IEEE

# BioCAS 2022 TAIPEI

Biomedical Circuits and Systems Conference

October 13-15, 2022 | TAIPEI, TAIWAN

Chang Yung-Fa Foundation, International Convention Center (CYFF)

**Intelligent Biomedical Systems for a Better Future**

## Program Book

IEEE BiOCAS 2022 TAIPEI
Biomedical Circuits and Systems Conference
October 13-15, 2022 | TAIPEI, TAIWAN
Intelligent Biomedical Systems for a Better Future

# Program-at-a-Glance

801, 8F, CYFF International Convention Center

## Day 1–Thur., October 13

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|---|---|
| 08:00 | **Registration** 08:00~18:00 |
| 08:30 | **Introduction and Welcome** |
| 09:00 | **Tutorial (1)** Ultrasound for Neuromodulation and Wireless Power Transfer<br>**Prof. Mehdi Kiani**<br>The Pennsylvania State University, USA |
| 10:30 | Coffee Break |
| 11:00 | **Tutorial (2)** Digital Auscultation for Cardiac and Respiratory Systems<br>**Prof. Yongfu Li**<br>Shanghai Jiao Tong University, China |
| 12:30 | Lunch Break |
| 13:30 | **Keynote Speech (1)** In-Memory Sensing and Computing<br>**Prof. Sandro Carrara**<br>École Polytechnique Fédérale de Lausanne, Switzerland |
| 14:30 | Mini Break |
| 14:40 | **Tutorial (3)** Medical Devices – from Research to Market<br>**Prof. Julius Georgiou**<br>University of Cyprus, Cyprus |
| 16:10 | **Coffee Break / Poster Session (1)－A1P-A** |
| 17:00 | **Tutorial (4)** Circuits and Technologies for Implantable Biomedical Devices<br>**Dr. Carolina Mora Lopez**<br>imec, Belgium |
| 18:30 | |
| 19:30 | **Welcome Reception & Live Interactive Demonstrations**<br>810B, CYFF 張榮發國際會議中心 |

## Day 2–Fri., October 14

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|---|---|
| 07:30 | **Registration** 07:30~16:30 |
| 08:00 | **Keynote Speech (2)** SOCs Powering Intelligent Neuro-Modulation Biomedical Systems - Innovations and Challenges<br>**Prof. Chung-Yu Wu**<br>National Yang Ming Chiao Tung University, Taiwan |
| 09:00 | Coffee Break |
| 09:20 | **Lecture Session (1)－B1L-B** Wireless Devices and Energy Harvesting |
| 10:50 | Mini Break |
| 11:00 | **Lecture Session (2)－B2L-B** Implantable Medical Electronics |
| 12:30 | Lunch Break |
| 13:30 | **Lecture Session (3)－B3L-B** Human Machine Interfaces and Electronics for Neuroscience |
| 15:00 | **Coffee Break / Poster Session (2)－B4P-A** |
| 16:00 | **Lecture Session (4)－B5L-B** Emerging Circuits and Systems for Diagnostics |
| 17:45 | |
| 18:30 | **Banquet**<br>3F, Dragon Hall, The Howard Plaza Hotel Taipei<br>台 北 福 華 飯 店 3 F 金 龍 廳 |

## Day 3–Sat., October 15

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|---|---|
| 07:30 | **Registration** 07:30~16:30 |
| 08:00 | **Keynote Speech (3)** Data Harmonization: An Imaging-driven Omics Database / Repository for Retrospective Understanding of COPD and Planning for Future Care<br>**Prof. Andrew Laine**<br>Columbia University, USA |
| 09:00 | Coffee Break |
| 09:20 | **Lecture Session (5)－C1L-B** Biosensor Devices and Interface Circuits |
| 10:50 | Mini Break |
| 11:00 | **Lecture Session (6)－C2L-B** Biosignal Recording and Processing |
| 12:30 | Lunch Break |
| 13:30 | **Lecture Session (7)－C3L-B** Point-of-Care Devices, Imaging and Bioinformatics |
| 15:00 | **Coffee Break / Poster Session (3)－C4P-A** |
| 16:00 | **Lecture Session (8)－C5L-B** Grand Challenge on Respiratory Sound Classification |
| 17:30 | **Award Ceremony** |
| 18:00 | |
| 18:30 | **Farewell Party**<br>2F, Rosa Room, Taipei Garden Hotel<br>台 北 花 園 酒 店 2 F 薔 薇 廳 |

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# Message from General Co-Chairs

**Kea-Tiong (Samuel) Tang**
Professor
National Tsing Hua University, Taiwan

**Shuenn-Yuh Lee**
Professor
National Cheng Kung University, Taiwan

Dear Friends and Colleagues,

On behalf of the entire Organization Committee, we cordially welcome you to the 2022 IEEE BioCAS conference. Originally, we planned to host the conference in person. However, as the situation of the pandemic varies from time to time, we had to make a difficult decision to make the conference a hybrid one. Nevertheless, we will have a physical meeting since 2019 (three years ago!) in Nara! We sincerely hope that you can join us to enjoy the exchange of latest findings and exciting research results in biomedical circuits and systems during the conference, regardless of attending in person or in virtual.

The conference topic in 2022 is "Intelligent Biomedical Systems for a Better Future". With the emergence of artificial intelligence (AI) in recent years, it is expected to add more "intelligence" to biomedical circuits and systems, enabling a better future for human beings. In line with this direction, we will have three invited keynote presentations as well as four tutorials from well-known and outstanding experts in their area, as well as a combination of 8 oral sessions, 3 poster sessions, and 1 live demo session. A new and nice element to this edition of the conference is the "Grand Challenge on Respiratory Sound Classification; many teams have participated in the contest, and the top five winners will present their works in a special session.

For the attendees who participate in the conference in person, the venue is located at a very popular meeting place, Chang Yung-Fa Foundation International Convention Center (CYFF), very close to the famous Chiang Kai-Shek Memorial Hall and 228 Peace Park. You will find that it is very easy to commute from Taipei Main Station, which can be easily reached from the Taiwan Taoyuan International Airport. The transportation system in Taipei, including MRT, bus, taxi, YouBike, and so on, will take you anywhere during your stay. For the attendees who participate in the conference online, in addition to the live Q&A session, you will have the opportunity to leave a message in the chatbox of every talk, and the authors will interact with you during the conference.

Once again, enjoy the conference, the technical program, the social program, the food, the culture, and the beautiful city of Taipei. I hope that we can meet each other face to face next year in Toronto.

My best wishes to you and your families,

Sincerely yours,

**Kea-Tiong (Samuel) Tang**

General Co-Chair of IEEE BioCAS 2022

**Shuenn-Yuh Lee**

General Co-Chair of IEEE BioCAS 2022

# Organizing Committee

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Department of Electrical and Computer Engineering
National Yang Ming Chiao Tung University

# Keynotes

## Sandro Carrara

Professor
Institute of Electrical and Micro Engineering, Engineering Faculty
EPFL, École Polytechnique Fédérale de Lausanne
Switzerland

**Biography**

Sandro Carrara (F'15) is an IEEE Fellow for his outstanding record of accomplishments in the field of design of nanoscale biological CMOS sensors. He is also the recipient of the IEEE Sensors Council Technical Achievement Award in 2016 for his leadership in the emerging area of co-design in Bio/Nano/CMOS interfaces. He is faculty at the EPFL in Lausanne (CH), former professor at the Universities of Genoa and Bologna (IT). He holds a PhD in Biochemistry and Biophysics from University of Padua (IT), a Master degree in Physics from University of Genoa (IT), and a diploma in Electronics from National Institute of Technology in Albenga (IT). Along his carrier, he published 7 books with prestigious publishers such as Springer/NATURE and Cambridge University Press. He has authored more than 340 publications and 15 patents. He is Editor-in-Chief of the IEEE Sensors Journal, the largest journal among 220 IEEE publications per topic, and Associate Editor of IEEE Transactions on Biomedical Circuits and Systems. He is a member of the IEEE Sensors Council and his Executive Committee. He was a member of the Board of Governors (BoG) of the Circuits And Systems IEEE Society (CASS). He has been appointed as IEEE Sensors Council Distinguished Lecturer for the years 2017-2019, and CASS Distinguished Lecturer for the years 2013-2014. His work received several international recognition as best-cited papers and best conference papers. He has been the General Chairman of the Conference IEEE BioCAS 2014, the premier worldwide international conference in the area of circuits and systems for biomedical applications, and he also was the General Chairman of the 16th Edition of IEEE International Symposium on Medical Measurements and Applications, IEEE MeMeA 2021.

