features in the classification algorithms significantly improved the key metrics of assessing sleep/wake detection performance (Fig 1). The best-performing algorithm to discriminate between sleep and wake phases was a Multi-Layer Perceptron with an accuracy of 85.1±8.5%. In particular, specificity, which is a good marker for assessing the overprediction of sleep, showed a strong increase in performance after adding RRV (63.5±22.3% vs. 72.4±17.2%). Our findings underscore the potential of including respiratory information, which can also be extracted from wearable sensors, to improve sleep/wake detection algorithms and, thus, help to transfer sleep laboratories into a home monitoring environment.

18:45 – 19:15
Buses from Venue to Dodoni
Room: ENTRANCE OF THE VENUE

20:00 – 22:00
Theatrical Perforance “Eirini” – Aristophanes, Dodoni Ancient Theater
Room: DODONI VILLAGE

Thursday, September 29, 2022

8:30 – 19:00
Registration
Room: FOYER ERATO

8:30 – 9:15
Keynote Lecture
Chair: Paolo Bonato, BSN2022 Chair, Harvard Medical School, USA
Room: ERATO

Bioelectronic tools to study the gut-brain axis
Prof. Roisin M. Owens
Department of Chemical Engineering and Biotechnology, University of Cambridge, Cambridge CB3 0AS, United Kingdom

Polymeric electroactive materials and devices can bridge the gap between hard inflexible materials used for physical transducers and soft, compliant biological tissues. An additional advantage of these electronic materials is their flexibility for processing and fabrication in a wide range of formats. In this presentation, I will discuss our recent progress generating 3D conducting polymer devices, to simultaneously host and monitor complex multi-cellular models of tissues and organs. Electrophysiological recording of parameters such as tissue impedance, epithelial and endothelial barrier tissue integrity and neuronal activity, are all made possible thanks to the conducting polymer devices and are validated with traditional biological readouts such as immunofluorescence or cytokine analysis. Building on our previous work that showcased a bioelectronic model of the human intestine, we are now incorporating elements of the microbiome and the immune system as well as the enteric nervous system. Coupling this model with our model of the neuro-vascular unit (including blood brain barrier) currently in progress, will bring us to our goal of a physiologically representative in vitro model of the gut-brain-microbiome axis. Alongside our in vitro work, I will show how our recent work on developing electronic probes to study the enteric nervous system. Transitioning from in vitro human and rat to in vivo rat models allows us to integrate electrophysiological recordings of neuronal activity with tissue impedance to really begin to unravel gut-brain axis signaling.

9:15 – 10:00
Keynote Lecture
Chair: May D. Wang, BHI-TC Chair, Georgia Institute of Technology and Emory Univ., USA
Room: ERATO

AI in Clinical Medicine: Lessons Learned this Decade and Future Paradigm for Clinical Impact
Prof. Anthony C. Chang
Founder of AIMed, Chief Intelligence and Innovation Officer (CIIO) and Medical Director of the Heart Failure Program, Children's Hospital of Orange County, USA

Artificial intelligence has gradually been introduced and adopted in the clinical medicine realm, but the clinical impact has not been as big as it was hoped. Among the issues include: lack of continual clinician/data scientist synergy, inadequate data and IT infrastructure, failure to maintain AI models that have generalizability, inadequate education for clinicians and administrators, and too little appreciation for the complexities of clinical medicine and decision making. The future of clinical medicine needs to have much stronger clinician involvement and direction so the level of cognition will be much higher. This future paradigm will need to involve AI technologies such as reinforcement learning and digital twins.

10:00 – 10:15
Coffee Break
Room: FOYER ERATO

10:15 – 11:45
BHI Session # 3 Clinical Informatics
Chair: George Matsopoulos, National Technical University of Athens, Greece**; Toshiyo Tamura,** Chiba University, Japan
Room: POLYMNIA

10:15
Analysis and optimization of parametric uncertainty in cuffless blood pressure estimation model
Zhangfeng Hu and Xiaorong Ding (University of Electronic Science and Technology of China, China)

Accurate measurement of blood pressure (BP) and its variability is of great significance to early screening, diagnosis and management of hypertension and hypertension related cardiovascular diseases. Cuffless BP estimation, e.g., via pulse transit time (PTT) method, has been extensively studied due to its advantage over traditional cuff-based BP monitor by providing unobtrusive continuous BP monitoring without an inflatable cuff. However, there usually exists aleatory and epistemic uncertainties in the cuffless BP estimation models, which can result in poor performance of the models. The former is manifested as the uncertainty of the parameters in the model. This study aims to investigate the impact of parametric uncertainties on the accuracy of the cuffless BP estimation models, and then propose an optimization strategy to mitigate the uncertainty. We defined an indicator - coefficient of variation (CV) to evaluate the variability of a parameter, and examined the parametric uncertainty by investigating the propagation of the model parameter variations to the model performance, and then employ Monte Carlo simulation to optimize model parameters with uncertainty for accurate estimation. Results show that BP estimation performance degraded with the increase of variability in model parameters, and the proposed optimization method can improve the accuracy of BP estimation to some extent.

10:27
Model-Free Reinforcement Learning for Automated Fluid Administration in Critical Care
Elham Estiri and Hossein Mirinejad (Kent State University, USA)

Fluid administration, also called fluid resuscitation, is a medical treatment to restore the lost blood volume and optimize cardiac functions in critical care scenarios such as burn, hemorrhage, and septic shock. Automated fluid administration systems (AFAS), a potential means to improve the treatment, employ computational control algorithms to automatically adjust the optimal fluid infusion dosages by targeting physiological variables (e.g., blood volume or blood pressure). Most of the existing AFAS control algorithms are model-based approaches, and their performance is highly dependent on the model accuracy, making them less desirable in real-world care of critically ill patients due to the model uncertainties and inter-patient and intra-patient variabilities in dose-response models. This work presents a novel model-free reinforcement learning (RL) approach for the control of fluid infusion dosage in AFAS systems. The proposed RL agent learns to adjust the blood volume to a desired value by choosing the optimal infusion dosages using a Q-learning algorithm. The RL agent learns the optimal actions without having the knowledge of the system dynamics by interacting with the environment. The proposed intelligent approach (i) overcomes the need for a precise mathematical model in AFAS systems and (ii) provides a robust performance in rejecting clinical noises and reaching the desired hemodynamic state, as will be shown by simulation results.

10:39
Predicting the impact of standard and hypofractionated schedules in prostate cancer radiotherapy with a mechanistic model
Carlos Sosa-Marrero (Université de Rennes 1, France); Aurélien Briens (CLCC Eugène Marquis, France); Pierre Fontaine (Unversité de Rennes 1, France); Bastien Rigaud (Université de Rennes 1, France); Renaud De Crevoisier and Oscar Acosta (University of Rennes 1, France)

Prostate cancer has been typically treated with a total radiation dose of 74-80 Gy administered in 2 Gy fractions. However, about 20% of patients suffer biochemical recurrence. Hypofractionated treatments may have a positive effect on tumour control. Nevertheless, the choice of an optimal personalised therapy is still compromised by the limited knowledge of the response of patients to high irradiation fractions. The purposes of this work were i) to predict biochemical recurrence after standard fractionation using our previously developed mechanistic model and ii) to explore the impact of hypofractionated treatments for patients who suffered biochemical failure. A cohort of 279 patients with localised prostate adenocarcinoma was used. Analogous virtual tissues were built from pre-treatment MRIs. The prescribed standard irradiation schedules were simulated using the mechanistic model. Biochemical recurrence was predicted from the in silico number of tumour cells at the end of treatment (AUC = 0.68). Then, alternative 2.5 and 3 Gy fractionations were simulated for patients who suffered biochemical recurrence. Significantly lower numbers of tumour cells at the end of treatment were obtained after these hypofractionated schedules. Significant decreases in total doses assuring tumour control were also observed for these patients (median of -10.3 and -14.0 Gy for 2.5 and 3 Gy fractionations, respectively).

10:51
An Efficient Multi-Scale Fusion Network for 3D Organ at Risk (OAR) Segmentation
Abhishek Srivastava (Northwestern University, USA & Machine and Hybrid Intelligence Lab, USA); Debesh Jha and Elif Keles (Northwestern University, USA); Bulent Aydogan (Department of Radiation Oncology, USA); Mohamed Abazeed and Ulas Bagci (Northwestern University, USA)

Accurate segmentation of organs-at-risks (OARs) is a precursor for optimizing radiation therapy planning. Existing deep learning based multi-scale fusion architectures have demonstrated a tremendous capacity for 2D medical image segmentation. The key to their success is aggregating global context and maintaining high resolution representations. However, when translated into 3D segmentation problems, existing multi-scale fusion architectures might underperform due to their heavy computation overhead and substantial data diet. To address this issue, we propose a new OAR segmentation framework, called \textit{OARFocalFuseNet}, which fuses multi-scale features and employs focal modulation for capturing global-local context across multiple scales. Each resolution stream is enriched with features from different resolution scales, and multi-scale information is aggregated to model diverse contextual ranges. As a result, feature representations are further boosted. The comprehensive comparisons in our experimental setup with OAR segmentation as well as multi-organ segmentation show that our proposed OARFocalFuseNet outperforms the recent state-of-the-art methods on publicly available \textit{Synapse multi-organ segmentation} and \textit{OpenKBP datasets}. Both of the proposed methods (3D-MSF and {OARFocalFuseNet}) showed promising performance in terms of standard evaluation metrics. Our best performing method (\textit{OARFocalFuseNet}) obtained high dice coefficient of 0.7995 and haudsoff distance of 5.1435 on {OpenKBP datasets} and dice coefficient 0.8137 on {Synapse multi-organ segmentation} dataset.

11:03
Domain over size: Clinical ELECTRA surpasses general BERT for bleeding site classification in the free text of electronic health records
Jannik Skyttegaard Pedersen and Martin S. Laursen (University of Southern Denmark, Denmark); Cristina Soguero-Ruiz (Universidad Rey Juan Carlos, Spain); Thiusius Rajeeth Savarimuthu (University of Southern Denmark, Denmark); Rasmus Hansen (Odense University Hospital, Denmark); Pernille Just Vinholt (University of Southern Denmark & Odense University Hospital, Denmark)

Bleeding can be a life-threatening condition which occurs for 3.2% of medical patients. Information about previous bleeding and bleeding site is used to predict the risk of future bleeding and guide anticoagulant treatment. However, obtaining this information is a time-consuming task as it is contained in the free text of electronic health records. Previous research has mainly been focused on extracting bleeding events but does not classify the bleeding site which is important for assessing the severity of the bleeding. This study creates the first dataset for developing and evaluating machine learning models for classification of bleeding site. The dataset consists of sentences annotated by medical doctors as belonging to one of ten bleeding sites. The sentences were annotated in 149,523 electronic health record notes from 1,533 patients of Odense University Hospital, Denmark, between 2015 and 2020. We compare different deep learning models on classifying bleeding site and find that a ~13M parameter ELECTRA model pretrained on clinical text achieves higher accuracy (0.905 ± 0.002) than a ~110M parameter general BERT model (0.884 ± 0.001) on a balanced test set of 1,500 sentences. We furthermore test different methods for dealing with unbalanced data without finding any significant differences between methods.

11:15
Mixture of Input-Output Hidden Markov Models for Heterogeneous Disease Progression Modeling
Taha Ceritli, Andrew Creagh and David Clifton (University of Oxford, United Kingdom (Great Britain))

A particular challenge for disease progression modeling is the heterogeneity of a disease and its manifestations in the patients. Existing approaches often assume the presence of a single disease progression characteristics which is unlikely for neurodegenerative disorders such as Alzheimer's disease and Parkinson' disease. In this paper, we develop a hierarchical approach based on mixtures of hidden Markov models that can identify similar groups of patients through time-series clustering and separately represent the progression of each group, unlike hidden Markov models which assume that a single dynamics is shared among all patients. The proposed model is an extension of an input-output hidden Markov model that takes into account the clinical assessments of patients' health status and the prescribed medications.
We illustrate the benefits of our approach using a synthetically generated dataset and a real-world longitudinal dataset for Parkinson's disease, obtained from the Parkinson's Progression Markers Initiative observational study. While the synthetic data experiments demonstrate the ability of mixture of personalized hidden Markov models to simultaneously learn personalized state effects and multiple disease progression dynamics when the true disease progression dynamics is known, real-data experiments show that a mixture of input-output hidden Markov models is favoured over an input-output hidden Markov model for disease progression modeling.

11:27
Discussion

10:15 – 11:45
Special Session: Atherosclerotic Cardiovascular Disease Risk Assessment
Chair: Efthyvoulos Kyriacou, Cyprus University of Technology, Cyprus; **Spyretta Golemati,** National and Kapodistrian University of Athens, Greece
Room: KLEIO

10:15
Carotid Ultrasound Motion Analysis
Spyretta Golemati (National Kapodistrian University of Athens, Greece); Konstantina S Nikita (National Technical University of Athens, Greece)

The carotid artery, the artery that provides blood to the brain, is in constant movement, following the periodic movement of the heart. Assessment of carotid artery wall motion can be achieved from sequences of B-mode ultrasound images. The typical analysis of ultrasound image sequences relies on speckle tracking using cross-correlation between image frames, yielding temporal waveforms of displacements over one or several cardiac cycles. The amplitude and shape of these waveforms are indicative of the tissue mechanical properties. An important implication of ultrasound-based carotid artery wall motion is the possibility to assess the longitudinal component of motion, which takes place along the commonly measured radial one. The application of the motion analysis methodology in real images of normal young and elderly adults has shown the expected periodic pattern of radial strain, which is lower in elderly subjects, some longitudinal strain, and shear strain, between adjacent wall layers, which is also characterised by a periodic pattern, with the same frequency as that of the radial strain. In diseased cases, symptomatic plaque demonstrated increased inherent relative movement. Plaque synchronisation patterns can quantified using cross-correlations of displacement waveforms, indicating within-plaque mean phase shifts of 0.2 s and 0.3 s, in the radial and longitudinal directions.

10:27
Metabolomics in the prediction of prodromal stages of carotid artery disease using a hybrid ML algorithm
Vasileios C. Pezoulas (University of Ioannina, Greece); Pashupati P. Mishra (Tambere University, Finland); Olli T. Raitakari (University of Turku, Finland); Mika Kahonen (Tambere University, Finland); Terho Lehtimäki (Faculty of Medicine and Health Technology, Tampere University, Finland); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece); Antonis Sakellarios (Institute of Molecular Biology and Biotechnology, FORTH, Greece)

Carotid artery disease (CAD) may be responsible for a stroke with fatal consequences for the patients. Early and non-invasive diagnosis and prediction of significantly high carotid intima media thickness (IMT) can reduce the death rates caused by cardiovascular disease. Machine learning can be applied for the development of robust models for this purpose when adequate data are available. In this work, we utilized metabolomics data from 2,147 patients in the Young Finns Study clinical trial to predict the high intima media thickness as a prodromal stage of the atherosclerotic carotid disease. An explainable AI based pipeline was developed which includes a novel employment of the Gradient Boosted Trees (GBT). More specifically, a hybrid loss function was used to adjust the effect of the dropout rates in the ‘dart' booster in the loss function topology. The results of our analysis demonstrate that the novel implementation of the GBT improves the results in terms of the sensitivity which is the most important requirement to our analysis (accuracy 0.80, sensitivity 0.86, AUC 0.85). Moreover, it is shown that metabolomics can be used to increase sensitivity in predicting the increased IMT.

10:39
Predicting the risk of cardiac adverse events in the post myocardial infarction setting
Nikolaos Pappas (Capemed, Greece); Dimitrios Gatsios (COO of Capemed EE, Greece); George Rigas (Capemed, Greeece)

I. INTRODUCTION Patients with Coronary Heart Disease (CHD), despite being treated consistently with current guidelines, are still at higher risk of experiencing intermittent major adverse cardiac events (MACE). Personalized management of patients during follow-up, especially in the post myocardial infraction setting, by taking into consideration their risk profiles, is of paramount importance for secondary prevention. Risk stratification models developed with machine learning can be used for such risk profiling and prognostication. II. METHODS A. Dataset To build these risk models we used the SERGAS dataset which consists of 1379 patients (6.6% women, age 65.78±11.02 years). These patients were admitted to the Hospital Clínico Universitario de Santiago de Compostela, with diagnosis of myocardial infarction with ST segment elevation (STEMI), myocardial infarction with no ST segment elevation (NSTEMI), unstable angina, percutaneous coronary intervention (PCI), evolved angina or coronary artery bypass grafting (CABG) and who have participated in an outpatient exercise based Cardiac Rehabilitation Program (CR) from 2015 to 2020. Patients are followed mainly in three time periods; at beginning of CR (first visit), at end of CR (end visit) and 6 months after discharge from the CR program (6 month follow-up). Major health events were registered until September of 2021. B. Machine learning pipeline We preprocessed and cleaned the dataset. We did not impute the missing values, to exploit any meaningful missingness and not introduce any

bias. We used a genetic algorithm for feature selection, because it is a global search method. We tried several ML classifiers (Neural Networks, Random Forests, Ada Boost, Logistic Regression, SVM, Gradient Boosting Trees). The only one that was able to handle missing values and had high discriminatory ability in these data was the LighGBM implementation of the Gradient Boosting Trees. We calibrated the probabilities of the model with logistic regression. We used the SHAP library [5] to produce explainability graphs. III. RESULTS We used the ROC-AUC, sensitivity, specificity scores to evaluate the models. To compute sensitivity and specificity we used the threshold that would give us the most balanced scores. We used 200 repeats of 4-fold cross validation because of the limited number of events and used these results to compute the 95% confidence intervals. IV. DISCUSSION The developed models, after additional validation in independent datasets, can become useful and efficient decision support tools for the clinicians. Specifically, the risk models can be applied in the post MI setting for STEMI and NSTEMI patients in order to predict the risk of MACE: i) right after the intervention when recurring events are mainly caused by the prior CHD status and the intervention itself; ii) during the CR program; iii) at the end of CR.

10:51

Identification of unstable carotid plaques associated with symptoms using ultrasonic plaque image and motion analysis - AtheroRisk

Efthyvoulos Kyriacou (Cyprus University of Technology, Cyprus); Constantinos Pattichis (University of Cyprus, Cyprus); Andrew Nicolaides (Vascular Screening and Diagnostic Centre, London, United Kingdom (Great Britain)); Christos P Loizou (Cyprus Univesrity of Technology & Electrical Enginerering Departement, Cyprus); Marios Pattichis (University of New Mexico, USA); Nicoletta Prentzas (University of Cyprus, Cyprus); Georgia Liapi (Cyprus University of Technology, Cyprus); Andreas S. Panayides (CYENS Centre of Excellence, Cyprus & 3AE Health LTD, Cyprus)

At present, there is no established set of ultrasonic features that can identify all the potentially unstable and high risk atherosclerotic carotid plaques in asymptomatic patients. The degree of stenosis is still the main criterion used to decide whether carotid endarterectomy is needed, but it has now been shown to be inaccurate. The overall objective of the AtheroRisk proposal is to develop an integrated intelligent software system for the identification of unstable carotid plaques associated with stroke by combining different clinical and imaging based features on the analysis of motion and morphology as well as raw pixel intensities of the ultrasound video and plaque images in asymptomatic patients with moderate to severe stenosis. The ultimate aim is to develop a method that can be used for stroke risk stratification. In addition to the degree of stenosis, the proposed system will rely on the development and integration of the following individual predictive approaches for the identification of symptomatic plaques: A Ultrasound video analysis model differentiating between concordant (potentially stable, safe) and discordant (potentially unstable, leading to stroke) plaque motion. B Adaptive multi-scale Amplitude Modulation-Frequency Modulation (AM FM) texture analysis system classifying (predicting) plaques associated with stroke based image characteristics. C Additional texture features such as Gray Scale Median (GSM), presence of a juxtaluminal black area without a visible echogenic cap (JBA), plaque area and presence of discrete white areas in an echolucent plaque, recently shown to be associated with unstable plaques. D New deep learning architectures and enhanced transfer-learning models relying on convolutional neural networks (CNNs), leveraging knowledge from (a) to (c). E Explainable AI: a novel approach to machine learning that integrates sub-symbolic methods with logical methods or argumentation to provide explainable solutions to learning problems.

11:03

Carotid Ultrasound Boundary Study (CUBS): findings and take-home messages

Kristen M Meiburger, Francesco Marzola and Filippo Molinari (Politecnico di Torino, Italy)

In this Special Session presentation, two recent multi-center studies focusing on the clinical and technical implications of computerized carotid ultrasound boundary segmentation (CUBS) methods for intima-media thickness measurement from B-mode longitudinal ultrasound images will be presented. The main findings and take-home messages of both studies will be discussed, and focus will be put on where this field of research is heading in the future. The two CUBS studies present important first-of-its-kind analyses on both a clinical and technical level for CIMT measurement systems, using the same large database and numerous different computerized methods and a standardized statistical analysis. The studies showed how computerized methods can be used instead of a skilled analyst's manual segmentation for CCA segmentation, CIMT quantification, and clinical outcome investigation. Computerized methods have the advantage of a favorable time-efficiency, full reproducibility, and being easily standardizable. Crucial technical considerations were given and the importance of standardizing computerized CIMT measurements was underlined. The inclusion of in-silico data with a known a-priori ground truth is analyzed, showing this important aspect particularly when considering deep learning-based methods. Finally, the entire databases of both studies have been made publicly available, as the intention of the two CUBS studies was to facilitate future studies by different research groups by providing a large, annotated data set, encouraging an open comparison and technical analysis.

11:15
Atherosclerosis Progression in the Carotid Artery - Coupled Agent Based with Finite Element Method
Nenad Filipovic and Smiljana Tomasevic (University of Kragujevac, Serbia); Andjela Blagojevic (Faculty of Engineering, University of Kragujevac & Bioengineering Research and Development Center, Serbia); Branko Arsic (Faculty of Science, University of Kragujevac, Serbia); Milos Anic (Faculty of Engineering, University of Kragujevac, Serbia); Tijana Djukic (Institute for Information Technologies, University of Kragujevac, Serbia)

The plaque progression model in the carotid artery with coupled Agent Based Method (ABM) and Finite Element Method (FEM) has been presented. The ABM was coupled with shear stress and LDL initial distribution from the lumen. Iterative calculation inside the wall for lipid infiltration and accumulation using a random number generator for each time step has been used. The wall artery geometry has been changed which is modeled with FEM where agents from ABM are positioned inside these large finite elements. The ABM was coupled with an initial WSS profile, which triggers a pathologic vascular remodeling by perturbing the baseline cellular activity and favoring lipid infiltration and accumulation within the arterial wall. The ABM model takes shear stress and LDL initial distribution from the lumen and starts iterative calculation inside the wall for lipid infiltration and accumulation using a random number generator for each time step. The results are validated for plaque progression for specific patients from baseline to 6 months. The plaque progression model including the separation of plaque components for the patient dataset from project TAXINOMISIS. The fibrous plaque is colored in yellow, the lipid plaque is colored in blue and the calcified plaque is colored in green.

11:27
Discussion

10:15 – 11:45
Virtual Session # 3 Machine learning, deep learning and decision support
Chair: Jessilyn Dunn, Duke University, USA; **Edward Sazonov,** Univ of Alabama, USA
Room: PANDORA C'

10:15
Video2IMU: Realistic IMU features and signals from videos
Arttu Lämsä, Jaakko Tervonen and Jussi Liikka (VTT Technical Research Centre of Finland, Finland); Constantino Alvarez Casado (University of Oulu, Finland); Miguel Bordallo Lopez (University of Oulu, Finland & VTT Technical Research Centre of Finland Ltd., Finland)

Human Activity Recognition (HAR) from wearable sensor data identifies movements or activities in unconstrained environments. Due to its relatively accurate performance and high utility, HAR has found its way into several consumer products for noncritical use cases. These products, equipped with inertial motion unit (IMU) sensors, include mobile devices and wearable devices such as smart watches and wristbands. HAR is a challenging problem as it presents great variability across subjects. Obtaining large amounts of labelled data is not straightforward, since wearable sensor signals are not easy to label upon simple human inspection. In our work, we propose the use of neural networks for the generation of realistic signals and features using human activity monocular videos. We show how these generated features and signals can be utilized, instead of their real counterparts, to train HAR models that can recognize activities using signals obtained with wearable sensors. To prove the validity of our methods, we perform experiments on an activity recognition dataset created for the improvement of industrial work safety. We show that our model is able to realistically generate virtual sensor signals and features usable to train a HAR classifier with comparable performance as the one trained using real sensor data. Our results enable the use of available, labelled video data for training HAR models to classify signals from wearable sensors.

10:27
Multimodality Multi-Lead ECG Arrhythmia Classification using Self-Supervised Learning
Thinh Tran Dac Phan (Chonnam National University, USA); Minh Duc Le (University of Arkansas, USA); Patel Brijesh and Don Adjeroh (West Virginia University, USA); Jingxian Wu, Morten Jensen and Ngan Le (University of Arkansas, USA)

Electrocardiogram (ECG) signal is one of the most effective sources of information mainly employed for the diagnosis and prediction of cardiovascular diseases (CVDs) connected with the abnormalities in heart rhythm. Clearly, single modality ECG (i.e., time series) cannot convey its complete characteristics, thus, exploiting both time and time-frequency modalities in the form of time-series data and spectrogram is needed. Despite the impressive ECG classification performance by the recent development of Deep Neural Networks (DNNs), shortage of annotated clinical data could impede the robustness and generalizability of the DNNs models, which are trained in a supervised learning manner. Leveraging the cutting-edge self-supervised learning (SSL) technique on unlabeled data, we propose SSL-based multimodality ECG classification. Our proposed network follows SSL learning paradigm and consists of two modules corresponding to pre-stream task, and down-stream task, respectively. In the SSL-pre-stream task, we utilize self-knowledge distillation (KD) techniques with no labeled data, on various transformations and in both time and frequency domains. In the down-stream task, which is trained on

labeled data, we propose a gate fusion mechanism to fuse information from multimodality. To evaluate the effectiveness of our approach, ten-fold cross validation on the 12-lead PhysioNet 2020 dataset has been conducted. Source code will be made publicly available, upon paper publication.

10:39

Interpretability with relevance aggregation in neural networks for absenteeism prediction

Júlio Gomes Junior (Universidade Tecnológica Federal do Paraná, Brazil); Fabrício Martins Lopes (Universidade Tecnológica Federal do Paraná & UTFPR, Brazil)

The lack of attendance of employees is called absenteeism and occurs for various reasons, such as vigorous physical activity, advanced age and high psychological demands of the work. The absenteeism affects the direct and indirect costs of the companies, and may reach 15% of the payroll. Therefore, it is fundamental to know its main causes and contribute to control and mitigation strategies. Neural networks have been successfully applied in the classification of several problems, but they are black boxes, because they do not explain which aspects are considered in their decisions. This aspect is very important in health applications, in which it is necessary to explain and clearly interpret the results. In this context, this work presents an approach to classify absenteeism through neural networks and Layer-wise relevance propagation (LRP) aggregation in order to identify the most relevant features and to assign relevance scores individually per class and among all classes. The proposed approach was assessed by considering a dataset widely used as a benchmark and compared to the existing literature methods. The proposed approach presented the highest assertiveness rates among the compared methods, reaching an average accuracy of 0.83, identifying the most relevant features for the classification of absenteeism through a relevance score. Therefore, the results allow the interpretability of the causes of each class of absenteeism, which contribute to the management of human resources, occupational medicine and the development of strategies for its mitigation.

10:51

Deep Learning based Automated Screening for Intracranial Hemorrhages and GRAD-CAM Visualizations on Non-Contrast Head Computed Tomography Volumes

Pon Deepika P (International Institute of Information Technology Bangalore, India); Prasad Sistla (CARE Foundation, India); Ganesh Subramaniam (Niyodaya Foundation, India); Madhav Rao (International Institute of Information Technology - Bangalore, India)

Intracranial Hemorrhage is a serious medical emergency which requires immediate medical attention. With most of the countries facing acute shortage of radiologists, it is important to develop an automated system which analyses the radiographic images and prioritize cases that require urgent medical attention. In this context, there has been attempts to apply deep learning (DL) techniques to the Head Computed Tomography (CT) slices to detect hemorrhage adequately in the past, where annotation effort is spent for individual slices of the CT volume for building a model. Our work aims to develop a robust model for the annotated CT volume dataset, which does not require slice level information for the presence of hemorrhage so that the annotation effort could be cut down substantially. A novel DL pipeline architecture based on the combination of convolutional neural network (CNN) and bi-directional long-short-term-memory (biLSTM) to capture both intra and inter slice level features for diagnosing hemorrhage from the non- contrast head CT volumes is introduced. The proposed model achieved a high accuracy score of 98.15%, specificity of 1, sensitivity of 0.96 and F1 score of 0.98 with 95.3% mitigation in the labelling effort of radiologists. However the performance scores are very well comparable to the scores achieved by the state-of-the-art models trained over the CT Volumes with slice wise annotation pertaining to intracranial hemorrhage detection. Additionally, the novel contribution is in integrating Gradient- weighted Class Activation Mapping (GRAD-CAM) visualization to the system, to offer visual explanations for the decisions made and provide supplementary information forming a strong advocate to radiologists in the clinical evaluation stage. The novel system is a first step towards building a robust autonomous assistive technology for radiologists, and leads to develop similar pipelined DL architecture for extracting information pertaining to other neurological disorders from Non-Contrast Head CT volumes. Clinical relevance- Radiologists supplemented with artificial intelligence (AI) and GRAD-CAM visualizations can make diagnosis and decision making efficient and error-free. AI can easily raise flag on abnormalities that are not abruptly visible to the human eye and on the subjects who require immediate medical attention.

11:03

A Random Survival Forest-based Fracture Risk Prediction Model for CKD Patients With Anemia

Yangfan Chai (National Institute of Health Data Science, Peking Unviersity, China); Guilan Kong (National Institute of Health Data Science, Peking University, China); Luxia Zhang (National Institute of Health Data Science, Peking Unviersity, China); Huaiyu Wang (National Institute of Health Data Science, Peking University, China); Pu Yufan (Peking university, China)

Chronic kidney disease (CKD) patients with anemia have a high fracture risk, and it may accelerate the progression of CKD. Therefore, it is important to identify the renal anemia patients with high fracture risk at early time and provide appropriate interventions to prevent fracture. In this study, the electronic health record (EHR) data collected by the Regional Health

Information System (RHIS) in Yinzhou (China) was used as data source, and all patients diagnosed as CKD with anemia between 2009 and 2014 were extracted for analysis. In model development, we split the longitudinal real-world EHR dataset into training and test datasets by a time point, employed both the random survival forest (RSF) and traditional Cox regression methods and used the Harrell's concordance index (C-index) and Brier score (BS) as performance measures to compare the RSF model with the traditional Cox regression model. In total, 9516 CKD patients with anemia were identified in the RHIS between 2009 and 2014. And among them, 6647 (759 patients experienced fracture) patients were used for model training, while 2869 (275 experienced fracture) were used for model test. Finally, we found that the RSF-based fracture risk prediction model had better prediction performance with a C-index of 0.65 and BS of 0.124. This study shows that the RSF-based prediction model has potentials to aid physicians to identify high fracture risk ones among CKD patients with anemia, and thus may help deliver optimal clinical interventions.

11:15
Stress Assessment using Real-time Electrocardiogram and Socio-demographic Factors with Boosting methods
Yufeng Zhang, Kira Birditt, Shuyang Cheng, Jonathan Gryak and Kayvan Najarian (University of Michigan, USA)

Psychological stress adversely impacts personal health and results in significant economic and societal burdens. In addition, stress has a disparate impact on socially disadvantaged groups, particularly African Americans. Therefore, determining the relationship between race and stress is essential and urgent for reducing disparate impacts and improving overall population health. Our study combined the features of cardiovascular activity and socio-demographics to detect the patient's stress status. The waveform features were extracted from the ECG raw recordings and then combined with the socio-demographic features by patient ID. These two types of features were used as input for final stress prediction. The model structure we used is Catboost, one of the boosting methods. The Catboost model was trained and evaluated using a patient-wise ten-fold cross-validation approach, with the mean Area Under the Curve (AUC) reaching 0.722 and the standard deviation at 0.08, outperforming all the other gradient-boosting or non-gradient boosting machine-learning methods. Furthermore, the post-hoc explanation tool, Shapley Additive exPlanations (SHAP), was applied to interpret every feature's contribution to the outcome classification. SHAP revealed that the race and waveform features extracted from ECG signals are significant risk factors in predicting stress status, while other social factors such as education can moderate racial health disparities.

11:27
Machine Learning Estimation of Hypertension Diagnosis: a Critical Perspective
Sara Montagna and Stefano Ferretti (University of Urbino, Italy); Claudio Borghi (University of Bologna, Italy); Claudio Ferri (University of L Aquila, Italy); Maria Lorenza Muiesan (University of Brescia, Italy); Guido Grassi (University of Milano Bicocca, Italy); Martino Pengo (Istituto Auxologico Italiano IRCCS, Italy); Gianfranco Parati (Istituto Auxologico Italiano IRCCS, Italy & School of Medicine and Surgery University of Milano-Bicocca, Italy)

Many modifiable and non-modifiable risk factors have been associated with hypertension. However, current screening programs are still failing in diagnosing appropriately hypertension. Therefore, there is an urgent need to find new strategies to improve hypertension diagnosis identifying specific phenotypes of patients to be screened systematically. In this paper we propose the adoption of five supervised machine learning algorithms - logistic regression, decision tree, random forest, support vector machine and XGBoost - to predict individual's risk of developing hypertension. We analysed a large dataset generated from questionnaires administered in Italy during the World Hypertension Day from 2015 to 2019. Variables acquired include demographic (sex, age), anthropometric (body mass index) and clinical (past medical history, symptoms) data, general knowledge and awareness on hypertension, blood pressure measurements. A total of 20206 subjects have been included for analysis. Results show that XGBoost provides the best scores, with a sensitivity of 0.701, a specificity of 0.601, an accuracy of 0.629 and the AUC of 0.710, but also draw our attention to limitations in techniques and quality of data that require further evaluation. Nevertheless, diagnosis of hypertension still remains challenging and a machine learning approach could help in making screening programmes more precise and cost effective.

11:39
Discussion

11:45 – 13:15
BSN Session # 2 Developing Novel Body-Worn Sensors
Chair: Maximilian Reiser, HAW Landshut, Germany; **Rita Paradiso,** Smartex s.r.l., Italy
Room: POLYMNIA

11:45
Additively Manufactured Dry Electrodes for Biosignal Measurements
Gerrit Bücken, Thomas Friedrich and Roman Kusche (Fraunhofer IMTE, Germany)

The acquisition of electrophysiological signals, such as electrocardiography or electromyography, is an integral part of medical diagnostics and therapy. In the clinical environment, these signals are typically recorded using adhesive gel electrodes which have particularly good electrical characteristics. Outside this environment, however, these electrodes are not practical, since they have to be placed manually and can only be used once. Instead, the use of dry electrodes can be beneficial, especially in complex systems such as wearables or prostheses. Unfortunately, these electrodes are not widely commercially available and their electrical characteristics are hardly documented. One major challenge is the occurring high interface impedance between the electrode and the skin. In this study, dry electrodes with different contact surfaces made of conductive polylactide acid are designed, additively manufactured and the corresponding electrode-skin impedances are examined on human subjects. The influences of different electrode radii as well as surface structures on the electrode-skin interface impedance are compared with each other. The result of the investigation is that the impedance decreases as the contact area increases, which corresponds to the electrical equivalent circuit. However, the chosen structuring of the surface has a negative impact on the impedance, although the effective electrode surface was expected to be increased. this environment, however, these electrodes are not practical, since they have to be placed manually and can only be used once. Instead, the use of dry electrodes can be beneficial, especially in complex systems such as wearables or prostheses. Unfortunately, these electrodes are not widely commercially available and their electrical characteristics are hardly documented. In this study, dry electrodes with different contact surfaces made of conductive polylactide are designed, additively manufactured and the corresponding electrode-skin impedances are examined. The influences of different electrode radii as well as surface structures on the electrode-skin interface impedance are compared with each other. The result of the investigation is that the impedance decreases as the contact area increases. However, the chosen structuring of the surface has a negative impact on the impedance, although the effective electrode surface was expected to be increased.

11:55

Non-contact temporalis muscle monitoring to detect eating in free-living using smart eyeglasses

Addythia Saphala, Rui Zhang and Thái Nam Trịnh (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Oliver Amft (Friedrich-Alexander Universität (FAU) Erlangen-Nürnberg, Germany)

We investigate non-contact sensing of temporalis muscle contraction in smart eyeglasses frames to detect eating activity. Our approach is based on infra-red proximity sensors that were integrated into sleek eyeglasses frame temples. The proximity sensors capture distance variations between frame temple and skin at the frontal, hair-free section of the temporal head region. To analyse distance variations during chewing and other activities, we initially perform an in-lab study, where proximity signals and Electromyography (EMG) readings were simultaneously recorded while eating foods with varying texture and hardness. Subsequently, we performed a free-living study with 15 participants wearing integrated, fully functional 3D-printed eyeglasses frames, including proximity sensors, processing, storage, and battery, for an average recording duration of 8.3 hours per participant. We propose a new chewing sequence and eating event detection method to process proximity signals. Free-living retrieval performance ranged between the precision of 0.83 and 0.68, and recall of 0.93 and 0.90, for personalised and general detection models, respectively. We conclude that non-contact proximity-based estimation of chewing sequences and eating integrated into eyeglasses frames is a highly promising tool for automated dietary monitoring. While personalised models can improve performance, already general models can be practically useful to minimise manual food journalling.

12:05

Simulation framework for reflective PPG signal analysis depending on sensor placement and wavelength

Maximilian Reiser (HAW Landshut & FAU Erlangen-Nürnberg, Germany); Andreas Breidenassel (HAW Landshut); Oliver Amft (FAU Erlangen-Nürnberg)

We analyse the influence of reflective photoplethysmography (PPG) sensor positioning relative to blood vessels. A voxel based Monte Carlo simulation framework was developed and validated to simulate photon-tissue interactions. An anatomical model comprising a multi-layer skin description with a blood vessel is presented to simulate PPG sensor positioning at the volar wrist. The simulation framework was validated against standard test cases reported in the literature. The blood vessel was considered in regular and dilated states. Simulations were performed with 10^8 photon packets for each condition, including wavelength, relative position of PPG sensor and vessel, and vessel dilation state. Statistical weights were associated to photon packets to represent absorption and scattering effects. A symmetrical arrangement of the PPG sensor around the blood vessel showed the maximum AC signal. PPG sensor displacement from the centered position deteriorated the signal by >= 4% at 660 nm and >= 5% at 940 nm. With more than 99% of light absorption, blood had the most profound effect on signal quality. The mean penetration depth is dependent on the blood vessel position for both wavelengths. Our simulation results demonstrate the susceptibility of reflective PPG measurement to interference and could explain wearable PPG sensor performance variations related to positioning and wavelength.

12:15

Wearable Vital Signal Monitoring Prototype Based on Capacitive Body Channel Communication

Qi Huang and Waseem Alkhayer (King Abdullah University of Science and Technology, Saudi Arabia); Mohammed E. Fouda (University of California-Irvine, USA); Abdulkadir Celik (King Abdullah University of Science & Technology, Saudi Arabia); Ahmed M. Eltawil (King Abdullah University of Science and Technology, Saudi Arabia)

Wireless body area network (WBAN) provides a means for seamless individual health monitoring without imposing restrictive limitations on normal daily routines. To date, Radio Frequency (RF) transceivers have been the technology of choice, however, drawbacks such as vulnerability to body shadowing effects, higher power consumption due to omnidirectional radiation and security concerns, have prompted the adoption of transceivers that use the human body channel for communication. In this paper, a vital signal monitoring transceiver prototype based on the human body channel communication (HBC), using commercially available chipsets is presented. RF and HBC communications are briefly reviewed and compared, and different schemes of HBC are introduced. A circuit model that represents the human body channel is then discussed and simulations are presented to illustrate the influence of the return path capacitance and receiver terminations on the path loss. The architecture of the transceiver prototype is then introduced where it is designed at a 21 MHz IEEE 802.15.6 standard-compliant carrier frequency. Finally, the performance of the transceiver, including the bit error rate (BER) and power efficiency, are characterized. Path loss is measured for two different scenarios, where variations of up to 5 dB were observed due to environmental effects. Energy efficiency measured at a maximum data-rate of 1.3 Mbps was found to be 8.3 nJ/b.

12:25

Range of Motion Sensors for Monitoring Recovery of Total Knee Arthroplasty

Minh Q Cao, Brett Bailey, Wenhao Zhang, Solana Fernandez, Aaron Han, Smiti Narayanan, Shrineel Patel, Steven Saletta, Alexandra Stavrakis, Stephen Speicher and Stephanie Seidlits (University of California, Los Angeles, USA); Arash Naeim (UCLA, USA); Ramin Ramezani (University of California Los Angeles, USA)

A low-cost, accurate device to measure and record knee range of motion (ROM) is of the essential need to improve confidence in at-home rehabilitation. It is to reduce hospital stay duration and overall medical cost after Total Knee Arthroplasty (TKA) procedures. The shift in Medicare funding from pay-as-you-go to the Bundled Payments for Care Improvement (BPCI) has created a push towards at-home care over extended hospital stays. It has heavily affected TKA patients, who typically undergo physical therapy at the clinic after the procedure to ensure full recovery of ROM. In this paper, we use accelerometers to create a ROM sensor that can be integrated into the post-operative surgical dressing, so that the cost of the sensors can be included in the bundled payments. In this paper, we demonstrate the efficacy of our method in comparison to the baseline computer vision method. Our results suggest that calculating angular displacement from accelerometer sensors demonstrates accurate ROM recordings under both stationary and walking conditions. The device would keep track of angle measurements and alert the patient when certain angle thresholds have been crossed, allowing patients to recover safely at home instead of going to multiple physical therapy sessions. The affordability of our sensor makes it more accessible to patients in need.

12:35

Windows to the Sole: Prototyping Soft Sensors for Wearable Ballistocardiography

Torjus L Steffensen, Simon Gjerde, Håvard Vestad and Martin Steinert (Norwegian University of Science and Technology, Norway)

Continuous measurement of cardiovascular parameters is important for monitoring cardiovascular health. Ballistocardiography is a noninvasive method of recording cardiovascular events. Here, we present a sensor system prototype for recording of the full-body ballistocardiogram in a wearable. An array of soft bladders in each sole are filled with water and connected to barometric pressure sensors. We demonstrate the use of the prototype to estimate the pulse transit time against continuous blood pressure in a validation experiment (n=14). Participants wore the sensor shoes while standing on a reference weight-scale. Simultaneous recordings were taken of the sole pressure arrays, finger-clip photoplethysmography, and continuous blood pressure via the volume-clamp method. Measurements were taken at rest, during cold-pressor intervention for 60 seconds, and 3 minutes following end of intervention. The waveform of the ballistocardiograms captured by the proposed sensor system corresponded well to the simultaneously collected waveforms from the reference weight-scale. Preliminary results from pulse-transit time estimates show inverse correlation to vasoconstriction-induced blood pressure increase, demonstrating the viability of the measurement. By demonstrating the use of the wearable system to compute a hemodynamic variable of interest to cardiovascular disease monitoring, we show the promise of shoes as a viable wearable sensor interface for cardiovascular monitoring.

12:45

Wireless Intra-Body Power Transfer via Capacitively Coupled Link

Noor Mohammed, Robert W Jackson and Jeremy Gummeson (University of Massachusetts Amherst, USA); Sunghoon Ivan Lee (University of Massachusetts, USA)

Over the past couple of years, the Capacitive Intra-Body Power Transfer (C-IBPT) technology, which uses the human body as a wireless power transfer medium via capacitive links, has received tremendous attention in the field as a potential solution to support a network of battery-free body sensors. However, circuit modeling of C-IBPT systems, despite its importance to support reliable operation of battery-free body sensors, have been significantly understudied in the field. This paper proposes a circuit-coupled finite element model (FEM) to estimate path loss and ground coupling capacitance of a C-IBPT system. As a demonstrative example, the model approximates a typical human forearm (from wrist to elbow) and allows for investigation of the transmission loss between a skin coupled power transmitter and a receiver in the electro-quasistatic domain. The computed transmission loss from the proposed model is further validated against experimental measurements obtained from five healthy human subjects using a wearable 40 MHz radio frequency (RF) transmitter and an isolated power receiver system in a laboratory environment. The preliminary experimental data show an approximate 40 dB transmission loss within 10 cm body channel length for the parallel plate electrode configuration with dimensions of 30 mm x 40 mm. The simulation finding also shows a lower gain of -35 dB and 13.5 fF ground coupling capacitance across a 10 cm body channel.

12:55

Prototype smartwatch device for prolonged physiological monitoring in remote environments

Bruno Miguel Gil Rosa (Hamlyn Centre & Imperial College London, United Kingdom (Great Britain)); Benny Lo (Imperial College, United Kingdom (Great Britain)); Eric Yeatman (Imperial College London, United Kingdom (Great Britain))

Wearable technology in the form of wristwatches, armbands, or fit monitors has fast widespread lately among technology enthusiasts that are eager for a quick hands-on experience with their own body parameters. Nonetheless, the accuracy, replicability and reproducibility of the measurements collected by these monitors is still highly debatable outside laboratory settings, thus resulting in their nonacceptance as valid medical diagnostic tools. Furthermore, the inability to collect temporally detailed physiological variables like heartrate, pulse plethysmography, skin temperature and galvanic skin response for extended periods of time has also been appointed as a factor contributing to wearables' nonacceptance within the biomedical research community. Even more so if the monitoring is to be performed in remote places, usually involving prolonged and arduous physical tasks performed by the participant. In this paper, we propose an inexpensive prototype smartwatch for prolonged physiological monitoring in remote environments. Equipped with sensing channels that monitor the aforementioned body variables, the device can also be instructed to operate in an asynchronous recording mode, thereby saving battery life and memory while recording some ambient variables (humidity, temperature, luminescence, and atmospheric pressure) in order to provide descriptive context awareness to the physiological processes taking place inside the human body at the same time

1**3:05**

Prototype of Optoelectronic Joint Sensor Using Curvature Based Reflector for Body Shape Sensing

Dalia Osman (Brunel University London, United Kingdom (Great Britain)); Wanlin Li (Institute for General Artificial Intelligence (BIGAI), Beijing, China); Xinli Du, Timothy Minton and Yohan Noh (Brunel University London, United Kingdom (Great Britain))

Wearable technology for monitoring the orientations, shapes, and motion patterns of human joints has emerged in health applications for robotic prosthesis, exosuits, gait analysis, physical therapy and rehabilitation, as well as areas such as

gaming and virtual reality. Wearable sensors for rehabilitation, prosthetics and robotics must be lightweight, miniature, and compact to allow comfortable range of motion without obstruction, and therefore, the integrated network of sensors and hardware must be adapted to this. This paper demonstrates a working prototype for shape sensing using miniature optoelectronic sensors integrated into a chain of rotational links. The sensing principle is based on light intensity modulation using a curvature varying reflector offers a low-cost, miniature modular design sensing configuration compatible for shape sensing in clinical applications. Intensity model is mathematically described. A prototype is constructed using the varying curvature reflector based on previously tested parameters, and calibration is carried out using a servo-motor experimental rig. Shape sensing estimation is evaluated to assess accuracy. A four-link rotational chain prototype shows average estimation errors of 2.4° for shape sensing compared to inertial measurement unit. The sensor features low power consumption, and does not exhibit signal disturbance due to magnetic, material, or electrical interference from other devices. The optics-based method ensures fast sampling rate, and the sensor cost is low, resulting in reduced cost of fabrication.

11:45 – 13:15
Special Session: European Alliance of Medical and Biological Engineering Society Fellows Class of 2022
Chair: Françoise Peyrin, University of Lyon, France; **Jari Hyttinen,** University of Technology, Tampere, Finland
Room: KLEIO

11:45
European Alliance of Medical and Biological Engineering Society
Françoise Peyrin
University of Lyon, France; Jari Hyttinen*, University of Technology, Tampere, Finland*

12:00
Using sound to hear, image, and treat cardiovascular function
Spyretta Golemati
Medical School, National and Kapodistrian University of Athens, Greece

12:25
Large-scale Biomedical Video Analysis for Computer Aided Diagnosis
Marios S. Pattichis
Department of Electrical and Computer Engineering, University of New Mexico, USA

12:50
The future of digital health
Dimitrios Koutsouris
Biomedical Engineering Laboratory, School of Electrical and Computer Engineering, National Technical University of Athens, Greece

11:45 – 13:15
Virtual Session # 4 Biomedical Modeling and Sensor Informatics
Chair: Leandro Pecchia, Universitá Campus Biomedico di Roma, Italy**; Dimitrios Koutsouris,** National Technical University of Athens, Greece
Room: PANDORA C'

11:45
Finite Element Modelling of a Pressure Ulcers Preventive Bed for Neonates
Adarsha Narayan Mallick (S S BHATNAGAR BLOCK, India & IIT ROPAR, India); Mukesh Kumar (IIT, ROPAR, India); Kamaldeep Arora (Dayanand Medical College & Hospital, Ludhiana, Punjab, India); Ashish Kumar Sahani (Indian Institute of Technology Ropar, India)

The continual pressure on a skin surface can hamper blood supply from the subcutaneous regions. Blockage of blood supply is the primary reason for the development of Pressure Ulcers (PUs) in patients admitted to hospitals with impaired mobility. The dermal layer of a preterm neonate is less than 60% of the thickness of an adult and has a much higher susceptibility to developing pressure ulcers. In Neonatal Intensive Care Units (NICUs), babies lie down immobile for long hours in fixed positions. Hence, there is a 23% prevalence of PUs in NICUs worldwide. Therefore, it is advised that nursing staff should ensure frequent posture changes to avoid the development of PUs. This leads to an increased workload on them. We designed a Finite Element Modelling (FEM) of a neonatal anti-PU bed made from elastic material with alternating pressure channels and carried out simulations in ABAQUS CAE to validate this problem. We first simulated a neonatal phantom made from hyper-elastic material and laid it down on a flatbed. The pressure on the skin was taken as the baseline. We found that by activating alternating channels, the pressure increases in inflated regions and decreases in deflated

regions compared to the baseline. As the inflation and deflation channels will be alternating, no long-term high-pressure points will be formed under the skin.

11:57
Joint Angle Measurements Using Magnetic Sensing: A Feasibility Study
Fereshteh Shahmiri, Nordine Sebkhi, Arpan Bhavsar, Keith W. Edwards and Omer T Inan (Georgia Institute of Technology, USA)

Inertial measurement units (IMUs) are extensively used for body motion tracking applications. Despite their ubiquity, they often suffer from sensor drift over time, and environmental disturbances. Additionally, their use cases are mostly limited to applications with slowly varying accelerations and low-dynamic motions.
Sensor fusion algorithms are used for scenarios where more dynamic, faster motions are encountered. However, such algorithms often come with high computational costs. In this work, we present a low drift, computationally-efficient motion tracking system that suppresses ambient magnetic noise and is applicable to various motion dynamics. We augmented inertial sensors with localized magnets, and implemented a localization algorithm that takes in the magnetic measurements and outputs the sensor positions as the sensors move in the vicinity of the magnets.
For applications with movements around a central joint, we extended our position tracking to a joint angle measurement platform.
We conducted two preliminary studies to evaluate our system performance, and validated our system against a computer vision system. Our first study uses a goniometric setup to evaluate drift-reductions in angle estimates. Our method is compared against a commonly-used IMU-based method. We collected 60 minutes of data from 4 study sessions, with both static conditions and various dynamic motions. The motions had angular velocities ranging from 0 to 47 degree per second. Results show the average root mean square error (RMSE) of 1 degree for static and 2.7 degree for dynamic motions. In the second study, an on-body setup monitors the knee flexions and extensions performed by a pilot user. We collected 30 minutes of data from 4 study sessions. Our system reports the average RMSE of 3.7 degree for dynamic motions with an average angular velocity of 17 degree per second. Based on these promising results, in future work we will extend our user studies to a greater number of users to evaluate the generalizability.

12:09
SmartAct: Energy Efficient and Real-Time Hand-to-Mouth Gesture Detection Using Wearable RGB-T
Soroush Shahi, Mahdi Pedram, Glenn Fernandes and Nabil Alshurafa (Northwestern University, USA)

Researchers have been leveraging wearable cameras to both visually confirm and automatically detect individuals' eating habits. However, energy-intensive tasks such as continuously collecting and storing RGB images in memory, or running algorithms in real-time to automate detection of eating, greatly impacts battery life. Since eating moments are spread sparsely throughout the day, battery life can be mitigated by recording and processing data only when there is a high likelihood of eating. We present a framework comprising a golf-ball sized wearable device using a low-powered thermal sensor array and real-time activation algorithm that activates high-energy tasks when a hand-to-mouth gesture is confirmed by the thermal sensor array. The high-energy tasks tested are turning on the RGB camera (Trigger RGB mode) and running inference on an on-device machine learning model (Trigger ML mode). Our experimental setup involved the design of a wearable camera, 6 participants collecting 18 hours of data with and without eating, the implementation of a feeding gesture detection algorithm on-device, and measures of power saving using our activation method. Our activation algorithm demonstrates an average of at-least 31.5% increase in battery life time, with minimal drop of recall (5%) and without impacting the accuracy of detecting eating (a slight 4.1% increase in F1-Score).

12:21
Digital Twins of Patients for Personalized Care: A Synthetic Modelling Experiment
Nalika Ulapane (Swinburne University of Technology, Australia); Nilmini Wickramasinghe (Swinburne University, USA); Elliot B Sloane and Vijay Gehlot (Villanova University, USA)

The use of Digital Twins (DTs)-i.e., digital replicas of physical entities-in the healthcare context is an emerging area. As a proof-of-concept prior to working with real patients, we attempt in this paper to create and use DTs in a synthetic environment making use of data that is all computer-generated. DTs of synthetic present patients are created making use of data of synthetic past patients. The clinical objective is to enable enhanced real-time clinical decision support to enable more precise and personalized care. The possibilities and challenges of DTs in healthcare are envisaged and reported.

12:33
Automated Temporal Segmentation of Orofacial Assessment Videos
Saeid Alavi Naeini (University of Toronto, Canada); Leif Simmatis (University of Toronto & University Health Network, Canada); Deniz Jafari (University of Toronto, Canada); Diego Guarin (Florida Institute of Technology, USA); Yana Yunusova (University of Toronto, Canada); Babak Taati (University Health Network, Canada)

Computer vision techniques can help automate or partially automate clinical examination of orofacial impairments to provide accurate and objective assessments in clinical context. Towards the development of such automated systems, we evaluated two approaches to detect and temporally segment (parse) repetitions in orofacial assessment videos. Recorded videos of participants with amyotrophic lateral sclerosis (ALS) and healthy control (HC) individuals were obtained from the Toronto NeuroFace Dataset. Two approaches for repetition detection and parsing were examined: one based on engineered features from tracked facial landmarks and peak detection in the distance between the vermilion-cutaneous junction of the upper and lower lips (baseline analysis), and another using a pre trained transformer-based deep learning model called RepNet (Dwibedi et al, 2020), which automatically detects periodicity, and parses periodic and semi-periodic repetitions in video data. In experimental evaluation of two orofacial assessments tasks, repeating maximum mouth opening (OPEN) and repeating the sentence "Buy Bobby a Puppy" (BBP), RepNet provided better parsing than the landmark-based approach, quantified by higher mean intersection over union (IoU) with respect to ground truth manual parsing. Automated parsing using RepNet also clearly separated HC and ALS participants based on the duration of BBP repetitions, whereas the landmark-based method could not.

12:45
Concurrent Validity of Automatic Speech and Pause Measures During Passage Reading in ALS
Saeid Alavi Naeini (University of Toronto, Canada); Leif Simmatis (University of Toronto & University Health Network, Canada); Yana Yunusova (University of Toronto, Canada); Babak Taati (University Health Network, Canada)

The analysis of speech measures in individuals with amyotrophic lateral sclerosis (ALS) can provide essential information for early diagnosis and tracking disease progression. However, current methods for extracting speech and pause features are manual or semi-automatic, which makes them time consuming and labour intensive. The advent of speech-text alignment algorithms provides an opportunity for inexpensive, automated, and accurate analysis of speech measures in individuals with ALS. There is a need to validate speech and pause features calculated by these algorithms against current gold standard methods. In this study, we extracted 8 speech/pause features from 646 audio files of individuals with ALS and healthy controls performing passage reading. Two pretrained forced alignment models - one using transformers and another using a Gaussian mixture / hidden Markov architecture - were used for automatic feature extraction. The results were then validated against semi-automatic speech/pause analysis software, with further subgroup analyses based on audio quality and disease severity. Features extracted using transformer-based forced alignment had the highest agreement with gold standards, including in terms of audio quality and disease severity. This study lays the groundwork for future intelligent diagnostic support systems for clinicians, and for novel methods of tracking disease progression remotely from home.

12:57
COVID-19 Detection Exploiting Self-Supervised Learning Representations of Respiratory Sounds
Adria Mallol-Ragolta and Shuo Liu (Universität Augsburg, Germany); Bjoern Schuller (Universität Augsburg & Imperial College London, Germany)

In this work, we focus on the automatic detection of COVID-19 patients from the analysis of cough, breath, and speech samples. Our goal is to investigate the suitability of Self-Supervised Learning (SSL) representations extracted using Wav2Vec 2.0 for the task at hand. For this, in addition to the SSL representations, the models trained exploit the Low-Level Descriptors (LLD) of the eGeMAPS feature set, and Mel-spectrogram coefficients. The extracted representations are analysed using Convolutional Neural Networks (CNN) reinforced with contextual attention. Our experiments are performed using the data released as part of the Second Diagnosing COVID-19 using Acoustics (DiCOVA) Challenge, and we use the Area Under the Curve (AUC) as the evaluation metric. When using the CNNs without contextual attention, the multi-type model exploiting the SSL Wav2Vec 2.0 representations from the cough, breath, and speech sounds scores the highest AUC, 80.37 %. When reinforcing the embedded representations learnt with contextual attention, the AUC obtained using this same model slightly decreases to 80.01 %. The best performance on the test set is obtained with a multi-type model fusing the embedded representations extracted from the LLDs of the cough, breath, and speech samples and reinforced using contextual attention, scoring an AUC of 81.27 %.