## Keynote 1 October 13, 2022 | 13:30-14:30

### In-Memory Sensing and Computing

**Session Chair:**
**Kea-Tiong (Samuel) Tang /** National Tsing Hua University, Taiwan

**Abstract**

The concept of in-Memory Computing is nowadays a well-established principle. Instead of separating the processing device by the memory units, as usually done in traditional von Neumann architectures, it proposes new architectures based on memory devices providing simultaneous computing. Indeed, this keynote speech proposes the new concept of in-Memory Sensing and Computing as a disruptive novel approach in edge-computing. This novel concept is here proposed as based on the fusion of three architectural functions: sensing, computing and memorizing. This novel concept is proposed by using a simple architecture based on a single-kind of devices simultaneously providing these three functions: the memristors. The proposed novel approach also provides a breakthrough in cancer diagnostics. If fact, the concept is here demonstrated by showing a well-known case in oncology: the estimation of the risk of prostate cancer based on the measure of Prostate Specific Antigen (PSA) and its Membrane isoform (PSMA). So, this keynote discusses the first-ever-reported direct computation of the cancer risk on cancer markers detected with memristive biosensors simultaneously with the computation and data storing. Memristive biosensors are quite a novelty emerged in literature with first publications starting from 2011. These new kind of devices are of interest for many reasons but especially for their excellent Limit-of-Detection, which is down to the attomolar-ranges in cancer markers detection. They are often fabricated on silicon nanowires and manufactured with standard lithographic processes. This means the whole architecture may be CMOS-based and the biosensors themselves can be physically microfabricated onto the same dye. Therefore, this keynote talk opens to an important new area of research and development: the possibility to build innovative circuits and systems providing simultaneous sensing, computing, and storing for true lab-on-a-chip applications.

# Keynotes


## Chung-Yu Wu

Emeritus Chair Professor
Institute of Electronics,
National Yang Ming Chiao Tung University
Taiwan


**Biography**

Dr. Chung-Yu Wu was born in 1950. He received the M.S. and Ph.D. degrees from the Department of Electronics Engineering, National Chiao Tung University, Hsinchu, Taiwan, R.O.C., in 1976 and 1980, respectively.

Since 1980, he has served as a consultant to high-tech industry and research organizations and has built up strong research collaborations with high-tech industries. From 1980 to 1983, he was an Associate Professor at National Chiao Tung University. During 1984 to 1986, he was a Visiting Associate Professor in the Department of Electrical Engineering, Portland State University, Portland, OR. Since 1987, he has been a Professor at National Chiao Tung University. From 1991 to 1995, he was rotated to serve as the Director of the Division of Engineering and Applied Science on the National Science Council, Taiwan. From 1996-1998, he was honored as the Centennial Honorary Chair Professor at National Chiao Tung University. He received the National Chair Professorship from Ministry of Education, 2015-2017. Currently, he is an Emeritus Chair Professor at National Yang Ming Chiao Tung University and Chairman/CTO of A-Neuron Electronic Corporation. He has published more than 300 technical papers in international transactions/journals and conferences. He also has 56 patents including 23 U.S. patents. His research interests are implantable biomedical integrated circuits and systems, intelligent bio-inspired sensor systems, RF/microwave communication integrated circuits, neural network, analog/mixed-signal integrated circuits, and nanoelectronics.

Dr. Wu is a member of Eta Kappa Nu and Phi Tau Phi Honorary Scholastic Societies. He was a recipient of IEEE Fellow Award in 1998, Third Millennium Medal in 2000, and the IEEE Life Fellow Award in 2020. In Taiwan, he received numerous research awards from Ministry of Education, National Science Council, and professional foundations.

## Keynote 2 October 14, 2022 | 08:00-09:00

### SOCs Powering Intelligent Neuro-Modulation Biomedical Systems - Innovations and Challenges

**Session Chair:**
**Tsung-Hsien Lin** / National Taiwan University, Taiwan

**Abstract**


Closed-loop neuro-modulation has been proven as an adaptive and optimal treatment for a range of intractable neurological disorders or diseases like drug-resistant epilepsy, Parkinson's diseases, chronic pain, dementia, etc. The biomedical systems realizing implantable closed-loop neuro-modulation have become a rapid growing and challenging research frontier. Enabled by CMOS IC technologies, the core circuits of implantable closed-loop neuro-modulation systems can be integrated together to form a SoC (System-on-Chip), instead of discrete components as in nowadays commercial products. Greatly powered by SoCs, the SoC-inside implantable neuro-modulation systems have the advantages of small size, low power dissipation, high speed, and high accuracy. This makes them more effective and efficient in closed-loop neuro-modulation.

Epilepsy is defined as a tendency to have recurrent seizures. Epileptic seizures are caused by a sudden burst of excess electrical activity in the brain. As the fourth most common neurological disorder, 70 million people have epilepsy worldwide and about 30% of them are intractable. It is quite feasible to use SoC-inside implantable closed-loop neuro-modulation systems on these patients to suppress epileptic seizures through electrical stimulation. An implantable CMOS closed-loop neuro-modulation system for epilepsy control has been developed since 2008. It consists of an extraocular chip and an intraocular SoC with rechargeable battery. Both are coupled by a pair of coils operated at 13.56 MHz for wireless power and bilateral data telemetry. The implantable SoC consists of ECoG (Electrocorticography) acquisition unit, biphasic CCS (Constant Current Stimulation) stimulators, BSP (Bio-signal Processor), power management unit, battery charger, and wireless telemetry circuits whereas the extraocular chip contains power amplifier, charging control circuits, and wireless telemetry circuits. The SoC-inside system detects patient's ECoG and automatically generates stimulus current pulses to suppress epileptic seizures. The design and measurement results of innovative SoC design and whole closed-loop neuro-modulation system will be presented. The results of initial clinical trial will be described.

The on-going research on closed-loop DBS (Deep Brain Stimulation) SoC for Parkinson's diseases will be highlighted. Finally, design challenges on circuits and systems for implantable neuro-modulation will be addressed. New discovery on dementia paving the road of neuro-modulation treatment will also discussed as a future perspective.

# Keynotes

## Andrew Laine

Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Professor of Radiology (Physics)
Columbia University

**Biography**

Andrew F. Laine received his D.Sc. degree from Washington University (St. Louis) School of Engineering and Applied Science in Computer Science, in 1989 and BS degree from Cornell University (Ithaca, NY). He was a Professor in the Department of Computer and Information Sciences and Engineering at the University of Florida (Gainesville, FL) from 1990-1997. He joined the Department of Biomedical Engineering in 1997 and served as Vice Chair of the Department of Biomedical Engineering at Columbia University since 2003 – 2011, and Chair of the Department of Biomedical Engineering (2012 – 2017). He is currently Director of the Heffner Biomedical Imaging at Columbia University and the Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Professor of Radiology (Physics).

He has served on the program committee for the IEEE-EMBS Workshop on Wavelet Applications in Medicine in 1994, 1998, 1999, and 2004. He was the founding chair of the SPIE conference on "Mathematical Imaging: Wavelet Application in Signal and Image Processing", and served as co-chair during the years 1993-2003. Dr. Laine has served as Chair of Technical Committee (TC-BIIP) on Biomedical Imaging and Image Processing for EMBS 2004-2009, and has been a member of the TC of IEEE Signal Processing Society, TC-BISP (Biomedical Imaging and Signal Processing) 2003-present. Professor Laine served on the IEEE ISBI (International Symposium on Biomedical Imaging) steering committee, 2006-2009 and 2009 – 2012. He was the Program Chair for the IEEE EMBS annual conference in 2006 held in New York City and served as Program Co-Chair for IEEE ISBI in 2008 (Paris, France). He served as Area Editor for IEEE Reviews in BME in Biomedical Imaging since 2007-2013. He was Program Chair for the EMBS annual conference for 2011 (Boston, MA). Professor Laine Chaired the Steering committee for IEEE ISBI, 2011-2013, and Chairs the Council of Societies for AIMBE (American Institute for Medical and Biological Engineers). He was the General Co-Chair for IEEE ISBI in 2022. Finally, he served as the IEEE EMBS Vice President of Publications 2008 – 2012, and was the President of IEEE EMBS (Engineering in Biology and Medicine Society) 2015 and 2016. He is a Fellow of IEEE, AIMBE and IFMBE.

## Keynote 3 October 15, 2022 | 08:00-09:00

### Data Harmonization: An Imaging-driven Omics Database / Repository for Retrospective Understanding of COPD and Planning for Future Care

**Session Chair:**
**Shuenn-Yuh Lee /** National Cheng Kung University, Taiwan

**Abstract**

Consistent imaging protocols will require normalization / harmonization of data sourced from multiple platforms, hospitals and vendors. AI has shown a remarkable ability to generalize and group / tease out patterns from high-dimensional data. Machine / deep learning algorithms should rely on mix-omics integration of imaging and physiological measures. There is an urgent need for new models of multi-modal transfer learning (e.g., understanding lung and heart functional interactions), and incremental learning as cohorts grow at an ever-faster face, combining data from states/countries.