13:09
Disccusion

13:15 – 14:15
Lunch
Room: PANDORA A’

13:15 – 14:15
European Health Data Space Panel
Chair: Christos N. Schizas, President of the Cyprus National eHealth Authority, Cyprus
Room: PANDORA A'

Yiannos Tolias
Legal Officer, European Commission's DG SANTE

Dimitris Koutsouris
Professor of Computer Engineering

Giuseppe Fico
Assistant Professor of Biomedical Engineering

Alexander Berler
Strategic Business Development Director at IHE Catalyst AISBL

14:15 – 15:00
Keynote Lecture
Chair: Constantinos Pattichis, BHI Chair (2021-2022), University of Cyprus, Cyprus
Room: ERATO

Building trustworthy AI systems with reliable components
Prof. Riccardo Bellazzi
University of Pavia, Italy

AI medical systems, designed to support diagnosis, therapy planning and monitoring, have a long history, but recently they received a renewed strong attention due to the advancements in machine and deep learning and to the large and increasing availability of digital data. The need of protecting citizens, providing them with safeguards against misuse of AI approaches, and in particular of data-driven technologies, has pushed towards the implementation of "trustworthy" AI systems, lawful, ethical and robust. This talk will discuss how components, based on reliability principles, may provide the basis for the design and implementation of successful AI solutions. Finally, the talk will advocate that only a proper socio-technical approach will eventually provide trustworthy systems.

15:00 – 16:30
Special Session: Towards the European Health Data Space: Challenges, Opportunities for Biomedical and Health Informatics
Chair: Giuseppe Fico, Universidad Politécnica de Madrid, Spain**; Francisco Lupiañez-Villanueva,** Open University of Catalunya, Spain
Room: POLYMNIA

15:00
Health Data and AI in medicine - Potentials and Challenges
Yiannos Tolias (European Commission, Belgium)

The abundance of health data combined with the advancements in digital Health (including AI) have created a great potential to transform healthcare. However, there is still a rather slow deployment of digital health including AI in clinical practice and patients do not yet fully reap the benefits of digital health including AI in healthcare. There are several factors to this rather slow deployment including the organization of health data, performance of AI systems, and the deployment of AI in real healthcare settings. The European Commission (EC) took a lead in addressing some of these challenges. It proposed a Regulation on AI (AI Act) in April 2021 concerning the development, deployment and use of AI systems. In May 2022, the EC proposed the European Health Data Space Regulation aiming to address issues concerning the collection, transfer and use of health data both for primary and secondary uses. Additionally, the EC aims to propose rules on liability governing new technologies including AI. This paper provides an overview of the published legislative initiatives and the correlations between them. It particularly focusses on challenges governing the deployment of AI systems in clinical settings, associated challenges and the human-AI collaboration in medicine. The views expressed are personal and do not necessarily represent the official position of the European Commission

15:12
Building New Generation of AI services for Chronic Disease on EHDS

Eleni Georga (University of Ioannina, Greece); Giuseppe Fico (Universidad Politécnica de Madrid, Spain); Jordi de Batlle (Group of Translational Research in Respiratory Medicine, Spain); Leandro Pecchia (Unicamps, USA); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

The GATEKEEPER large scale pilot (LSP) study, a federation of multicenter longitudinal cohort studies demonstrating the effectiveness and the cost-effectiveness of innovative KETs for the prevention of adverse events and the management of health in later life, generates unique real-world dynamic data trajectories predictive or reflective of one individual's health condition. GATEKEEPER LSP concentrates on the generation of high-quality health data, envisioning a significant contribution to the European Health Data Space (EHDS) and their secondary use for innovation and research. This multitude of data allowed us to define a rich medical research hypothesis base and formulate an equivalent number of AI/ML multivariate prediction problems. By adopting rigorous AI/ML-based model design, development and validation practices, we target at a high reproducibility of the results. By embracing guidelines for reporting (TRIPOD, TRIPOD-AI) and assessing the quality (PROBAST, PROBAST-AI) of AI/ML models, we also target at transparent unbiased outcomes. The integration of dynamic personal health record (PHR) data with electronic health record (EHR) data, transfuses dynamic/temporal characteristics to the AI/ML algorithms. The specification of the individual components of the AI/ML models development pipeline (multi-view AI/ML models, grade of explainability of the results) are driven by the intrinsic characteristics and complexity of each research problem, and the predefined modelling needs by medical experts. To this end, MLOps principles and rigorous ML testing methods are employed as a significant step towards the fluent integration of AI/ML-based software into medical decision support systems.

15:24
Biomedical and clinical engineering contribution in WHO response for COVID-19 pandemic
Leandro Pecchia (University of Warwick, United Kingdom (Great Britain))

The contribution of clinical and biomedical engineers during the COVID pandemic, in collaboration with practitioners and scholars from different disciplines, was unprecedented and paramount for Medical Devices (MDs) and Personal Protective Equipment (PPE). The collaboration among the global scientific society of biomedical and clinical engineering and the WHO has been constantly growing. This article aims to introduce the reader to the concepts of disaster preparedness, of the hierarchy of controls by the Centers of Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) applied to COVID-19, will report few reflections and use-cases on the innovations of medical devices and PPE for COVID-19, and finally share a series of reflections on the inadequacy of regulatory framework and international standards for medical devices and PPE. More biomedical and clinical engineering, as well as more innovation, is needed in the space of public-health, disaster preparedness and IPC. Yet, it is crucial to focus energies and effort towards real priorities as the ones stated recently by the WHO in the space of PPE. In order to achieve positive results, experts, policymakers, manufacturers, media and society have to cooperate in a new "social contract", where evidence is posed at the base for any responsible action. When responsible thinking and responsible actions are not possible due to the lack of knowledge, then a responsible silence is a solution too

15:36
Blockchain for Personalized Medicine Dataspaces: A conceptual design for Trusted Environments Supporting Patient-Centered Solutions
Maria Eugenia Beltran

15:48
In-Silico Modelling on to support patients with amyotrophic lateral sclerosis and multiple sclerosis and their clinicians
Maria Fernanda Cabrera
Universidad Politécnica de Madrid

16:00
Discussion

15:00 – 16:30
Special Session: Biomedical image and signal methods and applications for analysing human abnormal body responses
Chair: Fabrizio Pancaldi, University of Modena and Reggio Emilia, Italy; **Michalis Zervakis,** Technical University of Crete, Greece
Room: KLEIO

15:00
VECTOR: an algorithm supporting the diagnosis of interstitial lung diseases based on the analysis of lung sounds
Fabrizio Pancaldi (University of Modena and Reggio Emilia & Artificial Intelligence Research and Innovation Center, Italy); Marco Sebastiani (University of Modena and Reggio Emilia, Italy)

In this work we investigate the problem of automatic detection of velcro crackles, that represent a reliable and early marker of interstitial lung disease. In practice the patient is auscultated with a digital stethoscope and the acquired digital data are analyzed through a suitably developed software called VECTOR. Several retrospective clinical studies proved that the developed algorithms can pave the way for a massive screening campaign of interstitial lung diseases.
Interstitial lung disease (ILD) is one of the most frequent extra-articular manifestations of rheumatoid arthritis (RA). Although ILD significantly impacts prognosis and survival of RA patients, its diagnosis is often delayed and underestimated, since lung involvement in RA patients can be hardly suspected on the basis of symptoms. High resolution computer tomography (HRCT) remains the gold standard for diagnosis and it is mandatory in case of suspected ILD. Nevertheless, a routine use of HRCT for screening programs is not advisable for both high cost and X-ray exposure.
To improve the prescriptive appropriateness of HRCT for the early diagnosis of ILD, lung auscultation has been proposed to reveal fine bibasilar, end-inspiratory, "velcro-like" crackles, which may precede the development of clinically overt ILD. Recently, our group developed an algorithm named VECTOR (VElcro Crackles detecTOR) capable to recognize velcro crackles in pulmonary sounds from RA patients with a diagnostic accuracy of 83.9%. In addition, we developed another version of VECTOR suitable to detect the ILD related to connective tissue diseases (CTD) and interstitial pneumonia secondary to COVID-19, with overall diagnostic accuracy of 82.6% and 75%, respectively.

15:12
Using diffuse reflectance spectroscopy for real-time tissue assessment during upper gastrointestinal cancer surgery
Ioannis Gkouzionis, Scarlet Nazarian, Ara Darzi, Nisha Patel, Christopher J. Peters and Daniel S. Elson (Imperial College London, United Kingdom (Great Britain))

Cancers of the gastrointestinal (GI) tract remain a major contributor to the global cancer risk, with approximately 4.8 million new cases of GI cancer worldwide in 2018. The aim of surgery is for complete resection of tumour with clear margins, whilst preserving as much surrounding healthy tissue as possible. A positive circumferential resection margin (CRM) is associated with local recurrence of the tumour and poorer long-term survival, so it is paramount to establish tissue margins accurately. The current gold-standard for intraoperative CRM assessment is frozen sections. However, this method has been shown to have a sensitivity of 63%, and it is time-consuming, labour intensive and lengthens the operative time, affecting thus patient outcomes.
Diffuse reflectance spectroscopy (DRS) is a technique that allows discrimination of normal and abnormal tissue based on spectral data and presents a promising advancement in cancer diagnosis. Light emitted using a DRS fibre probe is absorbed and scattered by different structures within tissue and emitted back onto the probe. The wavelength and intensity of this collected light is specific to each tissue type, and in this way, different tissue can be distinguished based on spectral data.
An ex-vivo study was undertaken at Imperial College NHS Trust in the UK. Data was collected from consecutive patients undergoing stomach or oesophageal cancer resection surgery between July 2020 and March 2022. Spectral data were collected in the spectral range of 420 - 720 nm using a reflection fibre probe (Ocean Optics Inc.). Data was collected from oesophageal and stomach specimens ex-vivo immediately after surgical resection. Collected data was first normalised using the standard normal variate (SNV) method and outliers were automatically removed using the interquartile range technique. The most significant features were selected using the Boruta method to reduce redundancy and improve tissue discrimination accuracy.
Binary classification into healthy and tumour tissue was performed using supervised machine learning classifiers, such as light and extreme gradient boosting and random forest, as well as two 1-dimensional (1D) convolutional neural networks (CNNs). The SpecNet-I consists of one 1D convolutional layer followed by one max-pooling layer and one fully-connected (FC) layer. The SpecNet-II consists of four 1D convolutional layers each followed by a max-pooling layer. At the end of each network, we implement one FC layer with a softmax activation and two outputs to prepare the CNNs for the classification task. The classifiers were evaluated in terms of sensitivity, specificity, overall accuracy, and the area under the curve (AUC). For this study, 43 patients were included and a total of 16,349 spectra were collected. The SpecNet-I classifier was the best performing algorithm for both datasets, achieving an overall healthy versus tumour tissue diagnostic accuracy of 91.39%

for stomach and 96.34% for oesophagus. The sensitivity and specificity of the classifier were 92.68% and 90.70% for stomach, and 95.30% and 96.95% for oesophageal tissue.
The proposed pipeline allows real-time tissue classification with short data acquisition time to aid margin assessment in gastrointestinal cancer resection surgery and has the potential to be applied in routine surgical practice.

15:24
Monitoring short-time novelty of Electrocardiogram signals for epileptic seizure anticipation using Unsupervised Anomaly Detection
Apostolos Karasmanoglou (Technical University of Crete, Greece); Marios Antonakakis (Technical University of Greece, Greece & School of Electrical and Computer Engineering, Greece); Fabrizio Pancaldi (University of Modena and Reggio Emilia & Artificial Intelligence Research and Innovation Center, Italy); Michalis Zervakis (Technical University of Crete, Greece)

Epilepsy is one of the most common brain diseases with a major effect in more than 50 million people worldwide. Epilepsy is characterized by frequent recurrent seizures or "ictal" states during which a patient's neurons become hyperexcitable causing uncontrollable muscular contractions which induce loss of mobility and balance resulting in injury or even death. Deep investigation for a systematic approach to predicting and informing patients for oncoming seizures ahead of time is vital in alleviating part of the stress and anxiety felt by epileptic patients. Recent methodologies on seizure prediction were based on detecting electroencephalogram (EEG) abnormalities, however, in other recent studies, it is indicated how disturbances in the Autonomic Nervous System (ANS) can produce detectable alterations to the electrocardiogram (ECG) signals. The latter could potentially account for robust seizure prediction to be implemented on low-cost wearable devices. In this regard, the potential of devising seizure warning systems has been investigated using supervised machine learning models such as Support Vector Machines (SVM), Decision Trees, and others to classify a patient's state based on their Heart Rate Variability (HRV) parameters. Nevertheless, these approaches require the existence of patient-specific annotated ECG recordings in order to function, making deployment of such models significantly more difficult. In this work, we are investigating the potential of using unsupervised Anomaly Detection techniques such as One-Class SVM (OCSVM), Isolation Forrest (IF), Minimum Covariance Determinant Estimation, and Local Outlier Factor (LOF) to monitor an epileptic patient's state by quantifying the short-time novelty of their observed HRV parameters in order to implement a truly plug-and-play seizure warning device. A proposed methodology and results will be presented and discussed on the basis of openly available ECG databases.

15:36
Neural Functional Connectivity of Patients with Mild Cognitive Impairment using Finite Element Source Analysis
Marcos Revilla-Vallejo (Universidad de Valladolid, Spain & Biomedical Engineering Group, Spain); Carlos Gomez (Valladolid University, Spain); Hornero Roberto (University of Valladolid, Spain); Marios Antonakakis (Technical University of Greece, Greece & School of Electrical and Computer Engineering, Greece); Stavros I Dimitriadis (Artificial Intelligence and Information Analysis Laboratory, Greece); Ioannis Gkouzionis (Imperial College London, United Kingdom (Great Britain)); Miguel Ángel Tola-Arribas and Mónica Cano (Río Hortega University Hospital, Spain); Yoshihito Shigihara Action and Hideyuki Hoshi (Hokuto Hospital, Japan); Jesús Poza (University of Valladolid, Spain)

Complex properties of functional connectivity (FC) networks built using source-level neural electromagnetic signals are useful to characterize the alterations of mild cognitive impairment (MCI). The availability of recordings of MCI patients which progress to dementia and MCI patients which do not progress, may be useful to understand how the underlying alterations of dementia alter the FC network properties. Source-level signals were obtained from 20 electroencephalographic and 20 magnetoencephalographic longitudinal recordings of MCI patients using a finite element-based approach with a real-head model of five tissues (skin, skull, cerebrospinal fluid, gray, and white matter). Standardized low-resolution brain electromagnetic tomography was used for the source reconstruction. Afterwards, a multilayer functional network was built using amplitude-to-amplitude coupling (AAC). Finally, the robustness of the AAC network for each patient was computed by simulating two attack strategies: primary and random FC network pathways. Our results showed altered robustness of the AAC network comparing the MCI patients which progress to dementia with the MCI patients which remain stable. The characteristic changes that dementia induces on the brain may disrupt the FC network and thus, its robustness. In contrast, stable MCI may have some compensatory mechanisms which enhance the FC network, showing an unaltered network robustness. To sum up, network robustness reflects the alterations consequence of the dementia progression.

15:48
A Robust Temperature Sensor Design with Fault Detection Capability for eHealth IoT Application
Mashrafi Kajol, Joshua Calzadillas, Diliang Chen and Qiaoyan Yu (University of New Hampshire, USA)

eHealth IoTs need a reliable solution concerning the security aspects for making significant contributions to the modern healthcare system. As eHealth has a strong dependency on data collection, it is imperative to have robust sensors to perform robustly even in harsh conditions. Reliable sensor data is vital for healthcare providers to make decisions where a

false positive or negative symptom could lead to a catastrophic consequence for consumers. Various adversarial attacks can take place in any integrated sensors which jeopardize the sensitivity. To assure the robustness of the sensor nodes in eHealth IoT, some existing research made contributions to fault-detection systems. The techniques have complex structures or radio frequency circuits, which either consume a large area or result in a long delay(thus a loss of data during the faulty period).
The main contributions of this work include: (1) To address the limitation on complexity, delay overhead, and reliability, we propose a method to design a lightweight temperature sensor, which is only composed of a few MOSFETs, (2) able to tolerate the temperature variation and fabrication process variation, (3) based on the principle of temperature compensation, a zero temperature coefficient is derived to obtain a constant current in the sensor, (4) a real-time fault detection capability is available for anomaly monitoring. The process that assures the robustness of the temperature monitoring system is depicted in Fig.1. In the robust sensor design stage, we propose to use double modular redundancy to address the impact of temperature variation on the sensing result. By analyzing the drain current of the MOSFETs, we will be able to tell the presence of attacks. The proposed sensor was implemented in a 180nm CMOS technology with a supply voltage of 1.8V. Only nine transistors have been used which consumes around 90uW power, which is 57% lower than the existing work. The lower number of MOSFETs reduces the adversarial attacking area and low power consumption makes this design cost-effective. To evaluate the sensor's sensitivity to the fault, we first conducted an under-powering attack on the sensor circuit. During the period of voltage glitching, on-off state voltage transients create ambiguous acquisition circuitry for a high dynamic range. Consequently, the sensitivity of the sensors will be affected, and the sensor output is oscillated after regaining full supply voltage. There is a sharp spike at the rising edge of the voltage glitch with a magnitude of 284.9%. As the voltage glitch on the PTAT's supply voltage pin has a duration of 100ps, the sensor circuit has residual vibration on the current deviation. The vibration varies in a range of 42.85%. The maximum process variation(10.31%) has been found in the slowest corner.

16:00
Modeling of Plaque Progression in the Carotid Artery Using Coupled Agent Based with Finite Element Method
Nenad Filipovic and Smiljana Tomasevic (University of Kragujevac, Serbia); Andjela Blagojevic (Faculty of Engineering, University of Kragujevac & Bioengineering Research and Development Center, Serbia); Branko Arsic (Faculty of Science, University of Kragujevac, Serbia); Milos Anic (Faculty of Engineering, University of Kragujevac, Serbia); Tijana Djukic (Institute for Information Technologies, University of Kragujevac, Serbia)

In study, we presented a new computational model for atheromatic plaque growth progression in the carotid artery using specialized mathematical models and computational simulations which will enable the accurate prediction of the cardiovascular disease evolution. The simulated model with coupled Agent Based Method (ABM) and Finite Element Method (FEM) has been presented. The ABM was coupled with an initial WSS profile, which triggers a pathologic vascular remodeling by perturbing the baseline cellular activity and favoring lipid infiltration and accumulation within the arterial wall. The ABM model takes shear stress and LDL initial distribution from the lumen and starts iterative calculation inside the wall for lipid infiltration and accumulation using a random number generator for each time step. After ABM iterations, both wall lipid distribution and wall geometry are changed. This directly influences the wall artery geometry which is also modeled with finite element, with ABM elements inside these large finite elements. Then, fluid-structure solver is running and lumen domain is calculated again. The change of the shape of the cross-sections of the arterial wall is shown in three specific moments in time (baseline, after 3 months and after 6 months). One main pros of this new approach are the use of realistic 3D reconstructed artery providing in this way a more realistic, patient-specific simulation of plaque progression.

16:12
Discussion

15:00 – 16:30
Virtual Session # 5 Recent Developments in Health Technology (II)
Chair: Themistoklis Exarchos, Ionian University, Greece; **Antonis Sakellarios,** University of Ioannina, Greece
Room: KLEIO

15:00
Designing Digital Tools for ADRDs that Double as Assessments and Interventions
Prof. Diane Cook
Washington State University, USA

The world’s population is aging, and the increasing number of older adults with Alzheimer’s disease and related dementias (ADRDs) is a challenge our society must address. New modes of technology offer unprecedented opportunities to address some of the needs that accompany cognitive decline by providing automated health assessment and memory interventions. In this work, we create EMMA, a memory management app, that combines the two capabilities. Through participatory design with older adults and caregivers, we design an app that is accessible and effective as a compensatory aid for older adults

with memory decline. By collecting data from app usage in combination with sensor data, we extract digital markers that predict multiple clinical measures. We evaluate this app using data from 14 participants with mild cognitive impairment. We observed moderate to large correlations between predicted and ground-truth assessment scores for each clinical assessment.

15:45
Vision Transformer Based COVID-19 Detection Using Chest CT-scan images
Pranab Sahoo (Indian Institute of Technology, Patna, India); Sriparna Saha (IIT Patna & Department of CSE, India); Samrat Mondal (IIT Patna, India); Suraj Gowda (Narayana Institute of Cardiac Sciences, India)

The fast proliferation of the coronavirus around the globe has put several countries' healthcare systems in danger of collapsing. As a result, locating and separating COVID-19-positive patients is a critical task. Deep learning approaches were used in several computer-aided automated systems that utilized chest computed tomography (CT-scan) or X-ray images to create diagnostic tools. However, current Convolutional neural network (CNN) based deep learning algorithms cannot capture the global context because of inherent image-specific inductive bias. These techniques also require large and labeled datasets to train the algorithm, but not many labeled COVID-19 datasets exist publicly. To mitigate the problem, we have developed a self-attention-based Vision Transformer (ViT) architecture using CT scan images in this paper. The transformer architecture can exploit the unlabeled datasets using pre-training. The proposed ViT model achieves an accuracy of 98.39\% on the SARS-CoV-2 datasets, outperforming the existing state-of-the-art CNN based models by 1\%. We also provide the characteristics of CT scan images of the COVID-19-affected patients and an error analysis of the proposed model's outcome.
Our findings show that the proposed model can be an alternative option for medical professionals for effective COVID-19 screening. The implementation details of the proposed model can be accessed at https://github.com/Pranabiitp/ViT.

15:57
An End-to-end Posture Perception Method for Soft Bending Actuators Based on Kirigami-inspired Piezoresistive Sensors
Jing Shu, Junming Wang and Yujie Su (The Chinese University of Hong Kong, Hong Kong); Honghai Liu (Harbin Institute of Technology Shenzhen, China); Raymond Kai-Yu Tong (The Chinese University of Hong Kong, Hong Kong); Zheng Li (The Chinese University of Hong Kong, China)

Posture sensing of soft actuators is critical for performing closed-loop control of soft robots. This paper presents a novel end-to-end posture perception method for soft actuators by developing long short-term memory (LSTM) neural networks. A novel flexible bending sensor developed from off-the-shelf conductive silicon material was proposed and used for posture sensing. In the proposed method, the hysteresis of the soft robot and non-linear sensing signals from the flexible bending sensors have also been considered. With one-step calibration from the sensor output, the posture of the soft actuator could be captured by the LSTM network. The method was validated on a finger-size one DOF pneumatic fiber-reinforced bending actuator. Four kirigami-inspired flexible piezoresistive transducers were placed on the top surface of the actuator. Results show that the transducers could sense the posture of the actuator with acceptable accuracy. We believe our work could benefit soft robot dynamic posture perception and closed-loop control.
For the performance of the calibration neural network, the root-mean-square error (RMSE) of the selected region in the testing data set is 4.16 degrees. The coefficient of determination value of ground truth and prediction is 0.98.
For the performance of the calibration neural network in predicting the sinusoidal motion, the RMSE values are 8.73 degrees and 8.68 degrees when the period is 5 seconds and 8 seconds, respectively.

16:09
Discussion

16:30 – 16:45
Coffee Break
Room: FOYER ERATO

16:45 – 18:30
Poster Session #2
Room: FOYER ERATO

Screen 1

16:45
Detection of liquid slipping hazards using Convolutional Neural Networks
Stuart Albert Port, Daniel T. H. Lai and Rezaul Begg (Victoria University, Australia)

This paper investigates the performance of various convolutional neural network architectures in the application of liquid spills detection on tiled surfaces in an effort to prevent slips within the elderly community. Falls within the elderly community are of increasing concern to the health care community, with 21% of falls within the elderly community being caused by environmental factors such as spills and uneven flooring. Falls within the elderly community can be devastating to an individual and result in a loss of confidence in walking, also known as post-fall syndrome. This study determines the feasibility of liquid spill detection on tiled and laminated flooring using a non-linear machine learning model such as a Convolutional Neural Network. To achieve a high degree of accuracy, multiple convolutional neural network models will be tested, such as MobileNet_V1, MobileNet_V2, Inception_V3 and VGG-16. The listed models will be trained on a dataset containing 5,410 images of spills that can be broken down into 8 sets of classes. The spilled liquids have been categorised into 5 classes: Milk, Orange, Red, Coffee/Tea and Water. The training data also contains 3 classes of tiles containing no spills as a control group for the experiment. The classes with no spills consist of White, Brown, and light, with the light category containing a variety of cream and light brown coloured tiles. The models will also be tested on a testing dataset of 460 images that are categorised into the 8 classes listed above. The models under evaluation will be examined using the metrics of analysis, precision, recall, F1 score and accuracy. These metrics allow for comprehensive observation of how the different architectures performed under the same training and testing environment. Mobilenet_V1 yielded the highest accuracy with an average of 85% across all classes. It was seen that mobilenet_V2 and Inception_V3 suffered from overfitting which is expected to be from their larger network size.

16:55

MRI vs. US 3D computational models of carotid arteries: a proof-of-concept study

Panagiotis K. Siogkas (University of Ioannina, Greece); Vassilios Tsakanikas (Unit of Medical Technology and Intelligent Information Systems, Greece); Antonis Sakellarios (Institute of Molecular Biology and Biotechnology, FORTH, Greece); Vassiliki Potsika (Senior Researcher, Medlab, University of Ioannina, Greece); George Galyfos and Fragiska Sigala (National and Kapodistrian University of Athens, Greece); Igor Koncar (Clinic for Vascular and Endovascular Surgery, Serbian Clinical Centre, Belgrade, Serbia); Smiljana Tomasevic (University of Kragujevac, Serbia); Tijana Djukic (Institute for Information Technologies, University of Kragujevac, Serbia); Nenad Filipovic (University of Kragujevac, Serbia); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

The progression of atherosclerotic carotid plaque causes a gradual stenosis in the arterial lumen which might result to catastrophic plaque rupture ending to thromboembolism and stroke. Carotid artery disease is the main cause for ischemic stroke in the EU, thus intensifying the need of the development of tools for risk stratification and patient management in carotid artery disease. In this work, we present a comparative study between ultrasound-based and MRI-based 3D carotid artery models to investigate if US-based models can be used to assess the hemodynamic status of the carotid vasculature compared with the respective MRI-based models which are considered as the most realistic representation of the carotid vasculature. In-house developed algorithms were used to reconstruct the carotid vasculature in 3D. Our work revealed a promising similarity between the two methods of reconstruction in terms of geometrical parameters such as cross-sectional areas and centerline lengths, as well as simulated hemodynamic parameters such as peak Time-Averaged WSS values and areas of low WSS values which are crucial for the hemodynamic status of the cerebral vasculature. The aforementioned findings, therefore, constitute carotid US a possible MRI surrogate for the initial carotid artery disease assessment in terms of plaque evolution and possible plaque destabilization.

17:05

Computational modeling of atherosclerotic plaque progression through an efficient 3D agent-based modeling approach

Panagiota Tsompou (University of Ioannina, Greece); Vassiliki Potsika (Senior Researcher, Medlab, University of Ioannina, Greece); Nikola Petrović, Vasileios C. Pezoulas and Panagiotis K. Siogkas (University of Ioannina, Greece); Vassilios Tsakanikas (Unit of Medical Technology and Intelligent Information Systems, Greece); Dimitrios Pleouras (University of Ioannina, Greece); Michael Papafaklis (University Hospital of Ioannina, Greece); Sotirios Nikopoulos (Medical School, University of Ioannina, Greece); Antonis Sakellarios (Institute of Molecular Biology and Biotechnology, FORTH, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Since atherosclerosis has been declared as the leading cause of mortality worldwide, the imminent need for the design and development of straightforward computational modeling workflows to improve the existing cardiovascular disease risk stratification models is more important than ever. Agent-based modelling (ABM) is a promising computational approach which can be utilized for decision making in various domains from the healthcare sector to industrial applications. In the present study, we propose a straightforward approach for atheromatic plaque progression in the coronary and peripheral arteries using specialized mathematical models and computational simulations which will enable the accurate prediction of the cardiovascular disease evolution. The model incorporates the realistic 3D geometry of the artery and is the first ABM implemented in C#. According to our results, the 3D ABM was able to simulate the Trans Endothelial Migration of

Lymphocytes, Monocytes and Neutrophils, the artery wall cells, endothelium cells and plaque cells reducing the time step for each cycle from 40 seconds to 0.04 seconds per cycle.

17:15

Deep Learning based Face Detection for Fever Screening using Thermal Camera

Oyun Kwon (Yonsei University & Yonsei University College of Medicine, Korea (South)); Kyeong Teak Oh and Junhwan Kwon (Yonsei University College of Medicine, Korea (South)); Hayoung Kim (Yonsei University of Medicine, Korea (South), Korea (South)); Jiwon Choi (Yonsei University, Korea (South)); Sun Kook Yoo (Yonsei University College of Medicine, Korea (South))

Introduction - Fever has been reported to be a common clinical symptom in COVID-19 or other infectious diseases [1]. To prevent the spread of infectious diseases, the method for rapidly measuring body temperature in a non-contact manner is needed. The solution could be a thermal camera, which has a heat sensor and it can detect any difference in temperature. To measure body temperature using thermal camera, temperatures from different regions of the face such as forehead, nose, ears, and cheeks can be used [2]. In order to classify the corresponding areas, it is important to accurately detect the face region. Therefore, we propose a deep learning method for automatically detecting faces in thermal images.
Methods - For training and test the proposed network, the thermal data was acquired using FLIR A615 thermal camera. The thermal camera was installed above the entrance door and took video of pedestrians. The captured video was converted to a thermal image, and face regions were manually labeled for each image. The architecture of recurrent convolutional neural network (R-CNN) combined with region proposal network (RPN) [3]. Resnet-18 was used for feature extraction layer. Figure 1 showed the architecture of the proposed network. 18,500 labeled images were used to train the network. For the feasibility test, pedestrians were recorded five times on different days.
Results - Table 1 showed the evaluation matrix for each test case. Recall, precision, and F1-score can have values from 0 to 1. When these values are closer to 1, it means that the detection performance is better. The values showed similar results to the papers detecting faces using thermal camera.
Discussion and Conclusion - In this study, we presented thermal image based face detection method. The feasibility test showed the applicability of face detection when imaging pedestrians using thermal camera.

17:25

Computational Blood Flow Modeling in Healthy and Diseased Coronary Arteries; the effect of flow model

Georgia Karanasiou (Senior Researcher, Medlab, University of Ioannina, Greece); Panagiotis K. Siogkas (University of Ioannina, Greece); Antonis Sakellarios (Institute of Molecular Biology and Biotechnology, FORTH, Greece); Vasileios S. Loukas and Panagiota Tsompou (University of Ioannina, Greece); Gianna XXX Karanasiou (FORTH, Greece); Christos Katsouras (University Hospital of Ioannina, Greece); Lampros Michalis and Dimitrios Fotiadis (University of Ioannina, Greece)

Atherosclerosis is a multifactorial and complex disease initiated after the accumulation of lipids and immune cells in the arterial wall, closely linked and correlated with different factors, including biological, systemic and biomechanical. In the arterial wall, two types of mechanical loading occur as a result of the blood flow and pressure: (i) the Vascular Structural Stress, which is a result of the expansion of the arterial wall caused by the dynamic blood pressure and, (ii) the Wall Shear stress (WSS), which acts on the arterial lumen surface and is a result of the blood flow. Blood flow induced WSS plays a pivotal role in the onset and progress of atherosclerosis, and several studies have been investigating the association between atherosclerosis, the malfunctioning of the endothelial cells and the WSS. This study investigates the blood flow under normal and disease conditions and evaluates the effect of using the low Reynolds turbulence k-ω SST model, when computational modeling in arteries with moderate and severe stenosis, is performed. In particular, six computational models with differences: (i) in the degree of stenosis and, (ii) flow models (laminar vs k-ω SST), were simulated. The results demonstrate that for the models with 50% and 80% stenosis, the calculated Wall Shear Stress (WSS) is underestimated, when the laminar flow model is used, and this underestimation increases with the degree of stenosis. In addition, in the moderate stenosis (i.e., 50% stenosis case), the difference of peak WSS during end-systole is lower than the one observed for the more severe case (i.e., 80% stenosis) for both flow models, with the k-ω SST model exhibiting the highest WSS values.

17:35

Identifying Clinical Subgroups in Children Suspected of Auditory Processing Disorder using Machine Learning Methods

Hasitha Wimalarathna (University of Western Ontario, Canada); Sangamnatha Ankmal-Veranna (The University of Southern Mississippi, USA); Chris Allan, Minh Duong, Sumit K. Agrawal and Prudence Allen (The University of Western Ontario, Canada); Jagath Samarabandu and Hanif Ladak (University of Western Ontario, Canada)

Audiologists have made great efforts to understand auditory processing disorder (APD), however, APD remains challenging to diagnose accurately. The APD diagnostic test battery consists of objective and behavioral assessments. The objective

tests evaluate the integrity of the auditory system, while the behavioral tests measure the perceptual ability to process sounds. Audiologists must score and analyze each test in the battery to deliver a diagnostic report, which is time consuming and labor-intensive. The main aim of this study was to understand how machine learning (ML) methods can be adapted to analyze the data of the APD clinical test battery. We present suggestions to develop future automated platforms to detect APD in children using ML algorithms. Data was collected from 134 children between the ages of 5-17 years old who were referred to the H.A. Leeper Speech & Hearing Clinic (Western University, London, Ontario, Canada) for suspected APD. Data from both behavioral and objective tests were used. Behavioral data contained threshold values which were first converted to categorical variables by comparing with normative thresholds available in the literature. Behavioral assessments included: the Staggered Spondaic Word test (SSW), the Pitch Pattern Sequence test (PPS), the Word in Ipsilateral Competing Noise test (WIC), the Word in Noise test (WIN), frequency discrimination, gap detection, and amplitude modulation. Objective assessments included: auditory brainstem responses (ABRs), cortical evoked auditory responses (CEARs), and acoustic reflexes. The features from ABRs and CEARs were derived from continuous wavelet transform plots and contained features from the magnitude and phase plots. Acoustic reflexes were converted into categorical variables. The clinical data were scored by three experienced audiologists and categorized into four sub-groups based on behavioral and physiological normality/ abnormality. Two algorithms from the ensemble learning techniques were used in the study, namely Random Forest (RF) and Extreme Gradient Boosting (Xgboost). Experiments were conducted by adding and removing features derived from both behavioral and objective tests. Feature interpretation was performed using SHapely Additive exPlanations (SHAP). Accuracy, sensitivity, and specificity values were calculated. The performance of both RF and Xgboost algorithms showed similar scores across experiments. Both were able to categorize clinical data into sub-groups with an average accuracy value of 79% (±0.02%). Based on confusion matrices, sensitivity, and specificity scores, the Xgboost algorithm was determined to be superior. The Xgboost model revealed 86% and 96% average sensitivity and specificity scores, respectively. Based on the SHAP explanations, the order in which the features contributed to the model outcome was SSW, WIC/WIN, CEARs, ABRs, PPS, amplitude modulation, acoustic reflexes, frequency discrimination, and gap detection. The SSW was the greatest contributor, which is in accordance with clinical audiological assessment. The study revealed that ML models can be developed to assess suspected APD in children with good agreement to clinical assessment. It is expected that model accuracy will be further improved by collecting a larger clinical dataset. Translating this software into clinical use would offer advantages such as a reduced clinical workload and opportunities to train inexperienced audiologists to assess APD in children.

17:45

Latent State-Space Modeling of Physiological Responses to Non-Invasive Vagus Nerve Stimulation and Traumatic Stress

Asim H Gazi, Sungtae An, Shlok Natarajan and J. Antonio Sanchez-Perez (Georgia Institute of Technology, USA); Douglas Bremner (Emory School of Medicine, USA); Jin-Oh Hahn (University of Maryland, USA); Christopher Rozell (Georgia Tech, USA); Omer T Inan (Georgia Institute of Technology, USA)

Acute stress is characterized by increased sympathetic ("fight or flight") and decreased parasympathetic ("rest and digest") activity. These latent autonomic nervous system variations produce an array of measurable physiological changes. In recent work, transcutaneous cervical vagus nerve stimulation (tcVNS) has been shown to mitigate some of these stress-related physiological changes. However, the effects reported thus far have not considered the shared variance of physiological markers and have primarily been of single markers averaged over minutes. In this work, we address these limitations by jointly modeling the dynamics of cardiovascular and respiratory markers during traumatic stress and tcVNS or sham stimulation (N = 50 double-blind study) using participant-specific state-space models. After validating the models using both the mean ($p < .001$) and naive ($p = .02$) baseline tests for predictive models, we isolate the effects specific to tcVNS or sham stimulation, traumatic stress, and a neutral condition (included for control purposes) via model simulation. Projecting the simulated responses into two dimensions via principal component analysis, we observe marked differences between the trajectories associated with traumatic stress, neutral conditions, and tcVNS or sham stimulation. This suggests that latent state-space models can capture the underlying dynamics that characterize physiological responses to stressors and interventions.

17:55

Multimodal Study Uncovers Links between Grey Matter Volume and both Low- and High-frequency Connectivity States in Schizophrenia

Marlena Duda and Ashkan Faghiri (Georgia State University, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Multimodal neuroimaging fusion studies of complex disorders like schizophrenia (SZ) have revealed disease-specific links between brain structure and function that unimodal analyses alone could not produce. Here, we utilize a multi-set CCA + joint ICA (mCCA + jICA) fusion framework to study the connection between structural MRI and spectral connectivity states derived via filter-banked connectivity (FBC), a unified method for estimating connectivity across the frequency spectrum. This joint analysis showed functional connections in both low- and high-frequency SZ-dominant states were significantly

related to alterations in grey matter volume (GMV) in several areas in the frontal and temporal cortices, which have formerly been implicated in SZ.

Screen 2

16:45
Deep Learning based Scan-time Reduction using [18F]-AV45 PET
Kyeong Teak Oh (Yonsei University College of Medicine, Korea (South)); Oyun Kwon (Yonsei University & Yonsei University College of Medicine, Korea (South)); Junhwan Kwon and Sun Kook Yoo (Yonsei University College of Medicine, Korea (South))

Introduction [18F]-AV45(florbetapir) positron emission tomography (PET) is used in the evaluation of neurodegenerative diseases. It is a reliable biomarker for β-amyloid (Aβ) in aging and Alzheimer's disease (AD) as it is recognized as an effective Aβ-specific radiotracer in PET imaging[1]. To obtain high-quality PET images, a sufficient number of coincidence events recorded from either a high-dose injection and a short scan time, or a low-dose injection and a long scan time are needed. A high-dose injection increases radiation exposure by patient and long scan times cause motion artifacts and patient discomfort. To solve this problem, we propose a method.
Method For the training and test the proposed network, 40 subjects [18F]-AV45 PET data were acquired from Alzheimer's disease neuroimaging initiative (ADNI) data set. The [18F]-AV45 PET images which took 5 minutes after post injection was used as network input. The proposed network was trained to synthesize PET images which performed scanning for 20 minutes. 35 subjects were used for training and 5 subjects were used for testing the proposed network. The architecture of generative adversarial network (GAN) was used. The generator consists of contraction path and expansion path and composed of 6 convolutional layers and 3 resnet blocks. In contraction path, consecutive of three times of 5x5 convolutions to down sample the input image. For the feature extraction 3 resnet block were used. In expansion path, consecutive of 2x2 up-convolution and three times of 3x3 convolution was done to recover the size of synthesized PET image. The synthesized images were evaluated using NRMSE, PSNR, and SSIM.
Result Figure 1 showed the input image, synthesized PET image and real PET image. It can be seen that the synthesized image has reduced noise compared to the input image, and the amyloid pattern is well expressed compared to the real image. Table 1 showed the evaluation matrix of synthesized PET. The values showed similar results to the papers synthesizing PET of different modality of [18F]-FBB PET and FDG-PET [2-3]. The mean score of NRMSE, PSNR, and SSIM were 0.15724, 30.311, and 0.95364.
Discussion & Conclusion In this study, GAN based scan-time reduction method was presented. The feasibility test showed the clinical applicability of [18F]-AV45 PET to reduce the time.

16:55
Comparison of four deep learning architectures for automatic segmentation of the left atrium
Grigoris Grigoriadis, Dimitris Zaridis and Spyros Sioros (University of Ioannina, Greece); Stefan Simovic (Faculty of Medical Sciences, University of Kragujevac & BioIRC, Serbia); Nikolaos Tachos (Unit of Medical Technology and Intelligent Information Systems, Greece); Antonis Sakellarios (Institute of Molecular Biology and Biotechnology, FORTH, Greece); Katerina Naka and Lampros Michalis (University of Ioannina, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

The left atrium (LA) is one of the cardiac cavities with the most complex anatomical structures. Its role in the clinical diagnosis and patient's management is critical, as it is responsible for the most common arrythmia, the atrial fibrillation (AF). AF is a condition that promotes the thrombogenesis inside the left atrial appendage which has significant impact on the thrombus formation. The development of an automated approach with zero user interaction for LA segmentation is a demanding task mainly due to its anatomical complexity and its anatomical shape variation among different patients. In this study, a comparative analysis of 4 different deep learning architectures is presented. The approach was developed in such a way to be as much unbiased, by implementing cross-validation with 4 folds and 5 image segmentation performance evaluation metrics. Particularly, the U-Net, the R2U-Net, the U2-Net and the V-Net were developed and compared, regarding their performance on the automated segmentation of the LA. The results demonstrated that the U-Net achieved the best dice coefficient 0.85% ±0.18. Overall, all the developed architectures achieved good results indicating >80% dice coefficient.

17:05
Optimizing QoE for Medical Video Streaming
Ioanna Valiandi (CYENS Centre of Excellence, Cyprus); Konstantinos Ziliaskopoulos (SingularLogic & University of Thessaly, Greece); Stamatia Rizou (Singular Logic, Greece); Nacim Ramdani (University of Orléans, France); Costantinos S. Pattichis (University of Cyprus, Cyprus); Marios Pattichis (University of New Mexico, USA); Andreas S. Panayides (CYENS Centre of Excellence, Cyprus & 3AE Health LTD, Cyprus)

Video streaming applications have witnessed widespread adoption over the past decades becoming the dominant source of internet traffic. Toward this direction, medical video systems in standard clinical practice are steadily increasing driven by the growing reliability brought on by established and emerging enabling technologies. These technologies can be roughly categorized into video compression algorithms, wired/ wireless communication networks, and video quality assessment (VQA) metrics. Medical video applications range from remote diagnosis and care, to 2nd opinion provision and medical education, based on live and/ or on-demand video streaming of different medical video modalities. At the same time, emerging applications invest in the use of tele-operated robots for both diagnosis and surgery, while the use of augmented and extended reality technologies, coupled with 360o video streaming, have the potential to revolutionize medical education and treatment.
A key challenge in live medical applications, such as emergency telemedicine (e.g. from the ambulance) and scenarios that involve low resource settings (e.g., disaster incident sites), is guaranteeing the clinical quality of the communicated video. The latter is a non-trivial process, anchored in the time-varying and error-prone nature of the underlying wireless channels. As such, medical video systems need to adapt to the varying bandwidth throughput supported by the wireless medium, in a timely fashion, while securing the clinical capacity of the transmitted videos. The latter, necessitates adaptive, real-time video encoding and control. The present study proposes an adaptive video delivery methodology that enhances quality of experience (QoE) and aids towards the wider adoption of wireless medical video communication systems in standard clinical practice.

17:15

3D Reconstruction of the cerebral vascular tree from 2D image acquisitions using deep learning autoencoder

Matthieu Coupet (Université de Poitiers, France); Guillaume Herpe (CHRU Poitiers, France); Thierry Urruty (University of Poitiers, France & XLIM CNRS 7252, France); Mathieu Naudin (University of Poitiers, France); Hakim Belhaouari (University of Poitiers & XLIM CNRS 7252, France); Christine Fernandez-Maloigne (University of Poitiers & I3M Laboratory, France); Rémy Guillevin (CHRU Poitiers, France)

The therapeutic strategy for acute ischemic stroke must be initiated urgently and is based on intravenous (IV) thrombolysis with rt-PA associated with Mechanical Thrombectomy (MT). Mechanical Thrombectomy is an intra-arterial procedure consisting in removing the thrombus mechanically within arterial cerebral vasculature using X-ray Digital subtraction angiography (XA-DSA) as a navigation tool.
This imaging modality allows assessing real-time navigation using two plans. Due to the superposition of the vessels and artifacts within the two plans, some three-dimensional acquisitions have to be performed. Most of the solutions currently proposed to perform three-dimensional acquisition require more images and systematic manual intervention, and often algorithms with too long a calculation time to be used in the emergency of a stroke.
In this paper, we propose a new intelligence artificial framework with a robust and performing autoencoder model, with multiple inputs, including depth maps extracted from 2D cerebral vascular tree images. This model perform with only two 2D images simulated by Time-of-Flight Magnetic Resonance Imaging acquisitions from the public ADAM dataset.
The final performance allows on average a dice score of 0.95 between the predicted object and the ground truth
We propose a qualitative and quantitative study showing the performance of our proposal and its medical interest for our radiologists experts.

17:25

Enhancement for Estimation of Blood Flow Axial Velocity in Conjunctival Microvascular Networks via Smartphone Video

Min Jing and Agnes Awuah (Ulster University, United Kingdom (Great Britain)); Paul Brennan (Royal Victoria Hospital, United Kingdom (Great Britain)); Andrew McNeil (Vanderbilt University, USA); Julie Moore (Ulster University, United Kingdom (Great Britain)); Jonathan Mailey (Royal Victoria Hospital, United Kingdom (Great Britain)); Louise Robertson and Dewar Finlay (Ulster University, United Kingdom (Great Britain)); James Mclaughlin (University of Ulster, United Kingdom (Great Britain)); M. Andrew Nesbit (Ulster University, United Kingdom (Great Britain)); Emanuele Trucco (University of Dundee, United Kingdom (Great Britain)); Mark S. Spence (Royal Victoria Hospital Belfast, United Kingdom (Great Britain)); Tara Moore (Ulster University, United Kingdom (Great Britain))

Noninvasive imaging of conjunctival microvascular networks provides an effective way to assess the body's microcirculations. This study presents a new approach to enhance estimation of blood flow axial velocity (Va) in microvessels via videos taken by an iPhone camera attached to a slit lamp. The outcomes demonstrate the capability of smartphone-based devices for quantitative assessment of microvascular hemodynamics and potential in monitoring alterations associated with cardiovascular diseases conditions.

17:35

Spatio Temporal Wound Stage Classification

Alex Salman (University of California - Santa Cruz, USA); Michael J Briden (University of California Santa Cruz, USA); Narges Norouzi (University of California, Santa Cruz, USA)

With the increasing usage of neural networks and deep learning in the medical field, this work proposes an architecture for classifying wound healing stages of a series of wound images. We generate a series of consecutive wound image frames from a dataset of wound images inflicted on 4 young mice and 4 aged mice. We then fed the data into a 2D convolutional neural network (2D-CNN) combined with long short-term memory (LSTM) unit and a 3D convolutional neural network (3D-CNN) to learn spatio-temporal features associated with the healing trajectory. We found that the 3D-CNN model outperforms the 2D-CNN + LSTM framework. The 3D-CNN model is able to extract spatio-temporal features related to the healing stage and results in more clear activation maps around the wound area.
We further investigate the importance of removing visual features that are not related to the wound to avoid model distraction. After removing visual distractors from images, the model can focus on the area of interest and learn wound-related activations. Both models can extract visual features related to wound healing and have high classification accuracy and high generalization capability. The 2D-CNN + LSTM and 3D-CNN models achieve 81.3\% and 72.4% validation accuracy, respectively. Experimental results are outlined throughout the paper.

17:45
MIRAM: Masked Image Reconstruction Across Multiple Scales for Breast Cancer Risk Prediction
Hung Vo and Pengyu Yuan (University of Houston, USA); Zheng Yin, Kelvin Wong and Chika F Ezeana (Houston Methodist Hospital, USA); Son Ly and Hien Nguyen (University of Houston, USA); Stephen Wong (Houston Methodist Cancer Center, USA)

Self-supervised learning (SSL) has attracted significant interest in machine learning and computer vision communities. Two prominent SSL approaches have been contrastive-based learning and self-distillation with the help of cropping augmentation. Recently, masked image modeling has emerged to be a more powerful SSL approach that uses image inpainting as a pretext task. Following this success, our paper introduces a scalable and practical SSL approach based on more challenging pretext tasks to facilitate the learning of powerful features. Specifically, we use multi-scale image reconstruction from randomly masked input images as the basis for feature learning. We hypothesize that the reconstruction of high-resolution images will help the model attend to smaller but finer spatial details, which is especially useful for recognizing subtle details in medical images. Our method is the first work studying the effect of multi-scale SSL on medical data. The proposed SSL features significantly improve the performance of the Curated Breast Imaging Subset of Digital Database for Screening Mammography (CBIS-DDSM) dataset. Specifically, our method increases the average precision (AP) and the area under the receiver operating characteristic curve (AUC) by 3% and 1% in pathology classification, and by 4% and 2% in mass margins classification when being compared with state-of-the-art (SOTA) algorithms.

Screen 3

16:45
Wellness at Work: Personalized System for the Protection of Well-Being in the Workplace
Rita Paradiso (Smartex, Italy); Gianluca De Toma (Smartex s r l, Italy); Maria Pacelli (Smartex srl, Italy)

The workers safety is a crucial issue and in the last decades many actions have been taken to guarantee the improvement of work conditions in the respective environment and to prevent accidents and injuries. In literature the work-related stress in the healthcare sector has been reported, in particular the work-related muscle skeletal disorders. However, the biomechanical overload and the risk of muscle-skeletal system damage are only an aspect related to the worker health: the job stress dimension has an important role in the global wellness of the worker and there is a lack of methods and approaches useful to objectively evaluate this aspect. In this study we propose a framework based on wearable and cloud technologies to monitor and to extract significant information about work load, due to physical demand and stress physiological response, on physiotherapists, named Wellness@Work (W@W) platform.

16:55
Path Generation with Reinforcement Learning for Surgical Robot Control
Junhong Chen and Zeyu Wang (Imperial College London, United Kingdom (Great Britain)); Ruiqi Zhu (King's College London, United Kingdom (Great Britain)); Ruiyang Zhang and Weibang Bai (Imperial College London, United Kingdom (Great Britain)); Benny Lo (Imperial College, United Kingdom (Great Britain))

In the field of robotic surgery, Robot-Assisted Minimally Invasive Surgery(RAMIS) has shown its great potential of benefiting both surgeons and patients in the past few decades of research and practice. The current trend of RAMIS targets towards a higher level of autonomy in carrying out surgical tasks. However, most real RAMIS tasks still rely on manual control, thus the performance mostly depends on the dexterity of the surgeon. Their fatigue or small errors could cause life-threatening damages to the patients, especially high-workload surgeons. Since corrections and errors are inevitable in manual control, the actual tool paths in real operations are often deviated from ideal trajectories. For robot Learning from Demonstrations(LfD), these sub-optimal paths would eventually affect the robot's learning performance. Therefore, much

research is being explored in enhancing the performance of robot-generated instrument tool paths and at the same time reducing the reliance on manual manipulation demonstrations in surgical robot learning. In this paper, both Reinforcement Learning and Learning from Demonstration are used to generate a smooth moving trajectory without the use of manual robotic control kinematics data. Two tasks, peg transfer and pattern cutting, were chosen to verify the performance. The method was trained and validated in simulations, namely Asynchronous Multi-Body Framework (AMBF) and Moveit. Then da Vinci Research Kit is used to validate the real case performance. The results have shown that this path generation framework could automate different given repetitive surgical tasks, and potentially adapted to other surgical tasks.

17:05
Jumping acceleration to predict heart rate time series
Jasper Gielen and Jean-Marie Aerts (KU Leuven, Belgium)

Heart rate (HR) monitoring is a popular tool used in sports and exercise to quantify the cardiovascular load. It is often used in combination with monitoring the mechanical work to describe the training process in detail. In many sports and activities, there still exists the challenge to determine the internal-external load relation. The relation between jumping load and HR is especially interesting because the accelerations occur as short pulses of high intensity, whereas the heart's responses are not instant. Thus, there seems a need for explicitly capturing the dynamics of the system. ARX models have already been used for assessing the workload. In this study, we show that jumping acceleration is able to model and simulate the heart rate accurately using.
Eight male elite volleyball athletes were monitored during official competition matches. Every athlete participated in 4 to 10 matches, resulting in a dataset of 63 measurements. Athletes recorded 3D accelerometer data (gravitational units, GU) and heart rate (bpm) at 1Hz. We have randomly selected 40 volleyball spikes and 40 serves during the warm-up as well as the actual match to study individual jumping actions. In total, 160 jumps were studied.
The time series data for jumping actions performed during the warm-up were modelled with a mean (± SD) R^2 for simulation of 0,85 (± 0,19). For actions performed during the match, the R^2 was 0,80 (± 0,16). These results suggest that, on average, about 83% of the dynamic variation in the HR during jumps can be explained by overall acceleration. The HR during the entire match was also modelled with activity as input signal. The mean (± SD) R^2-value for the ARX model simulation is 0,67 (± 0,13), meaning that about two thirds of the dynamic variation in the HR can be explained by overall acceleration.
These results are interesting to the EMBS community because they illustrate how physical activity characterized by jumps and explosive movements can be used as an input signal to predict the cardiovascular load second-by-second by means of 2nd order ARX models.

17:15
Machine Learning-based Instrumental Gait Analysis for the Diagnosis of Patients with Major Depressive Disorder
Giulia Fransvea (The BioRobotics Institute, Italy & IRCCS Fondazione Don Carlo Gnocchi, Italy); Elisabetta Patron and Francesca Mura (Università di Padova, Italy); Christian Cipriani (The Biorobotics Institute Scuola Superiore Sant'Anna, Italy); Claudio Gentili (University of Padua, Italy); Andrea Mannini (IRCCS Fond. Don Carlo Gnocchi, Italy)

Instrumental gait analysis and Machine Learning can play a key role in the diagnosis of the Major Depressive Disorder (MDD). A Decision Tree classifier boosted with AdaBoost was cross-validated in discriminating MDD patients from age-matched controls. The results showed a 5-fold cross-validation accuracy of the 78%. This work looks at the possibility of automatically diagnosing the presence of MDD in young adults, using parameters extracted from gait analysis and wearable sensors.

17:25
A machine learning-based prognostic solution for post-stroke functional outcome prediction after rehabilitation
Silvia Campagnini (Scuola Superiore Sant'Anna, Istituto di BioRobotica, Italy); Piergiuseppe Liuzzi (Scuola Superiore Sant'Anna, Istituto di BioRobotica & IRCCS Fondazione Don Carlo Gnocchi, Italy); Bahia Hakiki (IRCCS Fondazione Don Carlo Gnocchi, Italy); Alessandro Sodero and Claudio Macchi (IRCCS Fondazione Don Carlo Gnocchi and University of Florence, Italy); Francesca Cecchi (IRCCS Fondazione Don Carlo Gnocchi and University of Florence, Spain); Andrea Mannini (IRCCS Fond. Don Carlo Gnocchi, Italy)

In the context of personalized rehabilitation, this work proposes the cross-validation and testing of a Machine Learning model for the prediction of functional outcomes in post-stroke patients. Results achieved pave the way for clinical usability studies to come: the modified Barthel Index at discharge was predicted with median absolute error [interquartile range] of 12 [16] points.

17:35
Parameters Selection for the Accuracy Assessment of Cuffless Blood Pressure Measurements: Mean Absolute Difference vs Root Mean Square Difference

Ting Xiang and Zijun Liu (City University of Hong Kong, Hong Kong); Nan Ji (Hong Kong Centre for Cerebro-Cardiovascular Health Engineering, Hong Kong); Yuanting Zhang (Hong Kong Centre for Cerebro-Cardiovascular Health Engineering (COCHE), Hong Kong)

The wearable cuffless blood pressure (BP) measuring devices without an occluding cuff have gained enormous attention in recent years. It is essential to select appropriate parameters for the assessment of the device accuracy, especially for the development of a performance evaluation standard. This study mainly compared the mean absolute difference (MAD) used in IEEE Std 1708TM with root mean square difference (RMSD) for assessing the accuracy of BP estimation. The results demonstrated the advantages of using MAD as an accuracy parameter over RMSD for the evaluation of cuffless BP devices. The disadvantages of MAD for performance evaluation were also summarized

17:45

Data Acquisition Platform for Monitoring Physiological Vital Signs and Patient-Reported Outcomes

Heejin Kim (Seoul National University Hospital, Korea (South)); Ki Young Huh (Seoul National University, Korea (South)); Meihua Piao (Peking Union Medical College, China); Hyeongju Ryu (Seoul National University, Korea (South)); Wooseok Yang (Seoul National University Hospital, Korea (South)); SeungHwan Lee and Kyung Hwan Kim (Seoul National University, Korea (South))

Various wearable devices have emerged via rapid advances in information and communications technology (ICT). This research aimed to establish an ICT-based data acquisition platform using wearable devices and self-reporting techniques. Physiological vital signs were acquired with different wearable devices, and multiple patient-reported outcomes were gathered with a mobile application. All data collected were transmitted to the hospital's internal network for immediate review by doctors and data centralization. The multi-center clinical trial evaluated the usefulness of such a platform.
I. INTRODUCTION Various wearable devices are used to monitor people's health today. However, for wearable health data to be utilized in actual diagnosis and treatment processes, those data need to be transmitted to hospitals to be reviewed by doctors and stored. However, information such as patients' physical condition and symptoms is hard to measure using wearable devices. These data can be retrieved as patient-reported outcomes (PROs). This study created and evaluated a novel information and communications technology (ICT)-based clinical data acquisition platform for managing patients' physiological vital signs and PROs.
II. METHODS Wearable electrocardiogram (ECG) and blood pressure (BP) measuring devices with Bluetooth connections were adopted for this platform. A mobile application (app) was developed to obtain both physiological vital signs and PROs. All data obtained were transmitted to the internal network of the Seoul National University Hospital Clinical Trials Center (SNUH-CTC). The Amazon web service virtual private cloud (AWS-VPC) was employed to show real-time vital signs to doctors in the SNUH-CTC.
III. RESULTS An external network (mobile app), demilitarized zone (DMZ), AWS-VPC, and the internal network of the SNUH-CTC were prepared to establish the entire platform. The mobile app handled not only vital signs, such as ECG, heart rate (HR) and BP, but also PROs, including physical condition, history of medication, and symptoms. ECG and HR were displayed in real-time through the cloud service. For data centralization and future research, all the acquired data were saved in the internal network. The performance of the integrated platform was evaluated. Data transmission was shown to be secure with a loss rate of less than 0.8%. Load testing showed that this platform could operate reliably with up to 200 users connected at once. Actual ECG data were acquired over 6 hours and saved during the multi-center clinical trial study. Approximately 80% of HR readings were within the valid range.
IV. CONCLUSION An ICT-based data acquisition platform was established to collect, transmit, observe and save physiological vital signs and PROs in real-time. Several clinical studies are planned to be conducted to evaluate the effectiveness and applicability of this new technology.