We are in the process developing harmonization methods that are applied to COPD patient imaging data. This phenotyping could lead to a better retrospective understanding of COPD disease pathways and prepare for future management of pulmonary-derived chronic pathologies. In addition, there are significant new chronic pathologies expected in COVID survivors (cardiomyopathy, pulmonary aspergillosis, hemoglobin / iron deficiencies) in the longer term, which will be challenging to treat and / or recognize. The harmonized baseline data during acute phases of disease would help tremendously in our ability to understand the implications of these pathologies.

The proposed harmonization platform would include normalization across vendors, sites, possible variations in protocols and patient size. We describe AI based harmonization methods to leverage a large number of baseline scans from existing and ongoing studies for density measures, texture and later airway topology. During this initial phase, the Columbia cohort would harmonize 2,500 subjects in total, sampling in proportion five distinct cohorts. In the long term we aspire to develop data sharing tools, with possible partnerships for long term / global infrastructure and computing, integrate expertise in multiple imaging modalities, lead an open AI approach to model, predict and understand stages of pulmonary disease including COPD.

# Tutorials


## Mehdi Kiani

Associate Professor
Electrical Engineering,
The Pennsylvania State University
USA


**Biography**

Mehdi Kiani received his Ph.D. degree in Electrical and Computer Engineering from the Georgia Institute of Technology in 2014. He joined the faculty of the School of Electrical Engineering and Computer Science at the Pennsylvania State University in August 2014 where he is currently an Associate Professor. His research interests are in the multidisciplinary areas of analog and power-management integrated circuits, ultrasound-based medical systems, wireless implantable medical devices, and neural interfaces. He was a recipient of the 2020 NSF CAREER Award. He is currently an Associate Editor of the IEEE Transactions on Biomedical Circuits and Systems and IEEE Transactions on Biomedical Engineering. He serves as the technical program committee member of the IEEE International Solid-State Circuits Conference in the IMMD subcommittee.

## Tutorial 1 October 13, 2022 | 09:00-10:30

### Ultrasound for Neuromodulation and Wireless Power Transfer

**Session Chair:**
**Chih-Ting Lin** / National Taiwan University, Taiwan


**Abstract**

The conventional application of ultrasound in the medical field is in tissue imaging. Over the past decade or so, ultrasound has increasingly found interesting applications in neuromodulation of neural activity as well as wireless power transfer to deeply implanted miniature (millimeter scale and smaller) medical devices. Although ultrasound is relatively a new modality for neuromodulation, several research groups across the globe have demonstrated on both animals and humans that ultrasound has a robust and safe effect on neural tissue for both activation and suppression of neural activity. Also, ultrasonic wireless power transfer to millimeter-scale implants have successfully been demonstrated in different applications, such as neural recording and stimulation. Both ultrasound neuromodulation and wireless power transfer applications still require significant amount of research and development in ultrasonic transducers, ultrasonic arrays, CMOS circuits (particularly high-voltage beamforming drivers), biomedical system integration, and in vivo validations, all of which are of great interest to the biomedical circuits and systems (BioCAS) community. In this tutorial, I will present the basics, recent developments, challenges, and applications of ultrasound neuromodulation and ultrasound wireless power transfer to millimeter-scale implants.

# Tutorials


## Yongfu Li

Associate Professor
Department of Micro and Nano Electronics,
Shanghai Jiao Tong University
China


**Biography**

Yongfu Li (S'09–M'14-SM'18) received the B.Eng. and Ph.D. degrees from the Department of Electrical and Computing Engineering, National University of Singapore (NUS), Singapore.

He is currently an Associate Professor with the Department of Micro and Nano Electronics Engineering and MoE Key Lab of Artificial Intelligence, Shanghai Jiao Tong University, China. He was a research engineer with NUS, from 2013 to 2014. He was a senior engineer (2014-2016), principal engineer (2016-2018) and member of technical staff (2018-2019) with GLOBALFOUNDRIES, as a Design-to-Manufacturing (DFM) Computer-Aided Design (CAD) research and development engineer. His research interests include analog/mixed signal circuits, data converters, power converters, biomedical signal processing with deep learning technique and DFM circuit automation.

## Tutorial 2 October 13, 2022 | 11:00-12:30

### Digital Auscultation for Cardiac and Respiratory Systems

**Session Chair:**
**Chih-Ting Lin** / National Taiwan University, Taiwan

**Abstract**

Inspection, palpation, percussion, and auscultation (IPPA) are the four key physical assessments to understand the condition of a patient. In particular, adventitious heart and respiratory sounds can be heard by performing auscultation on the anterior and posterior chest. However, auscultation requires a lot of experience to be able to determine the types of sounds heard. Furthermore, the inter-listener variability among physicians and the lack of quantitative measurements make lung auscultation a subjective process. Therefore, the digital stethoscope has been gradually adopted in several hospitals to provide digital recording, which can be used for further analysis. My tutorial will begin with an introduction to the auscultation of our cardiac and respiratory systems, followed by a discussion of heart and lung sounds. On this basis, we will review the different features of the digital stethoscope system and discuss how signal processing, machine learning, and deep learning models can improve the detection and classification of heart and respiratory sounds. Furthermore, in alignment with the BioCAS student design contest, we hope to encourage more people to be engaged in this meaningful research topic.

# Tutorials


## Julius Georgiou

Associate Professor
Electrical and Computer Engineering,
University of Cyprus
Cyprus


**Biography**

Julius Georgiou (IEEE M'98-SM'08) is an Associate Professor at the University of Cyprus. He received his M.Eng degree in Electrical and Electronic Engineering and Ph.D. degree from Imperial College London in 1998 and 2003 respectively. For two years he worked as Head of Micropower Design in a technology start-up company, Toumaz Technology. In 2004 he joined the Johns Hopkins University as a Postdoctoral Fellow, before becoming a faculty member at the University of Cyprus from 2005 onwards. In parallel, he has been involved in the founding of multiple medical device startup companies, based on patents stemming from his research.

Prof. Georgiou is a member of the IEEE Circuits and Systems Society, was the Chair of the IEEE Biomedical and Life Science Circuits and Systems (BioCAS) Technical Committee, as well as a member of the IEEE Circuits and Systems Society Analog Signal Processing Technical Committee. He served as the General Chair of the 2010 IEEE Biomedical Circuits and Systems Conference and is the Action Chair of the EU COST Action ICT-1401 on "Memristors-Devices, Models, Circuits, Systems and Applications - MemoCIS". Prof. Georgiou was an IEEE Circuits and Systems Society Distinguished Lecturer for 2016-2017. He is also is an Associate Editor of the IEEE Transactions on Biomedical Circuits and Systems and Associate Editor of the Frontiers in Neuromorphic Engineering Journal. He is a recipient of a best paper award at the IEEE ISCAS 2011 International Symposium and at the IEEE BioDevices 2008 Conference. In 2016 he received the 2015 ONE Award from the President of the Republic of Cyprus for his research accomplishments.

His research interests include Low-power analog and digital ASICs, implantable biomedical devices, bioinspired electronic systems, ElectroUteroGraph hardware, ElectroUteroGram signal processing, electronics for space, brain-computer-interfaces (BCIs), memristive devices, inertial and optical sensors and related systems.

## Tutorial 3 October 13, 2022 | 14:40-16:10

### Medical Devices – from Research to Market

**Session Chair:**
**Jun-Chau Chien** / National Taiwan University, Taiwan

**Abstract**


Technology has significantly impacted the capabilities of medical diagnostics and treatment, however only a fraction of the research conducted in the biomedical technology domain makes it to the market. The reason for this is because the process of developing and marketing novel medical devices is extremely complex and laden with many pitfalls. This tutorial aims to provide a brief overview of the issues that academics or researchers will face if they decide to embark on the long journey of taking their invention to market. The basic requirements of any product going to market is that the device provides a value proposition to the customer and that the company providing the product is economically viable. Thus this journey starts with understanding if there really is a business case and formulating a strategy for protecting the intellectual property early on. The options for exploiting the technology vary from licensing to becoming an academic entrepreneur through a startup company. This tutorial will focus on the startup route, where the academic will be closely involved with the founding and running of the company. Considerations to be taken into account are the structure of the startup, choosing a team and defining their roles, formulating a funding strategy, selecting a beachhead market and testing the various assumptions on a regular basis. Medical device companies have extra hurdles to overcome, which include that of acquiring regulatory approvals and that of designing and implementing a Quality Management System. In view of this, transitioning from an academic prototype to a product is not trivial. The final part of the tutorial will cover the basics of going to market, including postmarket surveillance, which is usually a legal requirement of medical device companies, to ensure the safety of the end users.