17:55

A Systematic Approach to Data Acquisition and Processing for the Use of Plantar Pressure for Diagnosis of Diabetic Foot Ulcers

Seohu Lee and Jaehyeok Lee (Sungkyunkwan University, Korea (South)); Jayun Hyun (Hippo T&C Inc., Korea (South)); Chan-Yong Park and TaiMyoung Chung (Sungkyunkwan University, Korea (South))

This paper describes the development process of a smart insole device called, DfuKare, designed as digital therapeutics for diagnosing and managing diabetic foot ulcers. We applied a unique oversampling method for data acquisition to collect pressure data efficiently. Moreover, we introduce a preprocessing method that extracts valid stance phases and normalizes them. The preprocessed results can be used as input for an artificial intelligence engine.

Screen 4

16:45
Closed-Loop Control of Mean Arterial Pressure in Fluid Resuscitation using Reinforcement Learning
Elham Estiri and Hossein Mirinejad (Kent State University, USA)

Fluid resuscitation, also called fluid therapy, is a common critical care treatment. Automated fluid resuscitation (AFR) systems employ computational control algorithms to automatically adjust the fluid infusion dosages by controlling a physiological variable (e.g., blood volume or pressure). This work presents a model-free reinforcement learning (RL) approach for the control of mean arterial pressure (MAP) in AFR systems. The proposed RL agent learns to adjust the MAP to the desired value by choosing the optimal infusion dosages using a Q-learning algorithm. This is accomplished by interacting with the environment and without having the knowledge of the system dynamics. The proposed approach overcomes the need for a precise mathematical model in AFR systems and can potentially provide a robust performance in reaching the desired hemodynamic states.

16:55
Data driven parcellation and structure-function brain mapping using joint-cmICA
Lei Wu (TReNDS Center, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

We present a new approach for integrating structural-functional brain connectivity to extract common cortical segregations from two distinct connectivity modalities. Our approach maps joint structural white matter tracts and functional connectivity network to these cortical parcellations. Overall, joint-cmICA provides an effective and convenient tool for connectivity-based multimodal data fusion in brain.

17:05
Analysis of Systolic and Diastolic Blood Pressures of Obese Young Males After Aquatic Therapy
Samer Arafat (KFUPM, Saudi Arabia)

This paper describes and analyzes blood pressure variable outcomes after treatment with either immersion in water or WATSU® therapy of 26 obese young males. The objective of this initial extended abstract is to show that subjects have shown a near random relation between systolic and diastolic blood pressures, before aquatic therapy of 26 obese subjects, and that the relation was corrected after aquatic therapy, in the sense that it demonstrated a near linear correlation and is what is shown in medical literature. This correction underlines and highlights the significance of aquatic therapies for obese subjects as demonstrated by the outcome of systolic and diastolic blood pressures.

17:15
An Explainable AI model in the assessment of Multiple Sclerosis disease
Andria Nicolaou and Antonis Kakas (University of Cyprus, Cyprus); Christos P Loizou (Cyprus Univesrity of Technology & Electrical Enginerering Departement, Cyprus); Marios Pantzaris (Cyprus Institute of Neurology and Genetics, Cyprus); Costantinos S. Pattichis (University of Cyprus, Cyprus)

Multiple Sclerosis (MS) is characterized by a complex and heterogeneous nature. Explainability methods aim to assist the experts in difficult medical cases by giving the appropriate information for disease diagnosis and progression. The objective of this study was to propose an explainable AI (XAI) model related to MS disease focusing on the assessment of the brain magnetic resonance imaging (MRI) lesions and their interrelation to disability in MS subjects based on texture feature analysis. The proposed model consisted of two main parts. The first part included the extraction of lesion features' rules using machine learning algorithms. The second part covered argumentation-based reasoning, where the extracted rules were modified to object-level arguments. The use of priority arguments removed the contradictory options and improved the overall performance of the model. The general findings showed that the argumentation theory based on the MS lesions' features can differentiate the subjects with a benign course of the disease and subjects with advanced accumulating disability by giving explanations. Thus, an XAI model focused on MS disease maybe light up the way for a better medical diagnosis and follow-up the disease evolution.

17:25
Argumentation-based Explainable ML (ArgEML) framework: a real-life use case on stroke prediction
Nicoletta Prentzas, Antonis Kakas and Costantinos S. Pattichis (University of Cyprus, Cyprus); Andrew Nicolaides (Vascular Screening and Diagnostic Centre, London, United Kingdom (Great Britain)); Efthyvoulos Kyriacou (Cyprus University of Technology, Cyprus)

This paper presents the application of a general methodology of Argumentation-based Explainable Machine Learning (ArgEML) to a real-life use case with aim to validate the approach and to provide feedback for its further development. Our

work is motivated by the natural suitability of argumentation in explainable AI (XAI), and other studies that explore how to integrate Machine Learning (ML) and argumentative reasoning.

17:35

Comparison of Proteomic Approaches in Autoinflammatory Disease Classification

Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece); Orestis D. Papagiannopoulos, Costas Papaloukas and Vasileios C. Pezoulas (University of Ioannina, Greece); Harmen J.G. van de Werken (University Medical Center, The Netherlands); Christophe Poulet (GIGA-Research CHULiège, Belgium); Yvonne Mueller and Peter Katsikis (University Medical Center, The Netherlands); Dominique de Seny (GIGA-Research CHULiège, Belgium)

A cross-analysis study was conducted to compare proteomic platforms in classifying patients with Systemic Autoinflammatory diseases, using proteins extracted from different profiling experiments. The datasets used were obtained from SomaScan assays and Mass Spectrometry (MS). A separate analysis was performed to each dataset based on the false discovery rate (FDR) in order to extract statistically important proteins. Conventional machine learning algorithms were subsequently employed to evaluate the denoted proteins as candidate biomarkers and compare the predictive capabilities of the two proteomic platforms. Using the SomaScan assay, we managed to achieve higher classification metrics compared to the MS dataset. An improvement was also attained on the classification results when the features used were extracted from the MS data and applied on the SomaScan dataset, compared to the opposite combination. Finally, the proteins derived from the FDR analysis in both datasets proved to be highly correlated regarding their importance score.

17:45

Effects of multi-variants on gene expression and concurrent regulation of multiple genes of eQTLs through chromatin higher-order many-body 3D interactions

Jie Liang, Hammad Farooq, Lin Du and Alan Perez-Rathke (University of Illinois at Chicago, USA); Constantinos Chronis (900 S Ashland Ave, USA & UIC, USA)

Chromatin folding plays an important role in the regulation of gene expression, which control cellular activities and are the basis of differentiation. With long-range spatial chromatin interactions, functional elements far away from the target gene contribute to gene regulation. While there is a large amount of data on eQTLs, which are variants that are linked to gene expression, how distal variants modulate gene expression are not well understood. The three-dimensional structure of the human genome has been shown to have significant effects on gene expression. The genetic variation observed in human population and the functional impact of such variants are reflected by the variability of the gene expression in eQTLs. However, the underlying mechanism governing the variability in gene expression is unknown. Here we tested the hypothesis that eQTLs regulate their target genes through physical chromatin interaction. We carry out simulations of 3D chromatin folding and examine spatial configurations of chromatin conformations at eQTL loci. We apply the CHROMATIX algorithm and generate large ensembles (2x104) of independent 3D single-cell chromatin conformations using population Hi-C data. We reconstruct single-cell chromatin conformations from Hi-C data and show direct physical interactions between 1-to-many and many-to-1 gene-eQTL, suggesting that multiple eQTLs regulate the expression of target gene through physical interaction, and one eQTL may affect expression of many genes.

Screen 5

16:45

Discriminating Healthy and IUGR fetuses through Machine Learning models

Beniamino Daniele and Giulio Steyde (Politecnico di Milano, Italy); Edoardo Spairani and Giovanni Magenes (University of Pavia, Italy); Maria G Signorini (Politecnico di Milano, Italy)

The purpose of this study is to develop and understand whether Machine Learning models can classify CTG recordings of healthy fetuses or IUGRs, highlighting how a large amount of data can have unexpected effects. We started from other findings in the literature to see what Machine Learning model remained consistent even with a large amount of data. The CTG records used in this study were collected at the Department of Obstetrics of the Federico II University Hospital in Naples, Italy, from 2013 to 2021. From this dataset, we chose 1548 IUGR fetuses and 1548 healthy fetuses to train our models. Each recording contained several parameters, ranging from features calculated on the entire CTG tracing, features calculated every 3 and 1 minute of recording and features related to the pregnant woman, such as age and week of gestation. We trained our machine-learning models on this dataset, checking the results obtained before and after adjusting the hyperparameters, noting that among the best models was Random Forest, which has already been present in other studies, and that the Multilayer Perceptron and the AdaBoost classifier were overall the best performing. This work can surely form a basis for future works in the fetal heart rate classification thus leading to real clinical applications.

16:55

Changes in Brain Networks During Aging Using Neuroimaging Data

Haleh Falakshahi (Georgia Institute of Technology, USA); Hooman Rokham (Georgia Institute of Technology, USA & Translational Research in Neuroimaging and Data Science (TReNDS), USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Changes in whole-brain functional networks during the aging process are still not well studied. In this study, we adopted different approaches to analyzing changes in brain networks of individuals from ages 36 to 100 years old from the human connectome project aging study. We investigate static functional network connectivity (sFNC) and dynamic functional network connectivity (dFNC) with the calculation of dynamic metrics using resting-state functional magnetic resonance imaging data. Next, we apply the network science and graph theory approach using the Gaussian graphical model (GGM) to study both static and dynamic networks in a more global manner. Results show a significant difference between the default mode network and cognitive control between the youngest and the oldest age groups in sFNC analysis. dFNC analysis reveals that the centenarian group tends to occupy one of the dynamic states of the brain more than other states where there is positive connectivity between the cerebellar and the visual domain. Our static GGM analysis showed that local efficiency, transitivity, and modularity decrease with the aging process. In dynamic GGM analysis, we observed a significant difference between some graph metrics in some brain states. Results provide insights into how aging affects functional connectivity between brain areas.

17:05

Spectrogram Image-based Machine Learning model for Carotid-to-Femoral Pulse Wave Velocity Estimation using PPG signal

Juan Manuel Vargas (King Abdullah University of Science and Technology, Colombia); Taous-Meriem Laleg-Kirati (King Abdullah University of Sciences and Engineering (KAUST), Saudi Arabia); Mohamed A. Bahloul (King Abdullah University of Science and Technology, Thuwal, Saudi Arabia)

Carotid-to-femoral pulse wave velocity (cf-PWV) is a critical biomarker for evaluating arterial stiffness and cardiovascular risk. Monitoring cf-PWV is essential for cardiovascular disease diagnosis and prediction. However, the complexity during the measurement process of cf-PWV makes it prone to present errors and inaccuracies. For this reason, a learning-based non-invasive measurement of cf-PWV using peripheral signals could overcome some of the difficulties presented in the classical measurement process and improve the quality of the estimation. In this paper, a spectrogram-based machine learning model obtained from the photoplethysmogram (PPG) waveform is proposed for the estimation of the cf-PWV. For this purpose, two machine learning models have been developed using three different types of features. The first category is based on an adaptive signal processing method called Semi-Classical Signal Analysis (SCSA) that relies on the spectral problem of the Schrodinger operator; the second type proposed is energy texture-based, and the third is the statistical texture representation. Finally, the training and testing datasets were extracted from in-silico, publicly available pulse waves and hemodynamics data. The obtained results provide evidence for the feasibility and robustness of the spectrogram to transform the signals into an image and machine learning method as a tool for estimating the cf-PWV.

17:15

Relationship of Hemodynamic Delay and Sex Differences Among Adolescents Using Resting-state fMRI Data

Hooman Rokham (Georgia Institute of Technology, USA & Translational Research in Neuroimaging and Data Science (TReNDS), USA); Haleh Falakshahi (Georgia Institute of Technology, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Among the non-invasive neuroimaging techniques, resting-state functional magnitude imaging is the most widely used method for capturing whole brain activity. Functional connectivity enables us to extract brain networks which exhibit temporal coherence from resting-state fMRI data. However, there are some limitation to fMRI which limit the questions we can ask. The latency estimated from fMRI is a mixture of the sluggish hemodynamic delay and neural latencies. Due to the large spatially varying delays related to hemodynamics, the pattern and order of activities between brain regions in a very short period will be driven by hemodynamics in this case. In this study, we proposed a method to estimate the hemodynamic delays between brain regions. We performed cross-correlation between pairs of time courses and estimated the optimal lags such that the correlation is maximized. We applied our method to a large dataset of adolescents and investigated the differences between males and females on different lag measures. In addition, we proposed short and long-time delay graphs to visualize the differences between groups more easily. Our result suggests that the female subjects had shorter hemodynamic delay compared to the male group of the same age. Significant differences were identified both within and between domain regions, including the cerebellar, somatomotor, default mode, cognitive control, and visual domain.

17:25

Conditional image synthesis for improved segmentation of glomeruli in renal histopathological images

Florian Allender (Université de Strasbourg & Laboratoire ICube, France); Rémi Allègre (ICube, Université de Strasbourg, CNRS, France); Cedric Wemmert (University of Strabourg, France); Jean-Michel Dischler (University of Strasbourg, France)

In a context of limited data availability, we consider the supervised segmentation of glomerular structures in patches of renal histopathological whole slide images. These structures are complex, include multiple substructures, and exhibit great variability in their shape, making their robust segmentation challenging. In this context, using appropriate data augmentation techniques is crucial to obtain more robust results. We investigate data augmentation based on random spatial deformations and conditional image synthesis for the training of a U-Net model. We rely on a SPADE model to perform the synthesis, using label maps built from the real patches available for training as input. Synthesis from ground truth masks only results in noisy patches, where substructures are absent, whereas additional structure information yield more realistic patches. We show that the best improvements of the segmentation performances are obtained by mixing real patches with synthetic patches generated from ground truth masks only, which yields an increase of up to 0.76 point of average dice score w.r.t. augmentation based on spatial deformations only. We conclude that, using conditional image synthesis, patches synthesized with no additional structure information better contribute to the robustness of glomeruli segmentation than patches synthesized with structure information extracted from available real patches.

17:35

A Temporal-oriented Broadcast ResNet for COVID-19 Detection

Xin Jing (University of Augsburg, Germany); Shuo Liu (Universität Augsburg, Germany); Emilia Parada-Cabaleiro (Johannes Kepler University Linz, Austria); Meishu Song (University of Tokyo, Japan); Andreas Triantafyllopoulos (AUDEERING GmbH, Germany); Zijiang Yang (ZD. B Chair of Embedded Intelligence for Health Care and Wellbeing, University of Augsburg, Germany); Bjoern Schuller (Imperial College London, United Kingdom (Great Britain))

COVID-19 pandemic is one of the main health challenge for our world. Although there are rapid testing methods, their efficiency is often limited by the capacity of the testing equipment. Indeed, ubiquitous low cost methods for detecting COVID-19 are still being explored. Detecting COVID-19 from audio signals, such as breathing and coughing, can be used as a fast and efficient pre-testing method to reduce the virus transmission. Due to the promising results of deep learning networks in modelling time sequences, and since applications to rapidly identify COVID in-the-wild should require low computational effort, we present a temporal-oriented broadcasting residual learning method that achieves efficient computation and high accuracy with a small model size. Based on the EfficientNet architecture, our novel network, named Temporal-oriented ResNet (TorNet), constitutes of a broadcasting learning block, ie the Alternating Broadcast (AB) Block, which contains several Broadcast Residual Blocks (BC ResBlocks) and a convolution layer. With the AB Block, the network obtains useful audio-temporal features and higher level embeddings effectively with much less computation than Recurrent Neural Networks~(RNNs), typically used to model temporal information. TorNet achieves 72.2% Unweighted Average Recall (UAR) on the INTERPSEECH 2021 Computational Paralinguistics Challenge COVID-19 cough Sub-Challenge, by this showing competitive results with a higher computational efficiency than other state-of-the-art alternatives.

17:45

Continual learning of longitudinal health records

Jacob Armstrong and David Clifton (University of Oxford, United Kingdom (Great Britain))

Continual learning denotes machine learning methods which can adapt to new environments while retaining and reusing knowledge gained from past experiences. Such methods address two issues encountered by models in non-stationary environments: ungeneralisability to new data if models remain fixed after initial training, and the catastrophic forgetting of previous knowledge if they are retrained on new data. This is a pervasive problem in clinical settings where patient data exhibits covariate shift not only between populations, but also continuously over time. However, while continual learning methods have seen nascent success in the imaging domain, there has been little application to or exploration of their performance on the type of multi-variate time-series data characteristic of patient medical recordings. Here we evaluate a variety of continual learning methods (both regularization and rehearsal based) on longitudinal ICU data in a series of representative healthcare scenarios. Scenarios include patient populations varying in ethnicity, age, geography, and different populations sampled over time. We find that while several regularisation and rehearsal based methods mitigate short-term forgetting, domain shift remains a challenging problem over a large series of shifts, with only rehearsal based methods achieving stable long-term performance. Code for reproducing all experiments can be found at https://github.com/iacobo/continual

17:55

Comparison of Missing Data Imputation Methods using the Framingham Heart study dataset

Konstantinos Stavros Psychogyios, Loukas Ilias and Dimitris Askounis (National Technical University of Athens, Greece)

Cardiovascular disease (CVD) is a class of diseases that involve the heart or blood vessels and according to World Health Organization is the leading cause of death worldwide. EHR data regarding this case, as well as medical cases in general, contain missing values very frequently. The percentage of missingness may vary and is linked with instrument errors, manual data entry procedures, etc. Even though the missing rate is usually significant, in many cases the missing value imputation part is handled poorly either with case-deletion or with simple statistical approaches such as mode and median imputation. These methods are known to introduce significant bias, since they do not account for the relationships between the dataset's variables. Within the medical framework, many datasets consist of lab tests or patient medical tests, where these relationships are present and strong. To address these limitations, in this paper we test and modify state-of-the-art missing value imputation methods based on Generative Adversarial Networks (GANs) and Autoencoders. The evaluation is accomplished for both the tasks of data imputation and post-imputation prediction. Regarding the imputation task, we achieve improvements of 0.20, 7.00\% in normalised Root Mean Squared Error (RMSE) and Area Under the Receiver Operating Characteristic Curve (AUROC) respectively. In terms of the post-imputation prediction task, our models outperform the standard approaches by 2.50\% in F1-score.

18:05

A Multi-modal Graph Convolutional Network for Predicting the Prognosis of Human Breast Cancer

Susmita Palmal and Nikhilanand Arya (Indian Institute of Technology Patna, India); Sriparna Saha (IIT Patna & Department of CSE, India); Somanath Tripathy (IIT Patna, India)

Breast cancer is one of the most often found malignancies in women. For more focused treatment and disease management, a better prognosis for breast cancer is crucial. To address this issue, we proposed a novel classification model in this study, that is based on multi-modal graph convolutional networks (MGCN). To extract features, we first build a graph convolutional network (GCN) for individual modalities. And then, we feed the concatenated features generated by GCN into the stack-based ensemble model. The GCN model explores the underlying non-regular structural information from the data. The proposed model outperforms the state-of-the-art in terms of precision, balanced accuracy, and Matthew's correlation coefficient as 0.869, 0.741, and 0.498, respectively.

Screen 6

16:45

Improving the quality of anthropometric measures during medical consultations with children aged under five years old in Burkina Faso

Aziza Merzouki (University of Geneva, Switzerland); Wessel Valkenburg and Marc Bayala (Terre des Hommes Foundation, Switzerland); Maroussia Roelens and Olivia Keiser (University of Geneva, Switzerland); Amara Amara (Terre des Hommes Foundation, China)

Background: Millions of medical consultations are conducted each year in Burkina Faso using the Electronic Register of Consultations (REC). Based on the consultation data collected, we present a method to quantify the quality of individual and ensembles of consultations conducted by frontline healthcare workers (FHWs).
Methods: We focus on anthropometric measurements and vital signs (age, weight, height, mid-upper arm circumference and temperature) of children aged between two months and five years old. We compare individual and ensemble of consultations to a multivariate probability distribution defined by an external population-specific, gold standard consultation dataset. By comparing the distributions of consultations to the reference probability distribution, we define a score to rate the quality of measurements and data entry of FHWs.
Results: The defined scores allow us to detect which measurements are most problematic. They also allow us to detect potential biases in the consultation and treatment of different patient groups. No systematic gender-bias was found among FHWs. Height measurements were the most challenging; consultations with the lowest scores were associated with underestimated heights in children. Among these consultations, height was found to be even more underestimated among boys than girls.
Conclusions: Our findings enable us to support capacity building of frontline healthcare workers. The REC can be enriched with real-time specific alert on errors, and individual FHW can be proposed targeted trainings. Dynamic dashboards can also support district managers to navigate the entire population of FHWs, understand FHWs' main challenges and prioritise their interventions in primary healthcare centres.

16:55

Detection of distorted gait and wearing-off phenomenon in Parkinson's disease patients during Levodopa therapy

Hamid Moradi (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Nils Roth (University of Erlangen-Nuremberg, Germany); Ann-Kristin Seifer (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Bjoern M Eskofier (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

Levodopa (L-dopa) is the gold-standard medication and the most commonly used substance in the treatment of motor complications in PD patients. "Wearing-off" phenomenon is the most frequent complication developed by long-term L- dopa therapy which results in the reemergence of the PD symptoms during the therapy and lower quality of life in patients. Detecting and monitoring the onset and the duration of wearing-off alongside the persistence of the symptoms; known as "delayed-on", would enable the patients to receive the medication changes in the required time whilst preventing them from extravagant use of L-dopa. Home monitoring systems using inertial measurement units have enabled us to measure gait parameters in unsupervised environments. By using patients' medication diaries and their gait parameters obtained from continuous real-world data in a course of two weeks, we developed a system to identify the distorted gait spans during L-dopa therapy utilizing personalized machine learning. Our algorithm differentiates between the two states of medication in effect, and the distorted gait states with the mean accuracy of 77% ± 3.37. Furthermore, by analyzing each model's feature importance, we found that maximum sensor lift was the most prominent feature affected in the distorted gait sequences. We contribute to a better understanding of the repercussions of wearing-off episodes on gait during L-dopa therapy, as well as proposing a system to facilitate clinicians in monitoring the severity of these episodes more efficiently.

17:05

Automating Treatment Recommendations for Children with Cerebral Palsy Based on Multi-Modal Clinical Data

Aishwarya Mahale, Yuanda Zhu and Sami Belhareth (Georgia Institute of Technology, USA); Adam Graf, Karen Kruger and Joseph Krzak (Shriners Children's, USA); May Dongmei Wang (Georgia Institute of Technology and Emory University, USA)

Cerebral Palsy (CP) is the most common cause of physical disability in children with a prevalence of 2.5 per 1000 births. The physical disability caused by CP can disrupt body movements such as gait, which is essential for healthy pediatric development and overall well-being. Using a diagnostic matrix of clinical history, physical examination, imaging, and gait analysis data, clinicians can quantify how musculoskeletal impairments are impacting movement. This data is necessary for evidence-based treatment planning. However, subjectivity and variability in interpretation of gait analysis data usually cause low agreement about CP interventions between clinicians or institutions. Consequently, the treatment planning process varies by clinicians and can take a significant amount of time to look over all of the data and years of expertise to reach the level of competency necessary to synthesize it. In this study, we presented an evidence-based clinical decision support system that automatically recommends treatment options for pediatric patients with CP based on an expert-verified clinical workflow. Our application integrated multi-modal clinical data, including patient demographic, physical exam, and gait analysis information. We further validated the automated clinical workflow using de-identified patient data, achieving an accuracy of 0.612 out of nine potential treatment options. Moreover, the proposed model generated interpretable results to facilitate clinicians who can understand and trust the automated clinical workflows. Our work could serve as the foundation for evidence-based, data-driven treatment planning in pediatric CP clinical practice and clinical research, thereby enhancing the efficiency and accuracy in cerebral palsy patient care.

17:15

Class Activation Maps for the disentanglement and occlusion of identity attributes in medical imagery

Laura Carolina Martínez Esmeral (Paris Lodron University of Salzburg, Austria); Andreas Uhl (University of Salzburg, Austria)

Deriving patients' identity from medical image data presents a very serious threat to privacy, due to the fact that these kind of data are usually acquired to support diagnosis or serve as an aid in human forensics (among other applications) but not to reveal identity-related features. Nonetheless, for many medical imaging modalities, ranging from X-Rays to MRI or even endoscopies, this type of identity breaches have been reported. In general, these methods are based on more traditional computer vision techniques like the employment of hand-crafted features. Still, the use of learned features by means of deep learning methodologies has slowly acquired some relevance in this field, specially for biometric purposes. In order to cope with this, some de-identification methods based on Generative Adversarial Networks have been explored in the literature. However, in this paper, we try to avoid the generation of synthetic data. Instead, we aim to perform a total occlusion of the personal identifiers directly on the images by means of Class Activation Maps, in such a way that areas, where features are gathered, are detected and, subsequently, removed. Nonetheless, when doing so, diagnosis related features must not get altered, otherwise the images would not be useful for their initial purpose.

17:25

Emotional State Identification of Elderly People in Daily Life

Zisheng Li (Hitachi, Japan)

We propose a prediction model which combines time series learning and feature learning for emotional state identification in daily life by only using heart rate data from wristband sensor. We collected heart rate signal from 8 elderly people in daily life for 3 weeks. Evaluation experiments on such dataset show that the average AUC is higher than 0.60 for identification of valence and arousal.

17:35

Healthy Aging Using Smart Home Technology - A Pilot Study on Evaluating Relationship Between Steps and Motion

Kang Wang, Shi Cao and Plinio P Morita (University of Waterloo, Canada)

The worldwide aging population is increasing at an unprecedented rate. Facing the challenges this demographic milestone brings to the homecare, smart home technologies have been widely used by families to support indoor healthcare for seniors. The purpose of this study is to evaluate the correlation between steps data from wearable devices and motion data from smart home devices, validating the hypothesis that smart motion sensors can be used to quantify and track individuals' steps count. Results show that there is a moderate association between motion counts from Swidget and steps from Fitbit, as well as a clear trend alignment between them.

17:45

Classification of Schizophrenia and Alzheimer's Disease using Resting-State Functional Network Connectivity

Reihaneh Hassanzadeh (Center for Translational Research in Neuroimaging and Data Science (TReNDS) & Georgia State University, USA); Anees Abrol (TReNDS, Georgia State University, USA); Vince Calhoun (Tri-Institutional Research Center in Neuroimaging and Data Science, USA)

Neuroimaging studies in Alzheimer's disease (AD) and schizophrenia (SZ) have compared AD or SZ subjects against control (CN) subjects. However, it is also of interest and more critical to identify potential biomarkers by comparing these disorders, which can share some overlap, to each other directly. In this study, we investigated similarities and differences in resting-state functional network connectivity (rs-FNC) between 162 AD + late mild cognitive impairment (LMCI) and 181 SZ subjects from two well-known datasets - Alzheimer's Disease Neuroimaging Initiative (ADNI) and Bipolar and Schizophrenia Network on Intermediate Phenotypes (B-SNIP). We applied standard machine learning algorithms on confounder-controlled FNC features to distinguish groups of subjects, achieving an accuracy of 89% in classifying AD+LMCI vs. SZ subjects and an accuracy of 68% in a three-way classification of AD+LMCI, SZ, and CN subjects. Our results indicate that support vector machine (SVM) with an RBF kernel outperforms linear SVM and other machine learning methods, including random forest (RF), logistic regression (LR), and k-nearest neighbor (KNN). Furthermore, we conducted experiments for monitoring the potential impact of biases and showed that our trained models perform reasonably in a dataset-agnostic way. Finally, our findings highlight cerebellum and cognitive control networks as notable domains in common and unique FNC changes in AD and SZ disorders.

17:55

Explainable computer vision analysis for embryo selection on blastocyst images

Athanasios Kallipolitis and Melina Tziomaka (University of Piraeus, Greece); Dimitris Papadopoulos (REA Fertility and IVF Unit, Greece); Ilias Maglogiannis (University of Piraeus, Greece)

Infertility significantly affects the life quality of people on social and psychological levels and is estimated to expand in the coming years. In vitro fertilization is the applied answer of modern medicine to the ever-rising problem of low fertility in economically developed countries. Designated experts base their decision on selecting the most suitable embryo for transfer in the uterus by reviewing blastocysts images. Therefore, subjectivity and erroneous judgement can influence the progress of the whole fertilization process since no repeatable criteria exist to characterize the quality of each embryo. Towards the quantization of the visual content of ‘wannabe babies' embryos, a comparative study between traditional machine and deep learning techniques is conducted in this paper. The utilization of a novel unsupervised segmentation scheme for the separation of trophectoderm and inner cell mass area provides a significant boost to the performance of traditional machine learning techniques. Moreover, an explainability technique that is based on the information retrieved by the Fisher Vector's generative model provides the necessary connection between the visual stimuli and the predicted results. The classification results of the proposed methodology are comparable with state-of the-art deep learning techniques and are accompanied by corresponding visual explanations that reveal the inner workings of each model and provide useful insight concerning the predictions' validity

Screen 7

16:45

Performance Analysis of Single Coreshell Magnetoelectric Microdevice for Electrical Stimulation

Ram Prasadh Narayanan and Fazel Rangriz (NTNU, Norway); Ali Khaleghi (Norwegian University of Science and Technology (NTNU) & Oslo University Hospital, Norway); Ilangko Balasingham (NTNU, Norway)

Electrical stimulation of biological cells and tissues is an established technique to stimulate cells such as neurons and cardiomyocytes to enable the treatment of some disorders like Parkinson's disease, cardiac arrhythmias, obstructive sleep apnea epilepsy, and depression. These devices use electronic circuits, batteries, and wires to transfer the stimulation signal to the target region. On the contrary, macro-scale devices such as scalp based bioelectrodes, surgical implants

etc., require invasive surgery and constant fault monitoring. The use of standalone bio-compatible wireless micro-devices that can enable remote control and monitoring, powering and stimulation of cells and tissues and, deliver the stimulation therapy without additional circuits and battery, can be a significant advantage. In this paper, we introduce the concept of using magnetoelectric (ME) material composition to generate controllable electrical stimulation patterns for the Central Nervous System (CNS) stimulation therapy. We propose the potential use of ME structures in multi-modal resonant frequencies, for active stimulation. A spherical ME coreshell microdevice is designed and the Multiphysics numerical computations are used to evaluate the strain induced voltage on the device by using a remote magnetic bias and alternating magnetic field. It is shown that using the ME device in the resultant strain mode can create a sufficient voltage gradient that can potentially be used for wireless stimulation.

16:55

Analyzing Retention in a Remote Digital Health Study: A Case Study with CovIdentify

Md Mobashir Hasan Shandhi, Peter J Cho, Tommy Tseng, Amrita Lakhanpal, Geoffrey S Ginsburg, Christopher W Woods, Ryan J Shaw and Jessilyn Dunn (Duke University, USA)

Investigating the effect of different demographic factors on retention in remote digital health studies can help us to understand the representativeness of different groups in studies and proactively design studies to mitigate attrition. I. INTRODUCTION Rapid growth in technology and growing prevalence of digital technologies, such as smartphones, smartwatches, and activity trackers, among the general population have demonstrated the potential and feasibility of digital clinical measures from these devices and/or electronic patient-reported outcomes in monitoring and tracking infectious diseases, including, influenza, Lyme disease, COVID-19 [1] and chronic diseases. Despite the promise and potential that digital health technologies have demonstrated to revolutionize remote patient monitoring and health studies/clinical trials, maintaining adherence in these remote longitudinal digital health studies remains a challenge [2], which is further exacerbating the lack of representation from the historically underserved and underrepresented populations.
II. METHODS We developed a mobile health platform "CovIdentify" to detect and monitor COVID-19 and influenza from wearable device data and patient-reported symptoms [1]. Participant enrollment began in April 2020. We collected wearable device data (e.g., Fitbit, Garmin, Apple Watch), and self-reported daily symptoms for 12 months using surveys sent via email, text message, or smartphone app. To date, we have enrolled 7401 participants, including 146 who tested positive for COVID-19. We performed statistical analysis (survival analysis with "right-censoring" and Cox proportional-hazard models) on the survey data for the first thirty days of the study for each participant who filled out at least one day of daily surveys to understand the effect of different demographic factors on the retention in the study. III. RESULTS AND DISCUSSION Of the 7401 participants enrolled in the study, 5706 participants filled out at least one day of daily symptom surveys with the maximum duration in the study of 135±133 days. We did not observe any difference in retention between genders (p-value > 0.05) but observed significantly lower retention (p-value < 0.05) among Black and Asian participants compared to White participants (Fig. 1(a)). Similarly, we have also observed a significant difference in retention (p-value < 0.05) among age groups (Fig. 1 (b)), with younger adults (age 18-29) showing the lowest retention and the elderly (age 60+) showing the highest retention, which is in accordance with findings from other studies [3]. IV. CONCLUSION AND FUTURE WORK We demonstrated how demographic factors can impact participant retention in a digital health study during the time of the COVID-19 infection. This can be translated to identify underrepresented and underserved communities in digital health studies, and proactively adjust study design to improve retention in future remote longitudinal health studies.

17:05

Medical knowledge extraction from graph-based modeling of electronic health record

Athanasios Kallipolitis (University of Piraeus, Greece); Andreas Menychtas (BioAssist S.A., Greece); Panayiotis Tsanakas (National Technical University of Athens, Greece); Dimosthenis Kyriazis and Ilias Maglogiannis (University of Piraeus, Greece)

Treating the wealth of heterogenous health data in a tabular manner deprives us from the knowledge that is hidden in interactions between the different types of data. In this paper, a novel graph-based data modeling approach is presented. Initial results demonstrate that the generation of compact medical representations based on graphs have a positive impact on the performance of machine learning tasks.

17:15

Development of a mobile Patient App for chronic respiratory disease patients using new wearable devices. The WELMO perspective

Evangelos Chatzis (Aristotle University, Greece); Nicos Maglaveras (Aristotle University of Thessaloniki, Greece)

Chronic respiratory diseases are leading causes of morbidity and mortality in EU and worldwide. The current management of respiratory diseases allows only a momentary patient assessment at the time point of outpatient department visit or hospitalization. The incorporation of novel low-cost electronics in garments presents great potential for making accurate and effective continuous monitoring of lung diseases feasible. The EU WELMO project (Wearable Electronics for Effective

Lung Monitoring) developed novel miniaturized sensors, integrated to a comfortable vest, enabling the accurate and continuous monitoring of the lungs, through the collection of lung sounds and EIT signals, that can be combined, processed and linked with specific clinical outcome, rendering the systematic, accurate and real-time evaluation of respiratory conditions possible. The data and features derived from lung sounds, EIT (Electrical Impedance Tomography) and medical sensors are best exploited in an integrated manner, towards identifying patterns of diagnostic value and patient coaching/adherence value. The proposed WELMO also offers novel algorithms for processing the collected data, and applications for presentation of the processing outcomes. Two user applications the Patient app and the HCP (Health Care Professional) app were developed. This paper presents the design of WELMO Patient App. The description of software design yields the systematic process to consider every aspect and challenge of the proposed system. The presentation focuses on the functionality of Patient Application and the ease of use by health experts. The design led to a functional software which complements the hardware and is an essential and novel part of the innovative lung monitoring system of WELMO

17:25
System Framework for Bluetooth-based Wireless Electromagnetic Tracking and Navigation System
Charu Pande (Tyndall National Institute & University College Cork, Ireland); Padraig J Cantillon-Murphy (Tyndall National Institute & Quadrant Scientific, Ireland)

Tracking and navigation plays an important role in image-guided procedures. Majority of existing tracking systems use wired sensors for navigation. This paper provides a system framework for the development of a Bluetooth-based wireless Electromagnetic tracking (EMT) system, compares the tracking data with its wired counterpart and provides system-level integration with standardized open interfaces and protocols. The experimental data analytics show that the tracking results are favorable for image-guided applications.

17:35
LETHE: A digital intervention for cognitive decline
Vasileios S. Loukas (University of Ioannina, Greece); Lefteris Koumakis (Computational Biomedicine Laboratory, FORTH-ICS, Greece); Thomas Kassiotis (Developer, Greece); Georgia Karanasiou (Senior Researcher, Medlab, University of Ioannina, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece); Sten Hanke (University of Applied Science - FH Joanneum, Austria); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Dementia is the main cause of disability in elderly populations with several pathological, lifestyle and heritable factors, which can be modifiable. The main target of LETHE is to design and implement a Big Data collection and analysis system for the prevention, personalized risk detection and intervention on cognitive decline. Through a subsequent 2-year clinical trial, the LETHE system will be evaluated and validated in terms of improved Quality of Life.

17:45
Safe Robot Navigation in Indoor Healthcare Spaces
Evropi Toulkeridou (University of Cyprus, Cyprus); Antreas Kourris (University of Cyprus & CYENS - Centre of Excellence, Cyprus); Eftychios G Christoforou (University of Cyprus, Cyprus); Raquel Juliá Ros and Marc Bosch (Robotnik Automation, Spain); Rafa Lopez (Robotnik Automation Sll, Spain); Arthur Perrot, Alexis Godart and Nacim Ramdani (University of Orléans, France); Costantinos S. Pattichis (University of Cyprus, Cyprus); Andreas S. Panayides (CYENS Centre of Excellence, Cyprus & 3AE Health LTD, Cyprus)

The present study proposes a safe robot navigation methodology in healthcare spaces and aids towards the wider application of studies on Human-Robot Interaction in less structured environments. Using state-of-the-art methods such as Convolutional Neural Networks, the robots should be able to detect the presence and identify the type of dynamic obstacles inside their visual field and adapt their navigation accordingly.

17:55
Security Flaws for a Medical IoT Application
Vasiliki Liagkou (University of Ioannina & Computer Technology Institute and Press Diophantus, Greece); Chrysostomos Stylios (PLATANI, Greece & Industrial Systems Institute, Athena RC, Greece); Sofia Sakka (University of Ioannina, Greece)

Human activity recognition systems are becoming more and more attractive in healthcare support and they have attracted the interest of academia. Despite their development, there are still doubts of the secure and trustworthy exchange of sensitive data between several kinds of participated parties with different aims and claims, regarding the security, data protection and trust issues. Initially, we list the security vulnerabilities on Human activity recognition systems. Then we focus on a specific attack, the Man in the Middle attack, where a third malicious entity interferes with communication between two entities and is associated with key exchange protocols. Finally we discuss various design considerations for protecting the

data that is transmitted and stored from different sources like smart wearables, mobile phones and cloud applications by using edge network devices.

18:05

Design & Development of Misinformation Analysis System for Government Prevention of Public Health Crises

Irfhana Zakir Hussain (University of Waterloo, Canada & SRM Institute of Science and Technology, India); Jasleen Kaur, Matheus Lotto, Zahid Ahmad Butt and Plinio P Morita (University of Waterloo, Canada)

Digital misinformation, primarily on social media, has led to harmful and costly beliefs in the general population. Notably, these beliefs have resulted in public health crises to the detriment of governments around the world and their citizens. Subsequently, there is a critical need for an expert system that can process large amounts of digital data related to health information to detect patterns of public health misinformation. Such a system would provide the means for government intervention before public health crises emerge. This study highlights the design and development of a big data pipeline and ecosystem named Misinformation Analysis System (MAS) for the identification and analysis of false information disseminated via social media on a certain topic or set of related topics. MAS is a platform-independent ecosystem developed in Python that depends on the Twitter V2 API and the Elastic Stack. The expert system MAS involves 5 different components as shown in figure 1: a) Data Extraction Framework; b) Latent Dirichlet Allocation (LDA) Topic Model; c) Sentiment Analyzer; d) Information Disorder Classification Model; e) Elastic Cloud Deployment (Indexing of data and visualizations). The Data Extraction Framework queries data through the Twitter V2 API after taking in user requirements. The LDA Topic Model, Sentiment Analyzer, and Information Disorder Classification Model are independently trained using a small, expert-validated subset of the extracted data. These models are then incorporated into MAS to analyze and classify the remaining data. Finally, the analyzed data is loaded into an index in the Elastic Cloud deployment and can then be presented in dashboards with advanced visualizations and analytics pertinent to misinformation analysis. At its current iteration, each component in the system is performing satisfactorily. The data extraction framework handles large loads of data within short periods of time. The LDA topic models have achieved relatively high coherence values (0.54) and the predicted topics are accurate and befitting to the data. The sentiment analyzer is performing sufficiently at a correlation coefficient of 0.61 but could be improved in further iterations. The information disorder classifier has attained a satisfactory correlation coefficient of 0.762 against the expert-validated data. Moreover, the Elastic cloud deployment is efficient in its storage of data and comprehensive in its visualization and analytics capabilities. In fact, the independent investigator has successfully utilized the system to extract interesting and important insights. The novel MAS pipeline has the potential to detect and analyze misleading information related to a particular topic or set of related topics. Furthermore, this approach can elaborate on integrating social media data into the dashboard for multiplatform analysis and testing of the ecosystem on other health use cases.

Screen 8

16:45

Spectrum Estimation of Heart Rate Variability Using Low-rank Matrix Completion

Lei Lu and Tingting Zhu (University of Oxford, United Kingdom (Great Britain)); Yuanting Zhang (City University of Hong Kong, China); David Clifton (University of Oxford, United Kingdom (Great Britain))

Heart rate variability (HRV) is an important non-invasive parameter to assess the cardiac autonomic nervous system. In particular, spectrum matrices of HRV data have been used for physical and mental health monitoring. However, measurement uncertainties from data acquisition and physiological factors can easily affect the HRV spectrum and degrade outcomes of health monitoring. In this paper, we propose a new model for incomplete spectrum estimation of the HRV data based on matrix completion (MC). We show that our model performs efficiently when estimating missing entries for the HRV spectra. Moreover, a refined model of matrix completion (RMC) is proposed in this paper that can be derived from correlation analysis of the HRV spectra. Two benchmark electrocardiography (ECG) datasets are retrieved and used to derive the HRV data, which are employed to evaluate the performance of our RMC method on the estimation of missing entries in the spectra. Furthermore, four different types of deep recurrent neural networks and the traditional MC method are used for comparison study, and our RMC method obtains the least estimation error with different masking ratios. The experimental studies and comparison results demonstrate advantages and robustness of our developed method for the estimation of incomplete HRV spectra.

16:55

A Multi-modal Clinical Dataset for Critically-Ill and Premature Infant Monitoring: EEG and Videos

Yongshen Zeng (Southern University of Science and Technology, China); Xiaoyan Song and Hongwu Chen (Nanfang Hospital of Southern Medical University, China); Weimin Huang (Shenzhen Children's Hospital, China); Wenjin Wang (Southern University of Science and Technology, China)

The comprehensive monitoring of cardio-respiratory and neurological events of premature infants is desired for the Neonatal Intensive Care Unit (NICU). Video-based infant monitoring is an emerging tool for NICU as it eliminates skin irritations and enables new measurements like pain assessment. A multi-modal clinical dataset across the measurement of EEG and videos will be helpful in developing novel monitoring solutions for infant care. In this paper, we created such a dataset by simultaneously collecting the EEG signal and video data from critically ill and preterm infants in NICU. Along with the recordings, we used the video-based cardio-respiratory measurements (heart rate and respiratory rate) to examine the validity of video recordings. We employed a classical video-based physiological measurement framework called Spatial Redundancy in combination with living-skin detection to measure the vital signs of recorded infants. The pilot measurements show the feasibility as well as the challenges that need to be addressed in algorithmic design in the next step. The dataset will be made publicly available to facilitate the research in this area. It will be useful for studying the video-based infant monitoring and its fusion with EEG, which may lead to new measurements such as a neonatal PSG for infant sleep staging and disease analysis (e.g. neonatal encephalopathy, neonatal respiratory distress syndrome).

17:05

Surveillance Camera-based Cardio-respiratory Monitoring for Critical Patients in ICU

Haowen Wang (Southern University of Science and Technology, China); Jia Huang (Intensive Care Unit, the Third People's Hospital of Shenzhen, China); Guowei Wang (Intensive Care Unit, The Third People's Hospital of Shenzhen, China); Hongzhou Lu (The Third People's Hospital of Shenzhen, China); Wenjin Wang (Southern University of Science and Technology, China)

Camera-based vital signs monitoring has been extensively researched in non-medical fields in recent years. Intensive Care Unit (ICU) typically requires continuous monitoring of patients' physiology for alarming the emergency such as patient deterioration or delirium. In this paper, we propose to use the surveillance CCTV cameras installed in ICU for cardio-respiratory monitoring of critically-ill patients, thus created a first clinical video dataset (including 10 deteriorated patients) in ICU using CCTV cameras. Along with the dataset, a video processing framework with the latest core algorithms designed for pulse and respiratory signal extraction has been demonstrated. A joint Region-of-Interest optimization approach using pulsatile living-skin maps and respiratory maps was proposed to improve the vital signs monitoring for ICU patients. A motion intensity based quality metric was designed to reject measurement outliers induced by patient motion or nurse operation. Based on the valid measurements selected by the metric, the overall Mean Absolute Error for heart rate is 2.17 bpm, and for breathing rate is 1.69 bpm. Preliminary clinical validations show that robust cardio-respiratory monitoring is indeed feasible for CCTV cameras in ICU, and such a warding solution can be quickly integrated into current hospital information systems for large-scale deployment, by leveraging the existing hardware and infrastructures of the Internet of Medical Things.

17:15

AI Methods for Personalized Suggestions on Smart Glasses Based on Human Activity Recognition

Dimitrios G Boucharas and Christos Androutsos (Biomedical Research Institute - FORTH, Greece); Nikolaos Tachos (Unit of Medical Technology and Intelligent Information Systems, Greece); Evanthia E Tripoliti (Unit of Medical Technology and Intelligent Information Systems & University of Ioannina, Greece); Dimitrios Manousos, Vasileios Skaramagkas and Emmanouil Ktistakis (Institute of Computer Science - FORTH, Greece); Kostas Marias (FORTH, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Smart wearables are becoming an irreplaceable part of daily living by supporting their users to maintain or adopt healthier lifestyles and monitor their current status. While the trend is increasing, little has been accomplished in the field of personalized solutions. In the present study, two models derived from distinct conceptual themes were developed, and the performance was evaluated utilizing a wearable prototype in the form of smart glasses. A statistical and a reinforcement learning approach were adopted to construct a personalization layer in terms of a predefined system reaction upon specific user behavior. The settings of the present study involve the user behavior derived from Artificial Intelligence (AI) based human activity recognition, among others, and the system reaction being a supportive Augmented Reality (AR) based functionality. Each approach yielding different benefits and drawbacks, imminently leads to a comparative analysis based on the efficiency offered by assessing the inference, update, and trend handling time. Both models are built upon the user's previous data, resulting in a data driven approach that is entirely different for each user and tailored to the user preferences. The results derived from the comparative analysis indicate that both approaches offer the personalization seeked, with the reinforcement learning approach to adapt faster.

17:25

Development and Independent Validation of Energy Expenditure Models Using SmartStep

Nagaraj Hegde (Hyperice, The Netherlands); Tracy Swibas (University of Colorado, USA); Edward Melanson (University of Colorado, The Netherlands); Edward Sazonov (The University of Alabama, USA)

In this work we developed and validated a method to capture the activities of daily living (ADL), transitions between ADL, and the associated Energy Expenditure (EE) using a novel insole based wearable system (SmartStep). A 15-participant study was conducted in a controlled laboratory environment while participants wore the SmartStep and performed various ADL. Machine learning models were developed using 4-branched and 8-branched steady-state activities to estimate the total energy expenditure (TEE) and physical activity energy expenditure (PAEE). Additional models accounting for transitions between activities were also developed. These models were validated in an independent study with 8-participants, performed in a whole room indirect calorimeter. In the controlled study, the 8-branched models had a lower root mean square error (RMSE, 0.58 vs. 0.67 kcal/min) and lower total error (-1.5% vs. 3%). In the validation study, the 8-branched models also had a lower RMSE (0.9 kcal/min vs. 1.2 kcal/min) and lower total error (-4.5% vs 11%). Accounting for activity transitions reduced the total error in the EE estimation to -1.3%. The results suggested that SmartStep can be used to accurately monitor the EE of the wearers in their daily living. The validation study results suggested that 8-branched models more accurately predict EE than 4-branched models and that accounting for activity transitions improves the estimation of EE in daily living.

17:35

Prediction of Lifted Weight Category Using EEG Equipped Headgear

Sencer Melih Deniz (TÜBİTAK BİLGEM, Turkey); Hamraz Javaheri and Juan Vargas (German Research Center for Artificial Intelligence, Germany); Dogan Urgun (TÜBİTAK, BİLGEM, Turkey); Fariza Sabit (TU Kaiserslautern, Germany); Mahmut Tok (TÜBİTAK BİLGEM, Turkey); Mehmet Haklidir (TUBITAK BILGEM, Turkey); Bo Zhou (German Research Center for Artificial Intelligence, Germany); Paul Lukowicz (DFKI and University of Kaiserslautern, Germany)

In brain-computer interface and neuroscience, electroencephalography (EEG) signals have been well studied with not only cognitive activities but also physical activities.
This work investigates if EEG can be used for detecting the motion as well as the variable weights a person is lifting. To this end, we used both commercial EEG headsets as well as open-source and open-protocol EEG hardware that is suitable for do-it-yourself designers. EEG data was obtained during performing biceps flexion-extension motions for different weight categories: lifting with no weight (empty), medium, and heavy lifting.
Through two experiments of the bicep curl lifting scenario, we validated the concept with a study designed according to neuroscience standards and explored the pathway towards real-world applications with wearable sensing and smart garments. Both feature-based classification methods and deep learning models were designed and evaluated, showing accuracy up to 78% of differentiating three levels of weight (empty, medium, and heavy) consistently outperforming similar the state of the art. Our approach to predict different categories of lifted weight could be used in further optimizations in different research areas such as rehabilitation, sport as well as industrial applications.
To encourage further research in this direction, the data sets acquired during this study will be publicly available.

17:45

Detecting Cough Recordings in Crowdsourced Data Using CNN-RNN

Roneel V. Sharan, Hao Xiong and Shlomo Berkovsky (Macquarie University, Australia)

The sound of cough is an important indicator of the condition of the respiratory system. Automatic cough sound evaluation can aid the diagnosis of respiratory diseases. Large crowdsourced cough sound datasets have recently been used by several groups around the world to develop cough classification models. However, not all recordings in these datasets contain cough sounds. As such, it is important to screen the recordings for the presence of cough sounds before developing cough classification models. This work proposes a method to screen crowdsourced audio recordings for cough sounds using deep learning methods. The proposed approach divides the audio recording into overlapping frames and converts each frame into a mel-spectrogram representation. A pretrained convolutional neural network for audio classification is trained to learn the spectral characteristics of cough and non-cough frames from its mel-spectrogram representation. It is combined with a recurrent neural network to learn the dependencies between the sequence of frames. The proposed method is evaluated on 400 crowdsourced audio recordings, manually annotated as cough or non-cough. An accuracy of 0.9800 (AUC of 0.9973) is achieved in classifying cough and non-cough recordings using the proposed method. The trained network is used to analyze the remaining audio recordings in dataset, identifying only about 67% of recordings as containing usable cough sounds. This shows the need to exercise caution when using crowdsourced cough data.

17:55

A Template Matching Based Cough Detection Algorithm Using IMU Data From Earbuds

Bishal Lamichhane (Rice University, USA); Ebrahim Nemati (Samsung Research America, USA); Tousif Ahmed (Samsung Research America Inc., USA); Md Mahbubur Rahman, Jilong Kuang and Alex Gao (Samsung Research America, USA)

Coughing is a common symptom across different clinical conditions and has gained further relevance in the past years due to the COVID-19 pandemic. An automated cough detection for continuous health monitoring could be developed using Earbud, a wearable sensor platform with audio and inertial measurement unit (IMU) sensors. Though several previous

works have investigated audio-based automated cough detection, audio-based methods can be highly power-consuming for wearable sensor applications and raise privacy concerns. In this work, we develop IMU-based cough detection using a template matching-based algorithm. IMU provides a low-power privacy-preserving solution to complement audio-based algorithms. Similarly, template matching has low computational and memory needs, suitable for on-device implementations. The proposed method uses feature transformation of IMU signal and unsupervised representative template selection to improve upon our previous work. We obtained an AUC (AUC-ROC) of 0.85 and 0.83 for cough detection in a lab-based dataset with 45 participants and a controlled free-living dataset with 15 participants, respectively. These represent an AUC improvement of 0.08 and 0.10 compared to the previous work. Additionally, we conducted an uncontrolled free-living study with 7 participants where continuous measurements over a week were obtained from each participant. Our cough detection method achieved an AUC of 0.85 in the study, indicating that the proposed IMU-based cough detection translates well to the varied challenging scenarios present in free-living conditions.

18:05

Single-lead ECG-based deep neural network to identify patients with Ventricular Arrhythmias

Ruhi Mahajan (Zywie, USA); Prachi Pundir (Virginia Tech University, USA); Alok Gambhir (Northside Hospital Cardiovascular Institute, USA); Sameer Adumala (Zywie Inc, USA)

Ventricular arrhythmias (VA) are lethal arrhythmias that need a timely diagnosis. This study proposes a novel 5-layer deep learning framework to identify patients with VA using their ECG recordings of two seconds duration. The model extracts significant features by learning from a large volume of ECG time-series data. The model achieved the F1 score of 0.97 for 10-fold cross-validation and held-out test set, and 0.96 on the external dataset, respectively. Results suggest that the proposed model is highly accurate in identifying VA and, therefore, can be used to improve the outcomes of cardiovascular care.

20:00 – 22:30
Gala Dinner
Room: VENUE RESTAURANT – SWIMMING POOL

Friday, September 30, 2022

8:30 – 18:00
Registration
Room: FOYER ERATO

8:30 – 9:15
Keynote Lecture (Virtual)
Chair: Paolo Bonato, BSN2022 Chair, Harvard Medical School, USA
Room: ERATO

AI-enabled Sensing and Interventions for Global Health
Prof. Jeffrey Palmer
Massachusetts Institute of Technology Lincoln Laboratory, USA

The challenges and opportunities to improve the global health cycle are at critical inflection points under the strain of a world-wide pandemic, international conflict, and large-scale environmental disasters. AI-enabled sensing, decision support, and actions can leverage the enormous data generated and consumed through the global health steps of monitoring, diagnosis, intervention, training, prevention, and informing the public. This presentation will discuss how body sensor networks and health informatics platforms can work in concert with population-level and environmental sensing to assess health threat phenomenology, exposure dosimetry, medical intervention efficacy. These advances can be used to scale interventions, guide health and emergency response policy, enhance training of healthcare providers and first responders, and more effectively engage the public.

9:15 – 10:00
Keynote Lecture (Virtual)
Chair: Dimitrios I. Fotiadis, BHI2022 Chair, Univ. of Ioannina, FORTH, Greece
Room: ERATO

Deep Learning based Medical Image Reconstruction
Prof. Dinggang Shen
School of BME, ShanghaiTech University, China, Shanghai United Imaging Intelligence Co., Ltd., China

This talk will introduce various deep learning methods we developed for fast MR acquisition, low-dose CT reconstruction, and low-cost and low-dose PET acquisition. The implementation of these techniques in scanners for real clinical applications will be demonstrated. Also, comparisons with state-of-the-art acquisition methods will be discussed.

10:00 – 10:15
Coffee Break
Room: FOYER ERATO

10:15 – 11:45
BSN Session #3 Analyzing Wearable Sensor Data Using Machine Learning Algorithms
Chair: Giovanni Magenes, University of Pavia, Italy; **Clauirton De Albuquerque Siebra,**University of Geneva, Switzerland
Room: POLYMNIA

10:15
CCA-based Spatio-temporal Filtering for Enhancing SSVEP Detection
Yue Zhang (University of Leeds, United Kingdom (Great Britain)); Shengquan Xie (University of Leeds, United Kingdom (Great Britain) & Binzhou Medical University, China); Zhenhong Li, Yihui Zhao, Kun Qian and Zhi-Qiang Zhang (University of Leeds, United Kingdom (Great Britain))

Brain-computer interface (BCI) can provide a direct communication path between the human brain and an external device. The steady-state visual evoked potential (SSVEP)-based BCI has been widely explored in the past decades due to its high signal-to-noise ratio and fast communication rate. Several spatial filtering methods have been developed for frequency detection. However the temporal knowledge contained in the SSVEP signal is not effectively utilized. In this study, we propose a canonical correlation analysis (CCA)-based spatio-temporal filtering method to improve target classification. The training signal and two types of template signals (i.e. individual template and artificial sine-cosine reference) are first augmented via temporal information. Three sets of augmented data are then concatenated by trials. The CCA is performed

twice, between the newly obtained training data and each template. The trained four spatial filters can be applied in the following test process. A public benchmark dataset was used to evaluate the performance of the proposed method and the other three comparing methods, such as CCA, MsetCCA, and TRCA. The experimental results indicate that the proposed method yields significantly higher performance. This paper also explored the effects of the number of electrodes and training blocks on classification accuracy. The results further demonstrated the effectiveness of the proposed method in SSVEP detection.

10:25
On-Device Machine Learning for Diagnosis of Parkinson's Disease from Hand Drawn Artifacts
Shubhankar Sabat, Sai Vaibhav Polisetti Venkata, Chinmay Deshpande, Asiful Arefeen, Daniel Peterson and Hassan Ghasemzadeh (Arizona State University, USA)

Neuro-degenerative diseases like Parkinson's and Alzheimer's are responsible for gradual decline in quality of lifestyle. Effective diagnosis of neuro-degenerative diseases is critical in providing early treatments, which in turn can lead to substantial savings in medical costs. Machine learning models with modern wearable technologies and smartphones can help with the diagnosis of such diseases like Parkinson's and aid in assessing disease symptoms. This work introduces a novel system that integrates pervasive computing, mobile sensing, and machine learning to classify hand-drawn images and provide diagnostic insights for screening of Parkinson's disease patients. We design a computational framework that combines data augmentation techniques with optimized convolutional neural network design for on-device and real-time image classification. We assess the performance of the proposed system using two datasets of images of Archimedean spirals drawn by hand and demonstrate that our approach achieves 76% and 83% accuracy respectively. Thanks to 4x memory reduction via integer quantization, our system can run fast on an Android smartphone. Our study demonstrates that pervasive computing may offer an inexpensive and effective tool for early diagnosis of Parkinson's disease. All the experiments and results presented in this paper are fully reproducible with the code and data made publicly available: https://github.com/Arefeen06088/On-Device-PD-Assessment

10:35
Respiration Rate Estimation from Remote PPG via Camera in Presence of Non-Voluntary Artifacts
Korosh Vatanparvar (Samsung Research America, USA); Migyeong Gwak (University of California, Los Angeles, USA); Li Zhu, Jilong Kuang and Alex Gao (Samsung Research America, USA)

Contactless measurement of vitals has been seen as a promising alternative to contact sensors for monitoring of health condition. In this paper, we focus on respiration rate (RR) as one of the fundamental biomarkers of a person's cardio and pulmonary activities. Remote RR estimation has gained attraction due to its various potential applications; use of RGB cameras to extract remote photoplethysmography (PPG) signal from subjects' face has been debated as one of the enabling technologies for remote RR estimation. The technology is challenged with respect to wide range of RR and non-voluntary motion in uncontrolled settings. We propose a novel methodology to enhance the quality of respiration signal and remove artifacts from the remote PPG signal. It achieves 3.9bpm MAE of 90% percentile (1.3bpm decrease) for estimating RR in range of 5-25bpm. We validate the performance using smartphone video recordings of 30 subjects with uniform distribution of skin tone.