# Tutorials

## Carolina Mora Lopez

Principal Member of Technical Staff &
R&D Team Leader, imec
Belgium

**Biography**

Carolina Mora Lopez received her Ph.D. degree in Electrical Engineering in 2012 from the KU Leuven, Belgium, in collaboration with imec, Belgium. From 2012 to 2018, she worked at imec as a researcher and analog designer focused on interfaces for neural-sensing applications. During this time, she was the lead analog designer and project leader of the Neuropixels development project which resulted in the conception and fabrication of the Neuropixels 1.0 and 2.0 neural probes. She is currently the principal scientist and team leader of the Circuits & Systems for Neural Interfaces team at imec, which develops circuits and technologies for electrophysiology, neuroprosthetics and BMI. Her research interests include analog and mixed-signal circuit design for sensor, bioelectronic and neural interfaces. Carolina is a senior IEEE member and serves on the technical program committee of the ISSC conference, ISSCC SRP, VLSI circuits symposium, and ESSCIRC conference.

## Tutorial 4 October 13, 2022 | 17:00-18:30

### Circuits and Technologies for Implantable Biomedical Devices

**Session Chair:**
**Jun-Chau Chien /** National Taiwan University, Taiwan

**Abstract**

Biological processes such as neuronal signaling and cell growth are among the most complex micro- and nano-scale processes in nature. Historically such processes have been studied at system level because there were no tools available to study individual components of the process. However, cellular-level interfacing is needed to provide better understanding of the brain and to develop more advanced prosthetic devices and brain-machine interfaces. With semiconductor technology innovations, much recent work has been focused on unraveling biological complexity, but also on driving new diagnoses, treatments and therapies that are tailored to the individual. One of the drivers behind those innovations is novel CMOS circuits enabling multi-modal, high-precision data collection and analysis at ultra-low power consumption. In this talk, I will present recent biomedical developments based on silicon technology, and I will discuss the requirements, materials, circuit techniques and design challenges of their ASIC and SoC platforms.

# Google University Relations Programs
## (research.google/outreach)

To cultivate collaborations with the academics, Google administers a variety of programs that provide resources and support to the academic and external research communities.

## Opportunities for Faculty

### / Google's Research Grant
Not for open calls. Please reach out to Google contact to apply for.

### / Award for Inclusion Research
[research.google/outreach/air-program]
Supports research addressing the needs of populations historically underrepresented in the tech industry (e.g. women, people with disabilities etc.). Applications open in Summer.

### / Research Scholar Program
[research.google/outreach/research-scholar-program/]
Supports research conducted by early-career faculty globally. Applications open in Fall.

### / Google Cloud Platform (GCP)
[edu.google.com/programs/credits/research/]
Provide researchers and PhD students with computing power, storage and AI tools to develop bold ideas and make cutting-edge discoveries. Applications open any time.

### / Academic Conference Sponsorship
Sponsorship to both international and domestic academic conferences on areas relevant to Google research priorities. Not for open calls. Please reach out to Googler contact to apply for.

### / exploreCSR (CSR diversity)
[research.google/outreach/explore-csr/]
Awards that support universities to host computer science research (CSR) workshops in order to increase the number of students from groups traditionally underrepresented in CS. Applications open in Spring.

### / Visiting Researcher Program
[research.google/outreach/visiting-researcher-program/]
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### / Research Exchange
Research talks by people from both sides to foster research interactions and sharing.

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Fellowships recognize outstanding PhD students doing exceptional and innovative research. Applications open in March.

### / Student Travel Grants
[buildyourfuture.withgoogle.com/scholarships/google-conference-scholarships]
Support outstanding research students to attend leading conferences. Applications open any time (APAC tab, East Asia form).

### / Student Researcher
[email to eastasia-ur@google.com]
Research internship to work with Google research / engineering teams at Google. Flexible internship period. BS, MS or PhD students are all eligible.

### / Visit to Google Office
Provides opportunities for students to visit Google offices and meet Googlers from different functions.

For any questions, please reach out to eastasia-ur@google.com

Google

# Lecture Sessions

## Lecture Session (1) - B1L-B October 14, 2022 | 09:20-10:50

### Wireless Devices and Energy Harvesting

Session Chair(s):
Yuanjin Zheng / Nanyang Technological University, Singapore
Yu-Te Liao / National Yang Ming Chiao Tung University, Taiwan

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**B1L-B1 09:20—09:35**

A Low Power Two Lenses Wireless Panoramic Micro-Endoscopy Implemented Using Voltage-Current Adjuster and 3D-PCB Stacking Technology

Xiang-Ren Yang, Sheng-Wei Hsu, Ching-Hwa Cheng, Don-Gey Liu
Feng Chia University, Taiwan

The main purpose of this paper is to develop a low-power design technology for a wireless two-lense panoramic micro-endoscopy. The voltage current adjuster (VCA) replaces the voltage-adjust method and does not increase the additional silicon cost without using voltage converters. A built-in voltage measurement mechanism provides that the voltage level can be automatically adjusted. The system achieves a 32~68% power reduction for video decoders using VCAs. The proposed technique can reduce system power consumption without performance degradation. Scalable system functions are successfully validated by a 3D-PCB stacking technique. The 3D stacking system comparison with the conventional flatten design, with good performance, less power-consumption and small volume size.

**B1L-B2 09:35—09:50**

Packaging Methods for Magnetoelectric Transducers Used as Wireless Power Receivers

Sujay Hosur, Sumanta Karan, Shashank Priya, Mehdi Kiani
Pennsylvania State University, United States

Magnetoelectric (ME) transducers have recently been demonstrated as a receiver in wireless power transfer (WPT) to miniature implantable medical devices (IMDs). Due to their complex mechano-magnetic-electric interactions, methods for biocompatible coating and packaging of ME transducers within a small IMD need to be investigated. This paper describes the effects of biocompatible coating and packaging using Polydimethylsiloxane (PDMS) on ME response. Three bar-shaped ~ 5×1×1 mm3 ME transducers were fabricated with a 508 μm thick piezoelectric layer and their performance was measured and compared.

**B1L-B3 09:50—10:05**

### A Flexible Wireless Integrated Microsystem for Continuous Respiration Sensing and Quantitative Healthy Status Monitoring

Sicheng Chen{2}, Yongqing Wang{1}, Yuanjin Zheng{2}
{1}China University of Geosciences, China; {2}Nanyang Technological University, Singapore

Respiration signals reflect many underlying health conditions, including cardiopulmonary functions, autonomic disorders, and respiratory distress, therefore continuous measurement of respiration is needed in various cases. In this work, we showcase a soft, wireless, and non-invasive device for quantitative and real-time evaluation of human respiration. Our device simultaneously captures respiration and temperature signatures using customized capacitive and resistive sensors, encapsulated by a breathable layer, and does not limit the user's daily life. We further propose a machine learning-based respiration classification algorithm with a set of carefully studied features as inputs and deploy it into mobile clients. Body status of users, such as being quiet, active, and coughing can be accurately recognized by the algorithm and displayed on clients. With our devices, individual and group respiratory health status can be quantitatively collected, analyzed, and stored for daily physiological signal detections as well as medical assistance.

**B1L-B4 10:05—10:20**

### A 433.92-MHz CMOS Rectifier with Dynamic VTH-Reduction for Wireless Biomedical Implants

Muhammad Abrar Akram, Sohmyung Ha
New York University Abu Dhabi, U.A.E.

A full-wave CMOS passive rectifier with an effective threshold voltage (VTH) reduction technique is proposed for wireless-powered biomedical implants. The VTH reduction is achieved by using a dynamically-biased switch and bootstrap capacitors, resulting in a significant increase in the power conversion efficiency (PCE) of the rectifier. The proposed rectifier is designed for an ISM-band frequency of 433.92 MHz and is fabricated together with two conventional bootstrap rectifiers for comparison in a 0.18-μm CMOS process. Measurement results confirm that the proposed rectifier outperforms the conventional bootstrap rectifiers in terms of the output DC voltage level and PCE. The proposed rectifier demonstrates the peak PCE of 68.5% at a load resistor of 3 kΩ at 433.92 MHz. passive rectifiers. Measurement results confirm that the proposed rectifier outperforms the prior rectifiers in terms of the output DC voltage level and PCE. The proposed rectifier demonstrates the peak PCE of 68.5 % at a load resistor of 3 kΩ.

### B1L-B5 10:20—10:35

#### A Flexible End-to-End Dual ASIC Transceiver for OFDM Ultrasound In-Body Communication

Thomas Bos, Marian Verhelst, Wim Dehaene
Katholieke Universiteit Leuven, Belgium

Ultrasound (US) wave intra-body communication is promising over other techniques due to its lower body attenuation, inherent security and well-studied physiological impact. While US communication systems have been proposed, they either neglect realistic channel conditions or fail to be integrated into small-scale, energy-scarce systems. This paper presents a highly flexible end-to-end ASIC transceiver with OFDM modulation tailored to robust intra-body US communication. This transceiver comprises a dual chip solution: i) a RISC-V microcontroller extended with two custom passband modulation accelerators; and ii) an analog front-end containing a 20V class-D power amplifier and low-power receive chain. Under typical in-body channel attenuation, OFDM-16QAM modulation and 470kbps datarate, the transceiver achieves both in Tx and Rx mode a BER below 1e-4 consuming 64/20.9nJ/bit Tx/Rx.