10:45
Multimodal Time-Series Activity Forecasting for Adaptive Lifestyle Intervention Design
Abdullah Mamun, Krista Leonard, Matthew Buman and Hassan Ghasemzadeh (Arizona State University, USA)

Physical activity is a cornerstone of chronic conditions and one of the most critical factors in reducing the risks of cardiovascular diseases, the leading cause of death in the United States. App-based lifestyle interventions have been utilized to promote physical activity in people with or at risk for chronic conditions. However, these mHealth tools have remained largely static and do not adapt to the changing behavior of the user. In a step toward designing adaptive interventions, we propose BeWell24Plus, a framework for monitoring activity and user engagement and developing computational models for outcome prediction and intervention design. In particular, we focus on devising algorithms that combine data about physical activity and engagement with the app to predict future physical activity performance. Knowing in advance how active a person is going to be in the next day can help with designing adaptive interventions that help individuals achieve their physical activity goals. Our technique combines the recent history of a person's physical activity with app engagement metrics such as when, how often, and for how long the app was used to forecast the near future's activity. We formulate the problem of multimodal activity forecasting and propose an LSTM-based realization of our proposed model architecture, which estimates physical activity outcomes in advance by examining the history of app usage and physical activity of the user. We demonstrate the effectiveness of our forecasting approach using data collected with 58 prediabetic people in a 9-month user study. We show that our multimodal forecasting approach outperforms single-modality forecasting by 2.2% to 11.1% in mean-absolute-error.

10:55
Forewarning Postprandial Hyperglycemia with Interpretations using Machine Learning
Asiful Arefeen, Samantha Fessler, Carol Johnston and Hassan Ghasemzadeh (Arizona State University, USA)

Postprandial hyperglycemia (PPHG) is detrimental to health and increases risk of cardiovascular diseases, reduced eyesight, and life-threatening conditions like cancer. Detecting PPHG events before they occur can potentially help with providing early interventions. Prior research suggests that PPHG events can be predicted based on information about diet. However, such computational approaches (1) are data hungry requiring significant amounts of data for algorithm training; and (2) work as a black-box and lack interpretability, thus limiting the adoption of these technologies for use in clinical interventions. Motivated by these shortcomings, we propose, DietNudge, a machine learning based framework that integrates multi-modal data about diet, insulin, and blood glucose to predict PPHG events before they occur. Using data from patients with diabetes, we demonstrate that our model can predict PPHG events with up to 90\% classification accuracy and an average F1 score of 0.93. The proposed decision-tree-based approach also identifies modifiable factors that contribute to an impending PPHG event while providing personalized thresholds to prevent such hyperglycemic events. Our results suggest that we can develop simply, yet effective, computational algorithms that can be used as preventative mechanisms for diabetes and obesity management. Being computationally lightweight, DietNudge is highly suitable for mobile health application.

11:05
Real-Time Breathing Phase Detection Using Earbuds Microphone
Zihan Wang (Samsung Research America, USA); Tousif Ahmed (Samsung Research America Inc., USA); Md Mahbubur Rahman, Mohsin Y Ahmed, Ebrahim Nemati, Jilong Kuang and Alex Gao (Samsung Research America, USA)

Tracking breathing phases (inhale and exhale) outside the hospitals can offer significant health and wellness benefits to users. For example, the breathing phases can provide fine-grained breathing information for proper meditation or breathing exercises. While previous works use smartphones and smartwatches for tracking breathing phases, in this work, we use earbuds for breathing phase detection, which has the potential to be a better form factor for breathing exercises as it requires less user attention from the user. We propose a convolutional neural network-based algorithm for detecting breathing phases using the audio captured through the earbuds during guided breathing sessions. We conducted a user study with 30 participants in both lab and home environments to develop and evaluate our algorithm. Our algorithm can detect the breathing phases with 80% accuracy by taking only a 500ms audio signal. Our work demonstrates the potential of using earbuds for tracking the breathing phases in real-time.

11:15
Deep Audio Spectral Processing for Respiration Rate Estimation from Smart Commodity Earbuds
Mohsin Y Ahmed (Samsung Research America, USA); Tousif Ahmed (Samsung Research America Inc., USA); Md Mahbubur Rahman, Zihan Wang, Jilong Kuang and Alex Gao (Samsung Research America, USA)

Respiration rate is an important health biomarker and a vital indicator for health and fitness. With smart earbuds gaining popularity as a commodity device, recent works have demonstrated the potential for monitoring breathing rate using such earable devices. In this work, for the first time we utilize deep image recognition techniques to infer respiration rate from earbud audio. We use image spectrograms from breathing cycle audio signals captured using Samsung earbuds as a spectral feature to train a deep convolutional neural network. Using novel earbud audio data collected from 30 subjects with both controlled breathing at a wide range (from 5 upto 45 breaths per minute), and uncontrolled natural breathing from 7-day home deployment, experimental results demonstrate that our model outperforms existing methods using earbuds for inferring respiration rates from regular intensity breathing and heavy breathing sounds with 0.77 aggregated MAE for controlled breathing and with 0.99 aggregated MAE for at-home natural breathing.

11:25
Discussion

10:15 – 11:45
Special Session: Emerging National EHR System Integration Towards Achieving The European Health Data Space
Chair: Costantinos S. Pattichis and Maria Papaioannou, University of Cyprus, Cyprus
Room: KLEIO

10:15
Towards a population-based biobank in the era of EU Health Data Space
Maria Papaioannou (University of Cyprus, Cyprus); Athos Antoniades (Stremble Ventures LTD, Cyprus); Apostolos Malatras, Panayiotis Savva, Michalis Yerou, Costantinos S. Pattichis and Constantinos Deltas (University of Cyprus, Cyprus); Christos Schizas (National eHealth Authority, Cyprus)

This paper presents the design framework of a population-based biobank addressing the requirements of the Cyprus and the European Health Data Space. The "biobank.cy" is an EU funded project that supports the building of a contemporary population-based biobank infrastructure that incorporates eHealth services supporting national coverage. The project started with the Covid-19 pandemic outburst which accentuated the urgent need of establishing connectivity between biobanks and other stakeholders of the national and international eHealth ecosystem (like national EHR systems [1], other biobanks, LIS systems, HIS systems, etc.). Investing in data sharing with other eHealth systems in a uniform and standardized manner will allow harvesting strong capabilities in data science and AI/ML applications in the future [2]. The biobank.cy uses the following types of data (Fig. 1): clinical data (e.g. vital signs, social history, conditions, etc.), genomic data, imaging data and specimen/samples data. Different systems are used for the collection/production for each type of data. The biobank.cy stores all data or their meta-data to a data warehouse (Fig. 1). The data warehouse is designed following a citizen-centric philosophy meaning that all data are organized per citizen (doner) and then categorized per research project and per visit. Certain tools can then pull data from the data warehouse to proceed with their analysis in the scope of a project.

10:27
Integrated National eHealth ecosystem in Cyprus (eHealth4U)
Maria Papaioannou, Andreas Neocleous, Panayiotis Savva and Francisco Garcia Miguel (University of Cyprus, Cyprus); Andreas S. Panayides (CYENS Centre of Excellence, Cyprus & 3AE Health LTD, Cyprus); Zinonas Antoniou and Marios Neofytou (University of Cyprus, Cyprus); Eirini C. Schiza (CYENS - Centre of Excellence & University of Cyprus, Cyprus); Kleanthis Neokleous, Ioannis P Constantinou, Constantinos Yiasemi and Christos Michael (University of Cyprus, Cyprus); George Panos (University of Patras School of Medicine, Greece); Costantinos S. Pattichis (University of Cyprus, Cyprus); Christos Schizas (National eHealth Authority, Cyprus)

In this paper, we present the implementation components of the prototype of the national integrated EHR system of the Cyprus (eHealth4U) with regards to certain principles governing the national eHealth ecosystem.

10:39
eHealth for Emergency and Prehospital Health Care Management- AVARIS
Efthyvoulos Kyriacou and Prokopis Frangos (Cyprus University of Technology, Cyprus); Zinonas Antoniou (University of Cyprus, Cyprus); Riana Constantinou, Charalambos Franjescos, Leonardo Koulouris, Alexis Kalavas and Georgios Pantelas (State Health Services Organization, Cyprus)

An integrated system for the support of prehospital and emergency health care is discussed in this study. An effort to reform the procedures followed for emergency call handling and Ambulance dispatch started on the Island of Cyprus in 2016. In order to help with the new procedures, we had started developing an electronic system which could help with the workflow management of the department. This system started regular operation at the end of 2018. One year later, when Covid-19 period started, we expanded it with the addition of several new features in order to support the handling of patients infected with the new virus. Currently the system is going through a major expansion which includes telemedicine support of rural health care centers and hospitals' accident and emergency departments information management. The goal is to have an integrated system which can support pre-hospital and emergency health care. This ambulance part of system has handled more than 175000 cases during the last 40 months. The main purpose of this study was to create an electronic system (eEmergency system) in order to support, improve, and help the procedures of emergenyc and prehospital health care on the island of CYprus. The main components and the architecture of this system are outlined in this paper.

10:51
eHealthPass: a patient application framework to support primary and secondary use of data in the context of the European Health Data Space

Alexander Berler (Gnomon Informatics S.A., Greece); Korina Papadopoulou (Gnomon Informatics SA, Greece); Fotis Gonidis (Gnomon Informatics S.A., Greece); Nenad Živković (& Gnomon Informatics S.A., Greece); Kostis Kaggelides (Gnomon Informatics S.A., Greece)

The recent pandemic has elevated the need to bring together population health data from multiple sources. Sharing health data is currently a hard-to-overcome task, primarily due to fragmented efforts. Secondary use of health data can play a crucial role in improving health systems. eHealthPassTM is a Remote Patient Management Suite that supports clinicians, caregivers, informal caregivers, and patients in the context of remote monitoring, digital therapeutics, disease management, electronic prescriptions, shared care plans, and information consent management and many more. The platform is a CE - Class IIa certified application based on EU regulations (MDD & ISO 13485). The platform via is interoperability suite can be connected and integrated with any type of clinical back end, EHR, PHR, CIS, HIS, LIS, etc. eHealthPassTM, act as a personal healthcare environment (PHE) for the patient. The platform can seamlessly integrate a various sets of medical and wellness devices for patient data automation either via Bluetooth or via a direct-to-cloud gateway. The platform can monitor a plethora of chronic conditions and can act as an ecosystem of integrated information systems and is proven compliant to the IPS standard on the patient summary as defined in WHO, GDHP (Global Digital Health Partnership) and G7 recommendations.

11:03
Deployment of Generic Cross Border eHealth Services in Cyprus
Marios Neofytou, Zinonas Antoniou, Ioannis P Constantinou, Panayiotis Savva, Maria Papaioannou, Andreas Neocleous and Constantinos Pattichis (University of Cyprus, Cyprus); Minas Kyriakides, Michalis J. Antoniou and Eraclis Kyriakides (National eHealth Authority of Cyprus, Cyprus); Christos Schizas (National eHealth Authority, Cyprus)

The aim of this short paper is to present the main components of the national architecture of cross boarder eHealth services in Cyprus, as well as to document the interoperability framework based on HL7 FHIR that will enable the successful deployment of the Cyprus national eHealth ecosystem contributing towards the creation of the European Health Data Space.

11:15
Discussion

10:15 – 11:45
Featured Virtual Talks
Chair: Manolis Tsiknakis, Technological Educational Institute of Crete and FORTH, Greece**; Themistoklis Exarchos**, Ionian University, Greece
Room: PANDORA C'

10:15
Near-human Sensing in Fabric Smart Space
Prof. Min Chen
Huazhong University of Science and Technology, China

In future network, the provisioning of ultra-low latency, non-intrusive and immersive service experience creates various challenges, among which near-human sensing is of great importance to obtain multi-modal information without disturbing user. This talk introduces the development of various functional fabrics, which have provided new thoughts for generating novel near-human services interconnected by fabric sensors, body area network, edge cloud and visualization system. In order to embrace digital intelligent world, this talk also presents the fabric smart space empowered by intelligent fabric agents, which gather multidimensional sensory data and interactive information via near-human sensing technologies. Finally, several examples with the use of fabric smart space are given in terms of sport, healthcare and medical scenarios.

11:45 – 13:15
BHI Session # 4 Imaging Informatics
Chair: Andreas Panayides, Co-founder and R&D Director, 3AE Health LTD (3AHealth), Cyprus; **Nenad D. Filipovic,** University of Kragujevac, Serbia
Room: POLYMNIA

11:45
TransResU-Net: Transformer based ResU-Net for Real-Time Colonoscopy Polyp Segmentation
Nikhil Tomar (SimulaMet, Norway); Annie Shergill (Larkin Community Hospital Palm Springs Campus, USA); Brandon Rieders (Yea Long Island Jewish Valley Stream, USA); Ulas Bagci and Debesh Jha (Northwestern University, USA)

Colorectal cancer (CRC) is one of the most common causes of cancer and cancer-related mortality worldwide. Performing colon cancer screening in a timely fashion is the key to early detection. Colonoscopy is the primary modality used to diagnose colon cancer. However, the miss rate of polyps, adenomas and advanced adenomas remains significantly high. Early detection of polyps at the precancerous stage can help reduce the mortality rate and the economic burden associated with colorectal cancer. Deep learning-based computer-aided diagnosis (CADx) system may help gastroenterologists to identify polyps that may otherwise be missed, thereby improving the polyp detection rate. Additionally, CADx system could prove to be a cost-effective system that improves long-term colorectal cancer prevention. In this study, we proposed a deep learning-based architecture for automatic polyp segmentation, called Transformer ResU-Net (TransResU-Net). Our proposed architecture is built upon residual blocks with ResNet-50 as the backbone and takes the advantage of transformer self-attention mechanism as well as dilated convolution(s). Our experimental results on two publicly available polyp segmentation benchmark datasets showed that TransResU-Net obtained a highly promising dice score and a real-time speed. With high efficacy in our performance metrics, we concluded that TransResU-Net could be a strong benchmark for building a real-time polyp detection system for the early diagnosis, treatment, and prevention of colorectal cancer. The source code of the proposed TransResU-Net is publicly available at \url{ https://github.com/nikhilroxtomar/TransResUNet}.

11:57

Towards Long-Range Pixels Connection for Context-Aware Semantic Segmentation

Muhammad Zubair Khan (University of Missouri-Kansas City, USA)

Semantic segmentation is one of the challenging tasks in computer vision. Before the advent of deep learning, hand-crafted features were used to semantically extract the region-of-interest (ROI). Deep learning has recently achieved enormous response in semantic image segmentation. The previously developed U-Net inspired architectures operate with continuous stride and pooling operations, leading to spatial data loss. Also, the methods lack establishing long-term pixels connection to preserve context knowledge and reduce spatial loss in prediction. This article developed encoder-decoder architecture with a sequential block embedded in long skip-connections and densely connected convolution blocks. The network non-linearly combines the feature maps across encoder-decoder paths for finding dependency and correlation between image pixels. Additionally, the densely connected convolutional blocks are kept in the final encoding layer to reuse features and prevent redundant data sharing. The method applied batch-normalization to reduce internal covariate shift in data distributions. We have used LUNA, ISIC2018, and DRIVE datasets to reflect three different segmentation problems (lung nodules, skin lesions, vessels) and claim the effectiveness of the proposed architecture. The network is also compared with other techniques designed to highlight similar problems. It is found through empirical evidence that our method shows promising results when compared with other segmentation techniques.

12:09

Automated Pulmonary Function Measurements from Preoperative CT Scans with Deep Learning

Young Sang Choi, Jieun Oh, Seonhui Ahn and Yul Hwangbo (National Cancer Center, Korea (South)); Jinho Choi (National Cancer Center, Korea, Korea (South))

Lung resections are the most effective treatment option for many types of lung cancer. Clinicians determine whether a patient is operable and the extent a lung can be resected based in part on the patient's pulmonary function parameters. In this study, we investigate the feasibility of generating forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) values from preoperative chest computed tomography (CT) scans. Our study population includes 546 individuals who had lung cancer surgery at an oncology specialty clinic between 2009 and 2015. All CT studies and pulmonary function tests (PFTs) were collected within 90 days before a subject's operation. We measure pulmonary function with convolutional neural network and recurrent neural network models, extracting image embeddings from axial CT slices with a ResNet-50 network and generating FEV1 and FVC measurements using a bidirectional long short-term memory regressor. We show that combining feature vectors extracted from mediastinal and lung Hounsfield unit windows and taking a multi-label regression approach improves performance over training with embeddings from only one window or single-task networks trained to measure only FEV1 or FVC values. Our work generates PFT measurements end-to-end and is trained with only computed tomography scans and pulmonary function labels with no manual slice selection, bounding boxes, or segmentation masks.

12:21

HeartSpot: Privatized and Explainable Data Compression for Cardiomegaly Detection

Elvin Johnson and Shreshta Mohan (Carnegie Mellon University, USA); Alex Gaudio (Carnegie Mellon University & University of Porto, Portugal); Asim Smailagic and Christos Faloutsos (Carnegie Mellon University, USA); Aurélio Campilho (Université of Porto, Portugal)

Advances in data-driven deep learning for chest X-ray image analysis underscore the need for explainability, privacy, large datasets and significant computational resources. We frame privacy and explainability as a lossy single-image compression problem to reduce both computational and data requirements without training. For cardiomegaly detection in chest X-ray

images, we propose HeartSpot and four spatial bias priors. HeartSpot priors define how to sample pixels based on domain knowledge from medical literature and from machines. HeartSpot privatizes chest X-ray images by discarding up to 97% of pixels, such as those that reveal the shape of the thoracic cage, bones, small lesions and other sensitive features. HeartSpot priors are ante-hoc explainable and give a human-interpretable image of the preserved spatial features that clearly outlines the heart. HeartSpot offers strong compression, with up to 32x fewer pixels and 11x smaller filesize. Cardiomegaly detectors using HeartSpot are up to 9x faster to train or at least as accurate (up to +.01 AUC ROC) when compared to a baseline DenseNet121. HeartSpot is post-hoc explainable by re-using existing attribution methods without requiring access to the original non-privatized image. In summary, HeartSpot improves speed and accuracy of cardiomegaly detectors, reduces image size, improves privacy and ensures explainability.

12:33

Benign and Malignant Breast Mass Detection and Classification in Digital Mammography: The Effect of Subtracting Temporally Consecutive Mammograms

Kosmia Loizidou (University of Cyprus, Cyprus); Galateia Skouroumouni (German Oncology Center); Gabriella Savvidou and Anastasia Constantinidou (Medical School University of Cyprus, Bank of Cyprus Oncology Center, Cyprus); Christos Nikolaou (Limassol General Hospital, Cyprus); Costas Pitris (University of Cyprus, Cyprus)

Breast cancer remains one of the leading cancers worldwide and is the main cause of death in women with cancer. Effective early-stage diagnosis can reduce the mortality rates of breast cancer. Currently, mammography is the most reliable screening method and has significantly decreased the mortality rates of these malignancies. However, accurate classification of breast abnormalities using mammograms is especially challenging, driving the development of Computer-Aided Diagnosis (CAD) systems. In this work, subtraction of temporally consecutive digital mammograms and machine learning were combined, to develop an algorithm for the automatic detection and classification of benign and malignant breast masses. A private dataset was collected specifically for this study. A total of 196 images were gathered, from 49 patients (two time points and two views of each breast), with precisely annotated mass locations and biopsy confirmed malignant cases. For the classification, ninety-six features were extracted and five feature selection techniques were combined. Ten classifiers were tested, using leave-one-patient-out and 7-fold cross-validation. The classification performance reached 90.85% accuracy and 0.91 AUC, using Neural Networks, an improvement, compared to the state-of-the-art algorithms that utilized sequential mammograms for the classification of benign and malignant breast masses. This work demonstrates the effectiveness of combining subtraction of temporally sequential digital mammograms, along with machine learning, for the automatic classification of benign and malignant breast masses.

12:45

Data Models for an Imaging Bio-bank for Colorectal, Prostate and Gastric Cancer: the NAVIGATOR Project

Sara Colantonio (Institute of Information Science and Technologies - ISTI-CNR, Italy); Gianluca Carloni, Andrea Berti, Rossana Buongiorno and Eva Pachetti (Institute of Information Science and Technologies - ISTI-CNR & University of Pisa, Italy); Maria Antonietta Pascali (ISTI-CNR, Italy)

Researchers nowadays may take advantage of broad collections of medical data to develop personalized medicine solutions. Imaging bio-banks play a fundamental role, in this regard, by serving as organized repositories of medical images associated with imaging biomarkers. In this context, the NAVIGATOR Project aims to advance colorectal, prostate, and gastric oncology translational research by leveraging quantitative imaging and multi-omics analyses. As Project's core, an imaging bio-bank is being designed and implemented in a web-accessible Virtual Research Environment (VRE). The VRE serves to extract the imaging biomarkers and further process them within prediction algorithms. In our work, we present the realization of the data models for the three cancer use-cases of the Project. First, we carried out an extensive requirements analysis to fulfill the necessities of the clinical partners involved in the Project. Then, we designed three separate data models utilizing entity relationship diagrams. We found diagrams' modeling for colorectal and prostate cancers to be more straightforward, while gastric cancer required a higher level of complexity. Future developments of this work would include designing a common data model following the Observational Medical Outcomes Partnership Standards. Indeed, a common data model would standardize the logical infrastructure of data models and make the bio-bank easily interoperable with other bio-banks.

12:57

Discussion

11:45 – 13:15
BHI Session # 5 Big Data and AI (II)
Chair: Manolis Tsiknakis, Foundation for Research and Technology Hellas, Greece; **Bjoern Eskofier,** FAU, Germany
Room: KLEIO

11:45
Molecular Dynamics forecasting of transmembrane Regions in GPRCs by Recurrent Neural Networks
Juan Manuel López-Correa (Universitat Politècnica de Catalunya, Spain); Caroline König (Universita Polytecnica de Cataluya, Spain); Alfredo Vellido (Universita Polytecnica de Catalunya, Spain)

G protein-coupled receptors (GPCRs) are a large and diverse super-family of eukaryotic cell membrane proteins that play an important physiological role as transmitters of extra-cellular signal, making them relevant for pharmacology. Signal transmission through the cell membrane depends on the conformational changes of the transmembrane region of the receptor and the investigation of the dynamics in these regions is therefore key. Molecular Dynamics (MD) simulations can provide information of the receptor's conformational states at the atom level and machine learning (ML) methods can be useful for the analysis of these data. Computer-assisted MD simulations allow the study of the dynamic behavior of the receptors, particularly in the presence of drugs. Research on MD simulations has gathered pace in recent years, facilitated by the existence of MD repositories, such as the GPCRMD for MD simulations of GPCRs. In this paper, Recurrent Neural Networks (RNNs) are used to evaluate whether the MD can be modeled focusing on the different regions of the receptor (intra-cellular, extra-cellular and each transmembrane regions). The best results, as measured by root-mean-square deviation (RMSD), are 0.1398 Å for TM7 of the 2rh1 (active state) and 0.1551 Å for TM7 of the 3p0g (inactive state), which are comparable to the state-of-the-art in non-dynamic 3-D predictions, showing the potential of the proposed approach.

11:57
RetainEXT: Enhancing Rare Event Detection and Improving Interpretability of Health Records using Temporal Neural Networks
Suraj Nario Ramchand and Gavin Tsang (Swansea University, United Kingdom (Great Britain)); Duncan Cole (Cardiff University, United Kingdom (Great Britain)); Xianghua Xie (Swansea University, United Kingdom (Great Britain))

A recurring theme during the pandemic is the shortage of hospital beds. Despite all efforts, the healthcare system still faces 25% of resource strain felt during the first peak of coronavirus. Digitisation of Electronic Healthcare Records (EHRs) and the pandemic have brought about many successful applications of Recurrent Neural Networks (RNNs) to predict the current and future states of patients. Despite their strong performance, it remains a challenge for users to the black-box, which has heavily influenced researchers to utilize more interpretable techniques such as 1D-Convolutional neural networks. Others, focus on using more interpretable machine learning techniques but only achieve high performance on a select subset of patients. With the effort of medical experts and artificial intelligence scientists, our study improves on REverse Time AttentIoN EX model, a feature and visit level attention network, for increased interpretability and usability of RNNs in predicting COVID-19 related hospitalisations. We achieve 82.40% area under the receiver operating characteristic curve and showcase effective use of REverse Time AttentIoN EXTension model and EHRs in understanding how individual medical codes contribute to hospitalisation risk prediction. This study provides a useful guideline for researchers aiming to design interpretable temporal neural networks using the power of RNNs and data mining techniques.

12:09
Multi-label Neural Model for Prediction of Myocardial Infarction Complications with Resampling and Explainability
Munib Mesinovic (University of Oxford, United Kingdom (Great Britain)); Kai-Wen Yang (Johns Hopkins University, USA)

With myocardial infarctions accounting for the largest percent of cardiovascular-related deaths, the need for machine learning tools in prediction and prevention has never been clearer. Specifically, in the case of in-hospital complications following acute myocardial infarction (AMI), even with decreased in-hospital mortality rate due to improved hospital care, patients who survive the acute phase of MI remain at risk for MI- associated complications or recurrent AMI such as bundle branch blocks and angina. In this paper, we propose a multi-label framework to predict the occurrence of 5 complications following admission of 1,700 patients after suffering an AMI episode. We evaluate the models using several multi-label prediction metrics as a test of robustness of our method beating numerous other alternatives and comment on the balance of cost-effectiveness of a compact deep learning model versus shallow machine learning in the multi-label context. Our neural network outperformed 13 other algorithms across all metrics, except Hamming loss. We also implement Shapley value analysis to this multi-label problem and observe interesting behaviour such as the duration of arterial hypertension and time elapsed from the beginning of the attack to the hospital being key predictive features of lethal outcome. This framework presents a novel approach in using multi-label learning, and especially compact cost-effective deep learning, simultaneous for prediction of several AMI complications which has not been explored previously.

12:21
Classification of Adventitious Respiratory Sound Events: A Stratified Analysis
Tiago Fernandes, Bruno M Rocha, Diogo Pessoa, Paulo Carvalho and Rui Pedro Paiva (University of Coimbra, Portugal)

Respiratory diseases are among the deadliest in the world. Adventitious respiratory sounds, such as wheezes and crackles, are commonly present in these pathologies. Automating the analysis of adventitious respiratory sounds can help health professionals to monitor patients suffering from respiratory conditions. The ICBHI Respiratory Sound Database, a benchmark dataset in respiratory sound analysis, has large and diverse data available publicly. Given its diversity in data, a stratified analysis by recording equipment, age, sex, body-mass index (BMI), and clinical diagnosis is proposed in this article. Regarding the experiments, three machine learning algorithms (Support Vector Machine (SVM), Random Undersampling Boosting (RUSBoost), and Convolutional Neural Network (CNN)) were employed in three tasks: 2-class crackles (crackles vs. others), 2-class wheezes (wheezes vs. others), and 3-class (crackles vs. wheezes vs. others). Overall the CNNs achieved better results in almost every category, except in equipment for Littmann3200 and Meditron, where RUSBoost achieved better results. In terms of stratification categories, we observed significant differences in classification performance, namely in terms of equipment, where the Littmann3200 underperformed the other equipment analysed. In addition, in the 3-class problem (crackles vs. wheezes vs. others), the CNNs achieved better results in Male subjects than Female subjects. In terms of BMI, the CNN of the Overweight class in the 2-class problem (wheezes vs. others), achieved lower results than the other two (Normal and Obese classes).

12:33
Toward Knowledge-Driven Speech-Based Models of Depression: Leveraging Spectrotemporal Variations in Speech Vowels
Kexin Feng and Theodora Chaspari (Texas A&M University, USA)

Psychomotor retardation associated with depression has been linked with tangible differences in vowel production. This paper investigates a knowledge-driven machine learning (ML) method that integrates spectrotemporal information of speech at the vowel-level to identify the depression. Low-level speech descriptors are learned by a convolutional neural network (CNN) that is trained for vowel classification. The temporal evolution of those low-level descriptors is modeled at the high-level within and across utterances via a long short-term memory (LSTM) model that takes the final depression decision. A modified version of the Local Interpretable Model-agnostic Explanations (LIME) is further used to identify the impact of the low-level spectrotemporal vowel variation on the decisions and observe the high-level temporal change of the depression likelihood. The proposed method outperforms baselines that model the spectrotemporal information in speech without integrating the vowel-based information, as well as ML models trained with conventional prosodic and spectrotemporal features. The conducted explainability analysis indicates that spectrotemporal information corresponding to non-vowel segments less important than the vowel-based information. Explainability of the high-level information capturing the segment-by-segment decisions is further inspected for participants with and without depression. The findings from this work can provide the foundation toward knowledge-driven interpretable decision-support systems that can assist clinicians to better understand fine-grain temporal changes in speech data, ultimately augmenting mental health diagnosis and care.