### B1L-B6 10:35—10:50

#### Fully Wireless and Batteryless Localization and Physiological Motion Detection System for Point-of-Care Biomedical Applications

Arkaprova Ray, Iman Habibagahi, Aydin Babakhani
University of California, Los Angeles, United States

Localization of wireless capsule endoscopes (WCE) is essential for advancement in the treatment of gastrointestinal (GI) tract diseases. Localization is also essential in biomedical applications such as detecting cancerous tissues, drug delivery, brain mapping, and robotic surgeries. Current localization systems are either battery-powered or require large coils for wireless power transfer, making them bulky and unfit for use in wearable or implantable applications. This paper proposes a fully battery-less localization system using wireless energy harvesting. Additionally, the system can be used for the detection of the rate of periodic physiological motions such as diaphragm motion during breathing. The proposed localization system uses ISM bands and transmits a locked sub-harmonic 13.56 MHz signal generated from the received 40.68 MHz radio frequency (RF) signal, eliminating the need for a power-hungry oscillator. The localizer has a small form factor of 17 mm × 12 mm × 0.2 mm and consumes an average power of 6 μW. Ex vivo measurements using the localizer inside the porcine intestine demonstrate a localization accuracy of less than 1 cm.

## Lecture Session (2) - B2L-B October 14, 2022 | 11:00-12:30

### Implantable Medical Electronics

Session Chair(s):
Mohamad Sawan / Westlake University, China
Jun-Chau Chien / National Taiwan University, Taiwan

**B2L-B1 11:00—11:15**

An Implantable Inductive Sensor for Direct and Continuous Monitoring of the Pulmonary Artery Cross-Sectional Area

Mustafa Besirli{1}, Kerim Ture{1}, Maurice Beghetti{2}, Catherine Dehollain{1}, Marco Mattavelli{1}, Diego Barrettino{1}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Geneva University Hospitals, Switzerland

This paper presents a novel method for the measure of the cross-sectional area (CSA) of an artery to be used for the direct and continuous (24/7) monitoring of cardiac output (CO). The method is based on the inductance change of an anchoring loop mounted on a miniaturized system implanted in a section of the pulmonary artery. The inductive sensor comprises an inductive readout circuit and a conductive anchoring loop, which changes its inductance according to the deformation of the artery and can be correlated to the diameter and CSA of the artery section. Direct and periodic measurement of the CSA can improve the accuracy of CO monitoring in heart failure patients. An oscillator-based inductive readout IC was realized in a 180-nm CMOS process and the anchoring loop was implemented by a nitinol wire. The readout IC achieves 0.42 nH inductance resolution in a range from 181 nH to 681 nH and draws 39.7 μA to 51.2 μA current from a 1.2 V supply. The correlation between the artery diameter and loop inductance is demonstrated and the sensor achieves 0.24 mm resolution in a diameter range from 20 mm to 30 mm, a factor of four higher than the lateral resolution of echocardiography.

**B2L-B2 11:15—11:30**

Wireless Monitoring of Small Molecules on a Freely-Moving Animal Using Electrochemical Aptamer Biosensors

Jun-Chau Chien{1}, Sam Baker{2}, Katherine Gates{2}, Ji-Won Seo{2}, Amin Arbabian{2}, Tom Soh{2}
{1}National Taiwan University, Taiwan; {2}Stanford University, United States

This paper presents a wireless electrochemical sensing system for in vivo small-molecule sensing with structure-switching aptamers. A 65-nm CMOS electrochemical sensing circuit with an on-chip waveform generator is integrated with a Bluetooth microcontroller and battery for robust wireless recording. The device performs data acquisition every 10 seconds and consume an average current of 3mA after duty-cycling. Real-time sensing of infused antibiotics (kanamycin) concentration in the interstitial fluids (ISF) are demonstrated on a freely-moving animal.

**B2L-B3 11:30—11:45**

### A High-Frequency Beamforming Channel for Ultrasound Stimulation and Ultrasonic Powering

Hassan Rivandi, Ishaan Ghosh, Tiago L. Costa
Delft University of Technology, Netherlands

New non-imaging ultrasound applications, such as ultrasound stimulation and ultrasonic power transfer, demand a high-frequency phased array ultrasound transducer. On the other hand, the pitch size in a phased array must be half of the sound wavelength to avoid grating lobes in the ultrasound beam profile. While prior efforts have reached a maximum frequency of 8.3 MHz, this work presents two 15 MHz and 12 MHz pixel-level pitch-matched beamforming channels that deliver 20 V and 36 V to the ultrasound transducer load, respectively. Furthermore, the phase of the output is programmable with 3-bits resolution that allows fine control of focal spot location. The proposed beamforming channels have been implemented in 0.18-μm BCD technology.

**B2L-B4 11:45—12:00**

### Towards an Implantable Gastric Electrical-Wave Recording System Powered with Ultrasonic Beamforming

Zeinabalsadat Kashaniravandi, Mehdi Kiani
Pennsylvania State University, United States

This paper presents our recent progress towards the design and development of minimally invasive small gastric implants (i.e., Gastric Seeds) for high-resolution SW recording, including different low-noise amplifier structures for recording SW signals at ultralow frequencies (tens of mHz), US beamforming for powering a millimeter-sized implant, and integrated power-management for rectification, regulation, and over-voltage protection at 1.1 MHz. To achieve tens of mHz operation, four different amplifiers were fabricated in a 0.35-μm standard CMOS process, and their performance was measured. Also, a 32-element US array was optimized and simulated.

**B2L-B5 12:00—12:15**

### Spike Compression Through Selective Downsampling and Piecewise Curve Fitting Dedicated to Neural Recording Brain Implants

Mahdi Nekoui, Amir M. Sodagar
York University, Canada

This paper proposes a method for data reduction in high-density neural recording brain-implantable microsystems. In the proposed method, neural spikes are segmented based on selective downsampling on the implant side of the system. On the external side, neural spikes are reconstructed by piecewise fitting of third-order polynomials. Using this idea, a 128-channel spike compressor was designed in a 130-nm CMOS technology with a chip area of 1050 mx350 m. Tested using a library of four prerecorded neural signals with different waveshapes, an average compression rate of ~272 was achieved. Operated at a clock rate of 1 MHz, the circuit consumes 21 W @VDD=1V.

**B2L-B6 12:15—12:30**

### Wireless Fully-Passive Neural Recorder with Artifact Reduction by Optical Chopping

Shiyi Liu, Daniel Gulick, Ahmed Abed Benbuk, Jennifer Blain Christen
Arizona State University, United States

We present a miniaturized fully-passive wireless neural recorder thin enough to be implanted under the skull for long-term continuous neural recordings. Based on RF backscattering telemetry, the fully-passive sensor features a diameter of 6 mm, and has a near-zero power consumption. An artifact reduction method based on optical signal chopping was developed to improve the wireless signal integrity at low frequencies. Benchtop characterization verified measurement of electrical signals as low as 300 μVpp at 45 mm. In vivo verification by implanting the recorder onto a rodent skull and detecting seizure activity using two deep brain electrodes inserted through burr holes.

## Lecture Session (3) – B3L-B    October 14, 2022 | 13:30-15:00

### Human Machine Interfaces and Electronics for Neuroscience

Session Chair(s):
Yaoyao Jia / The University of Texas at Austin, USA
Hsin Chen / National Tsing Hua University, Taiwan

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**B3L-B1    13:30—13:45**

Hardware Evaluation of Spike Detection Algorithms Towards Wireless Brain Machine Interfaces

Alexandru Oprea, Zheng Zhang, Timothy G. Constandinou
Imperial College London, United Kingdom

This work has empirically compared the performance, resource, and power of three hardware-efficient spike emphasizers, NEO, ASO and ED, and two thresholding using mean or median. A novel median approximation is proposed, addressing that median operation is not hardware efficient. Algorithms were evaluated on an FPGA to estimate their efficiency in ASIC. Our results suggest ED-average provides the most hardware efficient choice, while using median has improved accuracy. This work is significant because it is the first to implement and compare the hardware and algorithm trade-offs that must be made before translating into hardware instances to design wireless implantable BMIs.

**B3L-B2    13:45—14:00**

A Wireless Headstage Prototype Based on a Neurorecorder IC

Markus Sporer, Stefan Reich, Holger Mandry, Joachim Becker, Maurits Ortmanns
University of Ulm, Germany

In this work, we present a prototype for a wireless headstage intended for in-vivo recording of neural signals. It allows 1.4 Mbit/s wireless recording from a previously reported 32 channel neurorecorder IC in the LFP and AP band. The prototype is currently configured for simultaneous recording and transmission of 8 LFP channels. The small weight of 3.2 g and an area of 23 x 20mm^2 makes the headstage suitable for small rodents. The low system power consumption of 12.6mW allows a sufficiently long battery life of almost 6 hours from a standard LIR1254 button cell battery.

**B3L-B3 14:00—14:15**

### An Accurate and Hardware-Efficient Dual Spike Detector for Implantable Neural Interfaces

Xiaorang Guo{2}, Mohammadali Shaeri{1}, Mahsa Shoaran{1}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Technische Universität Dresden, Germany

In this work, we propose a novel hardware-efficient and high-performance spike detector for implantable BMIs. The proposed design is based on a dual-detector architecture with adaptive threshold estimation. The dual-detector comprises two separate TEO-based detectors that distinguish a spike occurrence based on its discriminating features in both high and low noise scenarios. We evaluated the proposed spike detection algorithm on the Wave_Clus dataset. It achieved an average detection accuracy of 98.9%, and over 95% in high-noise scenarios, ensuring the reliability of our method. When realized in hardware with a sampling rate of 16kHz and 7-bits resolution, the detection accuracy is 97.4%. Designed in 65nm TSMC process, a 256-channel detector based on this architecture occupies only 682μm 2 /Channel and consumes 0.07μW/Channel, improving over the state-of-the-art spike detectors by 39.7% in power consumption and 78.8% in area, while maintaining a high accuracy.

**B3L-B4 14:15—14:30**

### LFP-Adaptive Dynamic Zoom-and-Tracking Dual-Band Neural Recording Front-End Using a Power-Efficient Incremental Delta-Sigma ADC

Sungjin Oh{2}, Hyunsoo Song{2}, Nathan Slager{2}, Jose Ruiz{2}, Sung-Yun Park{1}, Euisik Yoon{2}
{1}Pusan National University, Korea; {2}University of Michigan, United States

We report a power-efficient dual-band neural recording front-end using a LFP-adaptive dynamic zoom-and-tracking scheme. An incremental delta-sigma ADC (IADC) dynamically tracks slow-varying LFPs, and zooms into a sub-LFP range to resolve action potentials. This reduces the required ADC dynamic range significantly, saving analog power by 64.3%. The fabricated IADC achieved 69.5 dB SNDR with 6.8 μW/channel, resulting in the best Walden FoM (107.9 fJ/conv-step) and SNDR FoM (162.1 dB) among the state-of-the-art IADCs integrated in the neural recording front-ends. The proposed scheme also provides inherent dual-band recording. The functionality of the developed front-end was validated in an in vivo experiment.

**B3L-B5 14:30—14:45**

### Data Compression Versus Signal Fidelity Trade-Off in Wired-OR ADC Arrays for Neural Recording

Pumiao Yan{2}, Nishal Shah{2}, Dante Muratore{1}, Pulkit Tandon{2}, E.J. Chichilnisky{2}, Boris Murmann{2}
{1}Delft University of Technology, Netherlands; {2}Stanford University, United States

This paper investigates the efficacy of a wired-OR compressive readout architecture for neural recording, which enables simultaneous data compression of action potential signals for high channel count electrode arrays. We consider a range of wiring configurations to assess the trade-offs between compression rate and various task-specific signal fidelity metrics.We consider the fidelity in threshold crossing detection, spike assignment, and waveform estimation, and find that for an event SNR of 7-10 the readout captures at least 80% of the spike waveforms at ∼150x data compression.

**B3L-B6 14:45—15:00**

### A Biomimetic Multichannel Synergistic Calibration for Event-Driven Functional Electrical Stimulation

Nicolò Landra, Andrea Prestia, Andrea Mongardi, Fabio Rossi, Danilo Demarchi, Paolo Motto Ros
Politecnico di Torino, Italy

In this paper, we present the Profile Extraction (PE) algorithm, which allows the computation of a multi-channel profile highly correlated with voluntary muscle activity. This event-based profile can be used as biomimetic control during the calibration phase of a Functional Electrical Stimulation (FES) system. The adoption of the PE technique represents the preliminary step to extend the applicability of our event-driven paradigm to control the coordinated multi-joint movements. Through an experimental campaign, we tested the improvements made by the use of PE in the FES calibration, assessing the reproducibility between the voluntary and stimulated movements. Results show a 2% increase of the median correlation value for a single-channel exercise and a 3.6% increase for a dual-channel one. A statistical decrease of normalized Root Mean Square Error has been obtained for the dual-channel exercise ($p < 0.05$).

## Lecture Session (4) - B5L-B    October 14, 2022 | 16:00-17:45

### Emerging Circuits and Systems for Diagnostics

Session Chair(s):
Zulfiqur Ali / Teesside University, UK
Pau-Choo Chung / National Cheng Kung University, Taiwan

**B5L-B1    16:00—16:15**

Data Augmentation Using Image-to-Image Translation for Tongue Coating Thickness Classification with Imbalanced Data

Mingxuan Liu{2}, Yunrui Jiao{2}, Hongyu Gu{2}, Jingqiao Lu{1}, Hong Chen{2}
{1}Huangpu Joint Innovation Institute of Chinese Medicine, China; {2}Tsinghua University, China

In this paper, we propose a data augmentation method using image-to-image translation to solve the data imbalance problem. First, we use an image-to-image translation model based on generative adversarial networks (GANs) to translate thick and thin tongue coating images into each other, then we train the classification model using synthetic images together with real images. Finally, the trained classification model is used to classify the thickness of tongue coating. With our data augmentation method, the classification performance yields 0.92 accuracy and 0.922 F1-score, which is 3.37% and 3.95% higher than that with the re-sampling method.

**B5L-B2    16:15—16:30**

Evaluations of Deep Learning Methods for Pathology Image Classification

Sheng-Kai Huang, Cai-Rong Yu, Yi-Sheng Liao, Chun-Rong Huang
National Chung Hsing University, Taiwan

While the state-of-the-art deep neural networks have been shown their effectiveness to achieve the general image classification tasks, the performance evaluations of these networks on the pathology image classification have not been well discussed. In this paper, we aim to evaluate the state-of-the-art deep learning methods including the convolutional neural network, deep ensemble network and transformer on several public pathology datasets. By comparing these methods, we empirically find that the transformers and deep ensemble network serve as good backbone networks for pathology image classification.

**B5L-B3 16:30—16:45**

### Emerging Research Directions of Deep Learning for Pathology Image Analysis

Pau-Choo Chung{1}, Wei-Jong Yang{1}, Tsung-Hsuan Wu{1}, Chun-Rong Huang{2}, Yi-Yu Hsu{1}
{1}National Cheng Kung University, Taiwan; {2}National Chung Hsing University, Taiwan

Digital pathology image analysis has become a new emerging research trend in the medical domain. AI methods have been shown their effectiveness on conventional vision applications. However, applying AI methods on pathology image analysis is far from easy. Many practical challenging issues arise including pathology image analysis under insufficient and inaccurate annotations, recognizing pathology images of different data distributions, and training AI models based on decentralized data sources. In this paper, we focus on discussing these challenging issues of AI approaches for pathology image analysis. A survey of relevant pathology applications will be also conducted. The research directions of these techniques for future development in pathology image analysis are also presented in this paper.

**B5L-B4 16:45—17:00**

### Wearable Pressure Sensing for Lower Limb Amputees

Zhonghai Lu{1}, Wenyao Zhu{1}, Yizhi Chen{1}, Josephine Charnley{2}, Valter Dejke{5}, Andrii Pomazanskyi{3}, Siu-Teing Ko{4}, Begum Zeybek{6}, Pouyan Mehryar{6}, Zulfiqur Ali{6}, Michalis Karamousadakis{7}, Dejiu Chen{1}
{1}KTH Rotal Institute of Technology, Sweden; {2}Lusstech, United Kingdom; {3}Nuromedia GmbH, Germany; {4}Össur, Iceland; {5}RISE Research Institutes of Sweden, Sweden; {6}Teesside University, United Kingdom; {7}TWI Hellas, Greece

Pressure sensing in prosthetic sockets is valuable as it provides quantified data to assist prosthetists in designing comfortable sockets for amputees. We present a wearable pressure sensing system for lower limb amputees. The full system consists of three essential elements from sensing scheme (wearable sensors, sensor calibration and deployment), electronic measurement system (embedded hardware and software), to time-series database and visualization. The full system has been successfully applied in clinical trials to effectively collect pressure data in real-time.

**B5L-B5 17:00—17:15**

### Flexible SAR ADC with Resistive DAC for Conformable On-Body Sensing Applications

Feras Alkhalil, Thom Smith, Haibo Su, Francisco Rodriguez, Adam Rearden, Brian Cobb
PragmatIC Semiconductor, United Kingdom

Flexible Integrated Circuits (FlexICs) allow for ultra-thin intelligence to be added to wearable systems, reducing or eliminating the need for bulky rigid components and dramatically improving both form factor and cost of the final device. A flexible Successive Approximation Register Analog to Digital Converter (SAR-ADC) utilizing a resistive Digital to Analog Converter (DAC) has been demonstrated, allowing for an electrical interface to external transducers. Alongside approaches to simplify on-device calculation and wireless communication which have been validated in FlexICs, the design and included building blocks may be customized to enable a wide range of on-body sensing applications oriented towards comfortable, unintrusive, and transient monitoring approaches.