12:45
Discussion

11:45 – 13:15
Privacy Challenges in the Digital Health Transformation Panel (Sponsored by IEEE Future Directions DPI)
Chair: Neeli Prasad, Healthcare Subgroup, IEEE Digital Privacy Initiative
Room: PANDORA C'

Dan Bogdanov
Cybernetica, Estonia

Agata Ferretti
ETH Zurich, Switzerland

Charalampos Z. Patrikakis
University of West Attica, Greece

13:15 – 14:15
Lunch
Room: PANDORA A'

13:15 – 14:15
Meeting with EiCs
Chairs: Dimitrios I. Fotiadis, JBHI EiC, Univ. of Ioannina, FORTH, Greece**; Paolo Bonato,** OJEMB EiC, Harvard Medical School, USA
Room: PANDORA A'

14:15 – 15:45
Special Session: Artificial Intelligence and Real World Data for Personalised Support of Patients with Cardiovascular Diseases
Chairs: Manolis Tsiknakis, Technological Educational Institute of Crete and FORTH, Greece; **Yorgos Goletsis;** University of Ioannina, Greece
Room: POLYMNIA

14:15
Reinforcement learning application to provide suggestions for the exercise training prescription in the cardiac rehabilitation setting
Georgios Spithakis (University of Ioannina, Greece); Nikolaos Pappas (Capemed, Greece); Konstantinos Blekas (University of Ioannina, Greece)

Introduction CR is a multi-factorial and comprehensive intervention in secondary prevention with exercise training as a central component. Herewith we present a reinforcement learning method that aims to make tailored suggestions towards optimization to treating physicians for exercise prescription during Phase II of CR. Methods Dataset We used a dataset collected at Rehabilitation Clinic of University Witten/Herdecke. It consists of patients undergoing a 3-4 weeks long inpatient CR program. In this period, Prescribed and Executed Exercises (PEE) information (type, level of intensity, duration, METs, overall Kcal), results of two CPET exercise tests at the beginning and at the end of CR along with medical history (medication, diagnosis, comorbidities) and daily and weekly activity measurements from a Garmin activity tracker for all patients were recorded. Then, appropriate expansion and missing values imputation [1] of this dataset was performed to test the applicability of RL methods in the CR setting. Reinforcement learning pipeline We consider the Offline RL setting, where a policy can be learned, from a static dataset, without additional online data collection. In particular, we use the BCQ algorithm [2], a method that performs Q-learning, while discouraging out of distribution actions. The patient's state is a combination of weekly Garmin monitoring, medical history, initial exercise test and PEE as goal condition information. Our discrete actions, contain the upcoming week exercise training prescription (Daily Steps, Intensity Minutes, Frequency), formed in a way to capture the clinical standards. Based on this framework, we split the progressions of patients (trajectories) into Train set and Test set, so that the distribution of VO2 max change is the same in both sets (TABLE I). We consider that the success of a treatment depends to a large extend on VO2 max and we define the reward function (1), along each transition in a trajectory, to guide the model.
Results To assess the quality of our approach, we conduct experiments and evaluate the learned policies in both sets. In Fig. 1, we provide the distribution of executed action Q-value in the initial state of the trajectories, grouping them by VO2 max change.
The distribution of executed action Q-value in the initial state of trajectories for a learned policy. Discussion The experimental study we have done in this work, is largely limited by the quantity and the quality of the available dataset, as well as by the short time horizon. In the future, as a larger dataset become available, we can establish a longer time horizon (addressing also CR Phase III), with a bigger diversity in outcomes. We intend to include more suggestions, such as the level of intensity (low, moderate, high), but also to restrict them based on the clinical guidelines [3].

14:27
Exploiting Real World Data for personalised Heart Failure patient interventions - The RETENTION case
Maria Roumpi (Unit of Medical Technology and Intelligent Information Systems, Greece); Yorgos Goletsis (Associate Professor, Greece); Vasileios C. Pezoulas (University of Ioannina, Greece); Athanasios Pardalis (Unit of Medical Technology and Intelligent Information Systems, Greece); Ioannis Basdekis (Sphynx Technology Solutions AG, Greece); Dimitrios Koutsouris (National Technical University of Athens, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

RETENTION is a European research project that aims at developing and delivering an innovative platform supporting enhanced clinical monitoring and management and personalized interventions of patients with chronic HF, reducing in this way their mortality and improving their quality of life and well-being. In order to achieve its goals, the RETENTION system combines continuous monitoring at home and integration of heterogeneous data-medical, clinical, physiological, behavioral, psychosocial, and real-world data - with clinical decision making and data-driven analytics.

14:39
Real World Data and AI for CVDs - The SMART BEAR case
Ioannis Kouris (National Technical University of Greece, Greece); Dimitrios Koutsouris (National Technical University of Athens, Greece); Eleftheria Iliadou (National and Kapodistrian University of Athens, Greece); Ioannis Leontsinis (Hippocration General Hospital, Greece)

SMART BEAR is a multinational, interoperable European research project building and validating a platform that captures Real World Data (RWD) of elderly participants who suffer from Hearing Loss (HL), Cardio Vascular Diseases (CVD), Cognitive Impairments (CI), Mental Health (MH) issues and Balance Disorders (BD), and uses Artificial Intelligence (AI) and Big Data processing technologies to provide insights to the clinicians for the better management of the diseases. This paper presents the project design, the devices used to collect the Real World Data from medical and non medical consumer devices. The data collected are stored using the FHIR protocol, to allow the interoperability of the platform with the addition of more devices (if needed), and in addition to enable the exchange of data in a standardized way with other platforms. To that extend, SMART BEAR project is participating in the EU Large Scale Pilots Health Care Cluster synergies, exchanging data with another two research projects. Currently, a small-scale pilot is in progress to get initial feedback on the platform by the end users (patients, clinicians and scientists) before proceeding to the large scale study. For CVDs, the developed platform is used to define and execute Data Analysis workflows, including AI algorithms, to extract data-driven knowledge. The algorithms are continuously trained by the data digested into the platform and are providing the clinicians of the project with insights required for the fine tuning of the existing decision support system.

14:51
Utilizing Deep Neural Networks to Segment CARDIOCARE Project Echocardiographic Data
Georgios C. Manikis and Grigorios Kalliatakis (Foundation for Research and Technology, Greece); Georgia Karanasiou (Senior Researcher, Medlab, University of Ioannina, Greece); Elisavet Stamoulou (FORTH-Hellas, Greece); Georgios S. Ioannidis (Foundation for Research and Technology - Hellas, Greece); Grigoris Grigoriadis, Lampros Lakkas and Katerina Naka (University of Ioannina, Greece); Manolis Tsiknakis (Hellenic Mediterranean University, Greece & FORTH -ICS, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece); Kostas Marias (FORTH, Greece)

This preliminary study applies and evaluates state-of-the-art encoder-decoder deep convolutional neural networks for the task of segmenting cardiac structures from 2D echocardiographic images from the CARDIOCARE EU project. Delineation of the cardiac structures from 2D echocardiographic images remains essential in clinical tasks for measuring the cardiac morphology and function and to reach a diagnosis. For instance, accurate delineation of the left ventricular endocardium in both end diastole (ED) and end systole (ES) is required for the extraction of the ejection fraction (EF) of the left ventricle (LV). Automation of this task has been the subject of intense research over the past decade. To this end, we explore the use of CAMUS dataset, comprising publicly accessible 2D echocardiographic sequences and the corresponding annotations of 500 patients. The aim is two fold: a) to develop deep neural networks based on the CAMUS information for segmenting automatically the three corresponding areas of the echocardiography data, and b) to transfer and fine tune the implemented infrastructure to the CARDIOCARE EU project, assisting the project with automated segmentations of critical areas, further used for the extraction of high-dimensional cardiac morphology and functional imaging features using image analysis techniques. The final goal is to develop a novel cost-effective risk-stratification strategy and healthcare model based on echocardiography images to improve the management of the elderly multimorbid breast cancer patient at risk for cardiac toxicity.

15:03
Discussion

14:15 – 15:45
Special Session: Digital Transformation and Industry 4.0 for Health Technology Management and Clinical Engineering
Chairs: Giuseppe Fico, Universidad Politécnica de Madrid,Spain**; Leandro Pecchia,** Universitá Campus Biomedico di Roma, Italy
Room: KLEIO

14:15
Invited Talk
Prof. Min Chen (Huazhong University of Science and Technology, China)

14:45
Key Enabling Technologies for innovative services of the smart Hospital of the Future

Maria Teresa Arredondo (Life Supporting Technologies; Technical University of Madrid, Spain); Giuseppe Fico (Universidad Politécnica de Madrid, Spain)

During this talk, we will explore the most important innovations to be achieved through a 360º integrated view for monitoring hospitalsservices performance. This talk describes the impact and dissemination strategy designed and implemented in the ODIN project about the smart hospital of the future. To create the hospital of the future a 360-degree approach is needed to empower clinical and operational teams, at hospital and extended hospital (territorial healthcare provision) environments to easily collaborate and provide health valuable services through digital service management. The hospitals services performance, is supported by a 360º impact-oriented value based on the patient experience`s view that manages and balance several variables as measurable health/business-driven key performance indicators that will support a quadruple helix bottom-line result (profit, society, environment, and health future facing). This approach will be supported by a set of technologies, including Internet of Things, robotics, Artificial Intelligence (AI), 3D visualization, process & workflow engines, blockchain and cybersecurity, innovative cloud based native technologies and 5G communications. In this talk the following technologies and innovations will be presented: Integrated Robotics; Ubiquitous Personal Healthcare space; Operating Room of the future; Humanoid robots in the hospital; Enhancing Healthcare processes with deep learning; AI & high-performance networks for remote hospital assistance; The digital transformation in healthcare; The ubiquitous hospital; The Smart Pharmacy; Blockchain meets biometrics in the next generation hospital.

14:57
Healthcare 4.0 and the Hospital of the Future
Sergio Guillén (Ronda Auguste y Louis Lumiere, Spain); Giuseppe Fico (Universidad Politécnica de Madrid, Spain)

Recent breakthroughs in digital health technologies are transformative for reengineering care processes and improving health care outcomes such as care quality and patient safety and can also have major socio-economic impact. Information technology, systems engineering tools, and organizational innovations play critical roles to address the interrelated quality and productivity crises faced by health care systems around the world. Industry 4.0 has transformed manufacturing industry into a new paradigm, the smart and sustainable manufacturing era, and has produced substantial improvements in productivity, quality, and/or customer satisfaction of processes, products, and services. Health care delivery is at the dawn of a paradigm change to reach the new era, referred to as Health Care 4.0. Various diagnosis and treatment options are continuously and exponentially being introduced, extensive data are generated and reported, numerous wired and wireless equipment, sensors, and devices have been installed in hospitals, clinics, home, pharmacies, and many other care environments. Although we have seen progress in smart and connected health care, more research innovation, dissemination, and impact are needed. Health Care 4.0 provides numerous opportunities and challenges for health care system engineering. Many stakeholders must get involved, from engineering, health sciences and education, improvement of health care delivery, and health and health care technologies, with significant effort of mutual engagement, communication, coordination, and compromise among disciplines and perspectives. In addition to using quantitative methods, such as modelling, simulation, computation and optimization techniques, qualitative approaches, including survey, human-centred design, evaluation, and field observations, should also be utilized. Moreover, empirical studies and experimental projects, such as medical simulation, virtual reality, and pilot studies, are an essential complement to modelling; especially before, during and after implementation of new practices. This will allow for continuous learning and improvement of care processes and outcomes. Both hardware (medical equipment, devices, and tools) and software (modelling, computation, evaluation, etc.) should be connected to ensure effective connections and safe implementation of smart technologies. Finally, patients, caregivers and health care workers, should be at the centre of smart and connected health care, in both research and practice. It is critical to address the issue of disparities and inequities and ensure that Health Care 4.0 is designed to mitigate and reduce these inequities and allow all people access to high-quality, safe care.

15:09
A capacitive-based IoT wireless device for no-contact interaction
Marcello Chiurazzi (Scuola Superiore Sant Anna, Italy); Giorgia Spreafico (Scuola Superiore Sant'Anna & The Biorobotics Institute, Italy); Gastone Ciuti (Scuola Superiore Sant'Anna, Italy)

In the future scenario of smart hospitals, proximity sensors may be used to achieve contactless control over robotic agents and smart IoT devices (i.e., lights, plugs, etc.), representing an effective solution for enabling context awareness for a safe human-robot interaction and collaboration. A first prototype of a modular capacitive-based IoT device is presented in this work. Experimental tests were performed, showing a sensitive range of 0-30mm.
Capacitive-based sensing technologies for proximity detection can enhance human-robot (but also robot-robot and human-human) collaboration. In this work, the authors present the development of a standalone capacitive sensor unit which, starting from previously developed tethered version, was designed to be entirely wireless in order to improve modularity, integrability and flexibility. The working principle of the capacitive-based sensing element can be briefly summarized as follows: the capacitive sensor exploits a coplanar-plates configuration (arranged along concentric hexagonal spirals) and

measures the distortion of the electrical field caused by an approaching object entering into its electrical field, which determines an increase in the capacitance.
Telemetry Transport (MQTT) protocol was adopted to publish data in real-time and to make it available remotely. The implemented firmware instructions are: i) SPI communication protocol between a SoM board (Argon, Particle Industries Inc., U.S.A.) and an ADC (MCP33131/21/11-05), and ii) the instructions to publish data received by the ADC to an MQTT broker (i.e., MOSQUITTO™) on a specific topic.

15:21
Digital Transformation and Industry 4.0 for Health Technology Management and Clinical Engineering

15:33
Discussion

14:15 – 15:45
General Assembly
Room: PANDORA C'

15:45 – 17:15
BHI Session #6 Behavioral, Translational and Public Informatics
Chairs: Constantinos S. Pattichis, University of Cyprus, Cyprus**; Arredondo Waldmeyer, Maria Teresa;** Universidad Politécnica de Madrid, Spain
Room: POLYMNIA

15:45
Behavioural Data Categorization for Transformers-based Models in Digital Health
Clauirton A Siebra (University of Geneva, Switzerland & Federal University of Paraiba, Brazil); Igor Matias (University of Geneva, Switzerland); Katarzyna Wac (University of Geneva & Quality of Life group, Switzerland)

Transformers are recent deep learning (DL) models used to capture the dependence between parts of sequential data. While their potential was already demonstrated in the natural language processing (NLP) domain, emerging research shows transformers can also be an adequate modeling approach to relate longitudinal multi-featured continuous behavioral data to future health outcomes. As transformers-based predictions are based on a domain lexicon, the use of categories, commonly used in specialized areas to cluster values, is the likely way to compose lexica. However, the number of categories may influence the transformer prediction accuracy, mainly when the categorization process creates imbalanced datasets, or the search space is very restricted to generate optimal feasible solutions. This paper analyzes the relationship between models' accuracy and the sparsity of behavioral data categories that compose the lexicon. This analysis relies on a case example that uses mQoL-Transformer to model the influence of physical activity behavior on sleep health. Results show that the number of categories shall be treated as a further transformer's hyperparameter, which can balance the literature-based categorization and optimization aspects. Thus, DL processes could also obtain similar accuracies compared to traditional approaches, such as long short-term memory, when used to process short behavioral data sequences.

15:57
Towards acceptable emerging technologies for home monitoring and care: a feasibility study with COVID-19 patients
Despoina Petsani (Aristotle University of Thessaloniki, Greece); Evdokimos Konstantinidis (Medical Physics and Digital Innovation Laboratory, School of Medicine, Aristotle University of Thessaloniki); Michalis Timoleon, Nickolaos Athanasopoulos and Giorgos Tsakonas (Medical Physics and Digital Innovation Laboratory, School of Medicine, AUTH, Greece); Sokratis Nifakos and Natalia Stathakarou (Karolinska Institutet, Sweden); Michail Doumas (General Hospital Hippokration, Poland); Panagiotis Bamidis (Medical School of the Aristotle University of Thessaloniki, Greece)

Healthcare continuity and remote care are among the key components for tackling disease-related effects using technological solutions People recovering from home need high-quality of care and timely monitoring, resembling hospital care. This study proposes the use of a new device for person - machine interaction for home monitoring. The system takes advantage of automatic interaction initiated by the device on detecting patients symptoms and providing remote care in order to improve technology engagement features. The feasibility of the proposed system was tested in COVID-19 patients as a definitive case of stay-at-home care where the treatment depends on the current state of health and the severity of the symptoms. The study shows promising results in terms of usability the vast majority of the answers perceiving the system as useful (90.9 %) and easy to use (95.5%) and an overall System Usability Score (SUS) of the system is 65.25. The system usage adherence was also promising for the quarantine period (on average 7.2 days) but dropped after that. However, the

results from the clinical team interviews showed that there is a need for sufficient allocated time for clinicians to get acquainted with the system and for ED staff to explain the device to patients.

16:09

Data-driven cardiovascular risk prediction and prognosis factor identification in diabetic patients

Hugo C Calero and David Chushig-Muzo (Rey Juan Carlos University, Spain); Himar Fabelo (Fundación Canaria Instituto de Investigación Sanitaria de Canarias, Spain); Inmaculada Mora-Jiménez (Universidad Rey Juan Carlos, Spain); Conceiçao Granja (University Hospital of North Norway, Norway); Cristina Soguero-Ruiz (Universidad Rey Juan Carlos, Spain)

The increase of patients diagnosed with non-communicable diseases (NCDs) have reached high levels, becoming an important global health issue. These are the cause of decease of 41 million people yearly, accounting for 71% of all deaths worldwide. Among NCDs, cardiovascular diseases (CVDs) present an increasing prevalence, leading to severe complications and death. Patients with Type 1 diabetes are more prone to develop CVD events, and present greater mortality rates than the general population. An early risk prediction of developing CVD events in T1D patients could support clinicians in adequate interventions, including lifestyle changes or whether pharmacological or surgical treatments are necessary. In this work, we use feature selection techniques and data-driven models to identify relevant prognostic factors associated with the 10-year CVD risk and develop models for its earlier prediction. Demographic and clinical variables related to the patients' lifestyle were considered, including the interpretation of the variables' impact on the prediction models. Experimental results showed that linear data-driven models are best for CVD prediction, outperforming results of other techniques. Regarding the risk factors, the age was the most important variable for predicting CVD, being present in all models analyzed. This work showed to be promising for predicting CVD, identifying risk factors, and paving the way for clinical decision-making.

16:21

A federated AI-empowered platform for disease management across a Pan-European data driven hub

Vasileios C. Pezoulas and Fanis Kalatzis (University of Ioannina, Greece); Themis Exarchos (Ionian University & University of Ioannina, Greece); Andreas Goules and Athanasios Tzioufas (National and Kapodistrian University of Athens, Greece); Dimitris Fotiadis (Institute of Molecular Biology and Biotechnology, FORTH, Greece & University of Ioannina, Greece)

Nowadays there is an intensive need to move towards a universal health data ecosystem by breaking down data silos. Faced with a wealth of dispersed health data, there are still critical open issues and unmet needs to make this feasible, varying from secure data sharing to data quality and heterogeneity. Considering these challenges, we propose a novel federated platform to unlock the full potential of data from health data intermediaries through the secure sharing, curation, and Natural Language Processing (NLP)-based harmonization of dispersed and complex clinical data structures. The platform was deployed to establish a first Pan-European data hub on rare autoimmune and chronic diseases with 7551 harmonized patient records across 21 European countries with a 90% terminology overlap. An advanced data driven imputer was built to predict missing records in the real patient data based on high-quality synthetic data profiles (with Kullback-Leibler divergence less than 0.01). with reduced fault detection rate (less than 2%) compared to conventional imputers, such as, the kNN imputer. Customized and explainable federated AI algorithms were trained on top of the established data hub for lymphomagenesis modeling with 0.87 sensitivity and 0.74 specificity along with a set of validated biomarkers for disease onset and progression.

16:33

Integrative Bioinformatics Analysis of Transcriptomic Data Reveals Hub Genes as Diagnostic Biomarkers for Non-Muscle vs. Muscle Invasive Bladder Cancer

Michail Sarafidis (National Technical University of Athens, Greece); George Lambrou (National & Kapodistrian University of Athens, Greece); George Matsopoulos and Dimitrios Koutsouris (National Technical University of Athens, Greece)

Bladder cancer (BCa) is one of the most prevalent cancers worldwide and accounts for high socioeconomic impact. BCa can manifest in the form of nonaggressive and usually non-muscle invasive (NMIBC) tumors that recur and require chronic invasive surveillance, or aggressive and muscle invasive (MIBC) tumors with high associated mortality. These two subtypes exhibit distinct prognosis and require different therapeutic approaches. In the present study, we conducted an integrative bioinformatics analysis, combining transcriptomic data from various microarray experiments, in order to reveal a common signature of differentially expressed genes (DEGs) between the two subtypes. Subsequently, we constructed the protein-protein interaction (PPI) network of the DEGs and defined the hub genes based on 11 topological analysis methods. Then, the most significant hub genes were identified using least absolute shrinkage and selection operator (LASSO) logistic regression algorithm. The selected genes were finally used as features in supervised classification algorithms, namely support vector machines and random forests, for BCa subtype discrimination. The models' evaluation showed area under curve (AUC) values up to 96% as regards separating NMIBC from MIBC tumors. Genes driving the separation between

tumor subtypes may prove to be important biomarkers for BCa development and progression, and eventually candidates for therapeutic targeting.

16:45
Discussion

15:45 – 17:15
BHI Session # 7 Big Data and AI (III)
Chairs: Hassan Ghasemzadeh, Washington State University, USA; **Marios Pattichis,** University of New Mexico, USA
Room: KLEIO

15:45
Class-aware data augmentation by GAN specialisation to improve endoscopic images classification
Cyprien Plateau--Holleville and Yannick Benezeth (Université Bourgogne Franche-Comté, France)

The detection and gradation of digestive mucosal lesions require the analysis of endoscopic images by an expert gastrointestinal pathologist. However, the availability of medical practitioners is highly related to geographical location. Inequalities in access to care due to the trained professional unavailability can be offset with the help of Computer-Aided Diagnosis (CAD). An expert eye is often needed to correctly identify mucosal lesions within endoscopic images. Hence, computer-aided diagnosis systems could decrease the need for highly specialized senior endoscopists and the effect of medical desertification. Moreover, they can significantly impact the latest endoscopic classification challenges such as the Inflammatory Bowel Disease gradation. Most of the existing methods are based on deep learning algorithms. However, it is well known that these techniques suffer from the lack of data and/or class imbalance which can be lowered by using augmentation strategies thanks to synthetic generations. Late GAN framework progress made available accurate and production-ready artificial image generation that can be harnessed to extend training sets. It requires, however, to deal with the unsupervised nature of those networks to produce class-aware artificial images. In this article, we present our work to extend two datasets through a class-aware GAN-based augmentation strategy with the help of the state-of-the-art framework StyleGAN2-ADA and fine-tuning. We especially focused our efforts on endoscopic and IBD datasets to improve the classification and gradation of these images.

15:57
A Feasibility Study on Image Inpainting for Non-cleft Lip Generation from Patients with Cleft Lip
Shuang Chen and Amir Atapour-Abarghouei (Durham University, United Kingdom (Great Britain)); Jane Kerby (The Newcastle Upon Tyne Hospitals NHS Foundation Trust, United Kingdom (Great Britain)); Edmond S. L. Ho (University of Glasgow, United Kingdom (Great Britain)); David Sainsbury and Sophie Butterworth (The Newcastle Upon Tyne Hospitals NHS Foundation Trust, United Kingdom (Great Britain)); Hubert P. H. Shum (Durham University, United Kingdom (Great Britain))

Cleft lip is one of the most prevalent congenital malformations and patients typically need surgery to correct their facial appearance. The surgeon must have extensive experience and theoretical knowledge in order to perform the surgery. Artificial Intelligence (AI) has been proposed to guide surgeons in improving surgical outcomes. If AI can be used to predict what a repaired cleft lip would look like, surgeons could use it as an adjunct to adjust their surgical technique and improve results. To explore the feasibility of this idea while protecting patient privacy, we propose a deep learning-based image inpainting method that is capable of covering a cleft lip and generating a lip and nose without a cleft. We collect two real-world cleft lip datasets, CleftLip10 and CleftLip24, from real patients with cleft lips for testing. Patient photos will not be used in the training process to protect patient privacy. We use segmentation masks to cover the cleft lip and medical equipment, then our model automatically synthesizes a healthy nose and mouth. We compare our results with three state-of-the-art methods which challenged facial inpainting task. We invite three professional cleft lip surgeons to assess the results to demonstrate the feasibility of the proposed method. We also include quantitative results on CelebA to show the advantages of the proposed multi-task framework. Our model can simultaneously perform image inpainting and facial landmark prediction. The parameters in two tasks are shared through image-to-landmark and landmark-to-image feature fusion operations. The code is publicly available to enable better reproducibility.

16:09
A Localisation Study of Deep Learning Models for Chest X-ray Image Classification
James Gascoigne-Burns and Stamos Katsigiannis (Durham University, United Kingdom (Great Britain))

Deep learning models have demonstrated superhuman performance in a multitude of image classification tasks, including the classification of chest X-ray images. Despite this, medical professionals are reluctant to embrace these models in clinical settings due to a lack of interpretability, citing being able to visualise the image areas contributing most to a model's predictions as one of the best ways to establish trust. To aid the discussion of their suitability for real-world use, in this work,

we attempt to address this issue by conducting a localisation study of two state-of-the-art deep learning models for chest X-ray image classification, i.e. ResNet-38-large-meta and CheXNet, on a set of 984 radiologist annotated X-ray images from the ChestX-ray14 publicly available dataset. We do this by applying and comparing several state-of-the-art visualisation methods, combined with a novel dynamic thresholding approach for generating the bounding boxes, which we show to outperform the static thresholding method used by similar localisation studies in the literature. Results also seem to indicate that localisation quality is more sensitive to the thresholding scheme than the visualisation method used, and that a high discriminative ability, as measured by classification performance, is not necessarily sufficient for models to produce useful and accurate localisations.

16:21
Improve the trustwortiness of medical text interpretations
Siyue Song (School of Computing and Engineering & University of Huddersfield, United Kingdom (Great Britain)); Tianhua Chen and Grigoris Antoniou (University of Huddersfield, United Kingdom (Great Britain))

Currently, how to make a concrete and correct disease prediction is a popular research trend. Researchers made more efforts to develop various models to provide interpretations of the medical area, however, there is still lack of human-understandable explanations are provided due to the non-transparency structure of some machine learning and deep learning models. According to this work, there is one combined model application we would like to adopt. One of the multi-sense word embedding models called Probabilistic FastText (PFT) was applied to the experiment to classify the medical texts. After that, the topic model called LDA was combined with the PFT model based on the probability feature. Then the fuzzy C mean model was employed to assign the linguistic terms and extract the attributes, which were used to generate the fuzzy rules to provide interpretations of the classification results. After comparison experiments of classification and interpretation, it is found that evaluation metrics, such as accuracy, precision, recall, and F1 scores of the combination model were good. Then the interpretation evaluation was set up based on the different levels, such as word level, topic level, and document level. can address the issues from the latest interpretation models, and try to improve the trustworthiness of medical text interpretations.

16:33
COPER: Continuous Patient State Perceiver
Vinod Kumar Chauhan (University of Oxford, United Kingdom (Great Britain)); Anshul Thakur and Odhran O'Donoghue (Institute of Biomedical Engineering, United Kingdom (Great Britain)); David Clifton (University of Oxford, United Kingdom (Great Britain))

In electronic health records (EHRs), irregular time-series (ITS) occur naturally due to patient health dynamics, reflected by irregular hospital visits, diseases/conditions and necessity to measure different vitals at each visit etc. ITS presents challenges in training machine learning algorithms which mostly are built on assumption of coherent fixed dimensional feature space. In this paper, we propose a novel COntinuous patient state PERceiver model, called COPER, to cope with ITS in EHRs. COPER uses perceiver model and the concept of neural ordinary differential equations (ODEs) to learn the continuous time dynamics of patient state, i.e., continuity of input space and continuity of output space. The nerual ODEs help COPER to generate regular time-series to feed to perceiver model which has the capability to handle multi-modality large-scale inputs. To evaluate the performance of the proposed model, we use in-hospital mortality prediction task on MIMIC-III dataset and carefully design experiments to study irregularity. The results are compared with the baselines which prove the efficacy of the proposed model.

16:45
Discussion

15:45 – 17:15
Virtual Session by BSN Innovation and Business Opportunities in Digital Health Technology
Chairs: Paolo Bonato, BSN2022 Chair, OJEMB EiC, Harvard Medical School, USA; **Ali Hashemi,** Managing Director at Polymath Ventures, Colombia
Room: PANDORA C'

Joe Gwin
BestBuy Health

Shyamal Patel
Oura

Canan Dagdeviren
MIT

Dina Katabi
MIT

Julie Keysor
MGH

Ilkka Korhonen
Tampere Univ

17:15 – 17:30
Coffee Break
Room: FOYER ERATO

17:30 – 18:00
Closing Ceremony: Best Paper, Best Poster Awards
Room: ERATO

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