**B5L-B6 17:15—17:30**

### Roll-to-Roll Fabricated Self-Filling Polydimethylsiloxane Diagnostic Platforms for Multiplexed Pathogen Nucleic Acid Detection

Lauri Rannaste{2}, Olli-Heikki Huttunen{2}, Johanna Hiitola-Keinänen{2}, Jussi Hiltunen{2}, Christina Liedert{1}, Leena Hakalahti{2}
{1}Screentec Oy, Finland; {2}VTT Technical Research Centre of Finland Ltd, Finland

Here we describe a R2R-manufacturable, user-friendly (easy-to-operate and has a shelf-life of at least 6 months), self-filling and low-cost (<1 €, materials only) PDMS assay with LAMP-based and multiplexed fluorescence detection of nucleic acids from difficult sample matrixes, such as blood, for PoC diagnostics. The assay can detect up to 3 different sepsis-causing bacteria simultaneously (limit of detection, LOD, is 500 fg) from low-volume blood sample (2 µL) without pre-treatment in less than 1 h.

**B5L-B7 17:30—17:45**

### Reconfigurable Biochemical Circuit Synthesis from Biomachine Specification

Chang-Jun Wang, Jie-Hong Jiang
National Taiwan University, Taiwan

A synthetic biology approach to engineering non-living vesicles, referred to as biomachines, in contrast to living cells, much simplifies system design complexity and has proven effective in commercial health-care applications. Despite the relative simplicity of biomachine design, its design process requires tremendous efforts, including mining circuits from a real-world reaction database, which may not guarantee feasible solutions exist. For a multi-function design, prior work often requires constructing and implementing each individual function separately to prevent undesirable interference among the reactions of different functions. In this work, we devise a mechanism for reconfigurable circuit design and propose an effective algorithm for mining such circuits. Our method enables integrated multi-function design and allows flexible switch between different functions. A case study on a diabetes diagnostic application demonstrates the feasibility of our method.

## Lecture Session (5) – C1L-B    October 15, 2022 | 09:20-10:50

### Biosensor Devices and Interface Circuits

Session Chair(s):
Carrara Sandro / EPFL, Switzerland
Tsung-Heng Tsai / National Yang Ming Chiao Tung University, Taiwan

**C1L-B1    09:20—09:35**

A Reconfigurable Tri-Mode Frequency-Locked Loop Readout Circuit for Biosensor Interfaces

Siyuan Yu, Tzu-Hsuan Chou, Jacob Cook, Jaehyeong Park, Matthew L. Johnston
Oregon State University, United States

A reconfigurable frequency-locked loop (FLL) readout circuit is presented for temperature, pH, and electrochemical sensing. By reconfiguring the feedback network in the FLL and performing quantization in the time domain, it is able to digitize resistance, voltage, and current without additional dedicated active analog front-end interfaces. This reduces the analog circuitry overhead and enable the readout circuit to operate at less than 10 μW. A prototype IC was fabricated in a 180nm CMOS process. Functionalities were verified with temperature, pH, and glucose measurements.

**C1L-B2    09:35—09:50**

Body-Heat Powered Biosensor Readout Using Current-Mode Relaxation Oscillators

Tzu-Hsuan Chou, Siyuan Yu, Jacob Cook, Jaehyeong Park, Soumya Bose, Matthew L. Johnston
Oregon State University, United States

his paper presents a low-power current-mode re- laxation oscillator (RxO) which can be used as readout circuits for ultra-low-power sensors applications. A full system-on-chip with an energy harvester and a transmitter is built as a proof- of-concept. The system is able to demonstrate pH and glucose measurement with the power from the on-chip energy harvester connecting to an external thermoelectric generator (TEG). The RxO with a V-to-I converter demonstrating pH measurement consumes 2 μW at maximum, where the RxO consumes 0.6 μW. The linearity of the readout reaches R-square > 0.999.

**C1L-B3 09:50—10:05**

### Pseudo-Differential Neural-Recording Front-End Design Using High-Pass Cutoff Frequency Programmable Single-Ended Pixel

Taeju Lee, Minkyu Je
Korea Advanced Institute of Science and Technology, Korea

This paper presents a pseudo-differential neural-recording front-end design for a high-density recording channel. For differential signal processing, the proposed front-end comprises the pseudo-differential stage (PDS) and fully differential stage (FDS). The PDS consists of the AC-coupled single-ended pixels. Among the multiple pixels in the PDS, two pixels are selected and connected to the input of the FDS for differential processing. By employing a narrow-band buffer in the feedback loop of the PDS and FDS, the front-end can flexibly control high- and low-pass cutoff frequencies with low power consumption. For implementing the area- and current-efficient pixel without gain error, a one-stage amplifier with a current-reuse input pair and a cascode output stage is employed for each pixel. The proposed design, implemented in a 180-nm CMOS process, achieves an input-referred noise of 3.56 μVrms, 5.23 μVrms, and 7.01 μVrms over low-pass, wideband, and high-pass recording modes, respectively.

**C1L-B4 10:05—10:20**

### Reducing Drift in CMOS ISFET Arrays with Monolayer Graphene Sheets

Karina Goel, Christoforos Panteli, Nicolas Moser, Pantelis Georgiou
Imperial College London, United Kingdom

In this paper, we present the scaling of a post-processing method to reduce drift in CMOS Ion-Sensitive Field-Effect Transistor (ISFET) arrays using monolayer graphene sheets. Graphene\'s impermeability limits the modification of the sensing layers while providing physisorption sites to maintain pH sensitivity for the ISFETs. The results show, on average, a 55% reduction in drift and an 8% reduction in pH sensitivity for monolayer graphene ISFET arrays compared to plain ISFET arrays, with no effect on trapped charge, capacitive attenuation, and the spatial distribution of performance parameters across the ISFET array.

### C1L-B5 10:20—10:35

#### A Miniaturized Transcutaneous Carbon Dioxide Monitor Based on Dual Lifetime Referencing

Tuna Tufan, Ulkuhan Guler
Worcester Polytechnic Institute, United States

The ability to monitor blood gases, namely oxygen and carbon dioxide, in real-time is of critical importance to clinicians in diagnosing and treating respiratory disorders. Transcutaneous monitors measure the partial pressure of carbon dioxide diffused from the skin. These monitors are noninvasive and capable of continuously monitoring carbon dioxide. Conventional transcutaneous carbon dioxide monitors require a heating element and large calibration equipment for reliable measurements. We propose a miniaturized transcutaneous carbon dioxide monitor based on a luminescence sensing film and dual lifetime referencing technique to assess the partial pressure of carbon dioxide within the 0-75 mmHg range, covering the clinically relevant range for healthy humans, 35-45 mmHg. We measured the partial pressure of carbon dioxide with less than ∼ 1.6% error in the given range without any post-processing and heating.

### C1L-B6 10:35—10:50

#### Neural Recording Analog Front-End Noise Reduction with Digital Correlated Double Sampling

Akshay Paul{2}, Preston Fowler{2}, Yuchen Xu{2}, Min Lee{2}, Jun Wang{1}, Gert Cauwenberghs{2}
{1}Harvard University, United States; {2}University of California, San Diego, United States

Digital correlated double-sampling (CDS) is presented here as a related technique which relies on intermittent sampling of an internal reference voltage taken during brief disconnections from the sensor between real samples for a noise correction performed digitally post-acquisition. This work demonstrates the implementation of digital CDS on a neural interface system on chip (NISoC) and details the optimization of a windowed weighting correction algorithm to achieve 71% improvement in noise performance. In-Ear EEG and EOG recordings were performed with and without CDS for comparison.

## Lecture Session (6) - C2L-B October 15, 2022 | 11:00-12:30

### Biosignal Recording and Processing

Session Chair(s):
Gianluca Setti / Politecnico di Torino, Italy
Shuenn-Yuh Lee / National Cheng Kung University, Taiwan

**C2L-B1 11:00—11:15**

Improving PPG-Based Heart-Rate Monitoring with Synthetically Generated Data

Alessio Burrello{2}, Daniele Jahier Pagliari{1}, Marzia Bianco{2}, Enrico Macii{1}, Luca Benini{2}, Massimo Poncino{1}, Simone Benatti{2}
{1}Politecnico di Torino, Italy; {2}Università di Bologna, Italy

The first problem of PPG based heart-reate monitoring is fitting these algorithms into low-power memory-constrained MCUs. Further, the PPG signal usually has a low signal-to-noise ratio due to the presence of motion artifacts (MAs) arising from movements of subjects\' arms. In this work, we propose using synthetically generated data to improve the accuracy of PPG-based heart rate tracking using deep neural networks without increasing the algorithm\'s complexity. We show that the HR tracking Mean Absolute Error (MAE) can be reduced from 5.28 to 4.83 BPM on PPGDalia dataset, without increasing the energy consumption on an MCU.

**C2L-B2 11:15—11:30**

Estimating Heart Rate from Seismocardiogram Signal Using a Novel Deep Dominant Frequency Regressor and Domain Adversarial Training

Michael Chan, Asim Gazi, Moamen Soliman, Kristine Richardson, Calvin Abdallah, Goktug Ozmen, Mohammad Nikbakht, Omer Inan
Georgia Institute of Technology, United States

Deep learning (DL) approaches have demonstrated promise in estimating heart rate (HR) from seismocardiogram (SCG). However, dense layer-based DL approaches may overfit in low-data regime. It is also uncertain whether most of DL approaches can generalize to unseen subjects. We address these limitations by proposing Dominant Frequency Regressor with a Fast Fourier Transform layer, regularized by domain adversarial training. The model performance is tested using leave-one-subject-out cross validation on 19 subjects in seated posture for three minutes using our custom-built wearable patch and achieves a low mean absolute error of 1.42±1.66 bpm for HR with a range of 63-104 bpm.

### C2L-B3 11:30—11:45

#### Aggressively Prunable MAM²-Based Deep Neural Oracle for ECG Acquisition by Compressed Sensing

Philippe Bich{1}, Luciano Prono{1}, Mauro Mangia{2}, Fabio Pareschi{1}, Riccardo Rovatti{2}, Gianluca Setti{1}
{1}Politecnico di Torino, Italy; {2}Università di Bologna, Italy

Internet of Things (IoT) biomedical applications entail the reduction of data-acquisition energy requirements. Compressed Sensing (CS) reduces energy for acquisition/compression of sparse signals, transferring complexity to the reconstruction stage. Many works use Deep Neural Networks (DNNs) for signal reconstruction, so DNNs should fit in IoT devices. Pruning techniques, used to remove parameters to decrease storage requirements, are of great help in this effort. Here, a Multiply and Max&Min (MAM²) paradigm for DNNs is proposed. The result is an aggressively pruned structure, tested on a DNN-based CS reconstruction task. MAM² retain high performances with 6% remaining weights against 75% with MAC.

### C2L-B4 11:45—12:00

#### A 171μW PPG-Based Vitals Monitoring SoC for Asthmatic Patients

Sameen Minto{2}, Alaa Saadeh{1}, Wala Saadeh{2}
{1}Jordan University of Science and Technology, Jordan; {2}Lahore University of Management Sciences, Pakistan

This paper proposes a low-power and compact PPG-based physiological signals monitoring system-on-chip (SoC) for asthma patients to measure four vitals including heart rate (HR), heart rate variability (HRV), blood oxygen saturation (SpO2), and respiratory rate (RR). The proposed SoC comprises a power-efficient LED driver operating in pulsed mode for red and IR LEDs duty-cycled at 0.625%, along with a PPG readout that provides amplification, filtering, and digitization of the PPG signal. The analog front end employs a transimpedance amplifier followed by a switched integrator that provides both amplification and filtering while digitization of the single-ended PPG signal is achieved using a fully differential second-order, discrete-time, delta-sigma analog to digital converter (ΔΣ-ADC). The digitized PPG data is processed by the vitals extraction processor employing signal processing and feature extraction (FE) to compute vitals. The SoC consumes 171μW and is implemented in a 180nm CMOS process with an area of 4.5mm2.

**C2L-B5 12:00—12:15**

### Real-Time Smart Multisensing Wearable Platform for Monitoring Sweat Biomarkers During Exercise

Celine Lafaye{3}, Meritxell Rovira{2}, Silvia Demuru{1}, Shu Wang{4}, Jaemin Kim{1}, Brince Paul Kunnel{1}, Cyril Besson{3}, Cesar Fernandez-Sanchez{2}, Francisco Serra-Graells{2}, Josep Maria Margarit-Taulé{2}, Joan Aymerich{2}, Javier Cuenca{2}, Ilya Kiselev{4}, Vincent Gremeaux{3}, Mathieu Saubade{3}, Cecilia Jiménez-Jorquera{2}, Danick Briand{1}, Shih-Chii Liu{4}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Instituto de Microelectronica de Barcelona, CSIC, Spain; {3}Lausanne University Hospital, Switzerland; {4}University of Zürich and ETH Zürich, Switzerland

Sweat can provide valuable biomarker information during exercise in hot, humid conditions. Real-time noninvasive biomarker recordings are therefore useful for evaluating the physiological conditions of an athlete during endurance exercise. We describe a platform that includes different sweat biomonitoring prototypes of cost-effective, smart wearable devices for continuous biomonitoring of sweat during exercise. One prototype is based on conformable and disposable soft sensing patches with an integrated multi-sensor array requiring the integration of different sensors and printed sensors with their corresponding functionalization protocols on the same substrate. The second is based on silicon based sensors and paper microfluidics. Both platforms integrate a multi-sensor array for measuring sodium, potassium, and pH in sweat. We show preliminary results obtained from the multi-sensor prototypes placed on two athletes during exercise. We also show that machine learning algorithms can predict the percentage of body weight loss during exercise from biomarkers such as heart rate and sweat sodium concentration collected over multiple subjects.

**C2L-B6 12:15—12:30**

### A Power-Efficient Source-Follower Based Tunable Pseudo-RC Low-Pass Filter for Wearable Biomedical Applications

Hui Wu{2}, Xing Liu{1}, Jie Yang{2}, Mohamad Sawan{2}
{1}Fudan University, China; {2}Westlake University, Canada; {2}Westlake University, China

MOSFETs operating in the sub-threshold region (pseudo resistors) are widely used as resistors due to their large impedance with a small die area, which shows the potential to realize a considerable time constant LPF with acceptable capacitors. However, its linearity and impedance are limited by the applied voltage and suffer from process, voltage and temperature (PVT) variations. In this work, a subthreshold-source-follower (SSF) based LPF with self-biased pseudo-resistors (PRs) is presented. The self-biased scheme for PRs substantially increases the linearity and impedance without extra area consumption and results in a tunable low cut-off frequency.

## Lecture Session (7) – C3L-B October 15, 2022 | 13:30-15:00

### Point-of-Care Devices, Imaging and Bioinformatics

Session Chair(s):
Donald Lie / Texas Tech University, USA
Chris Gwo Giun Lee / National Cheng Kung University, Taiwan

**C3L-B1 13:30—13:45**

A Chip-Based NMR Relaxometry System for Point-of-Care Analysis

Frederik Dreyer, Qing Yang, Daniel Krüger, Jens Anders
Institute of Smart Sensors, University of Stuttgart, Germany

We present a miniaturized NMR relaxometry system for point-of-care analysis of body liquids, centered on an NMR-on-a-chip transceiver ASIC and a DDS-based reference frequency generator. Fabricated in 0.13µm BiCMOS, the ASIC co-integrates a low-IF receiver, a PA, and a PLL on a small footprint of 1100×900µm2. The presented system provides an excellent low-field concentration sensitivity of vc,min=5.4mM/pHz and, with arbitrarily adjustable phase, enables classical CPMG experiments as well as its modern adaptations. The system also includes an automatic frequency lock to prevent temperature-induced frequency drifts. Proof-of-concept NMR measurements on reference and biomedical samples demonstrate the excellent performance of the system.

**C3L-B2 13:45—14:00**

A Multichannel Miniaturized Dielectric Blood Coagulometer for Point-of-Care Assessment of Hemostasis

Christopher Delianides, Sina Pourang, Pedram Mohseni, Michael Suster
Case Western Reserve University, United States

This paper presents a standalone, multichannel, miniaturized impedance analyzer (MIA) for dielectric coagulometry measurements on human whole blood in a microfluidic sensor. The system incorporates a front-end interface board for 4-channel impedance measurements at 1 MHz, an integrated resistive heater to keep the blood sample at a physiologic temperature of 37C, an ADALM2000 software-defined instrument for signal generation and data acquisition, and a Raspberry Pi-based embedded computer with 7-inch touchscreen display for signal processing and user interface. Dielectric coagulometry measurements on human whole blood show a very good agreement between the MIA and a commercial benchtop Agilent impedance analyzer.

**C3L-B3 14:00—14:15**

### Person Identification Using Deep Neural Networks on Physiological Biomarkers During Exercise

Zuowen Wang{1}, Shu Wang{3}, Celine Lafaye{2}, Mathieu Saubade{2}, Vincent Gremeaux{2}, Shih-Chii Liu{3}
{1}Institute of Neuroinformatics, University of Zürich and ETH Zürich, Switzerland; {2}Lausanne University Hospital, Switzerland; {3}University of Zurich and ETH Zurich, Switzerland

Much progress has been made in wearable sensors that provide real-time continuous physiological data from non-invasive measurements including heart rate and biofluids such as sweat. This information can potentially be used to identify the health condition of a person by applying machine learning algorithms on the physiological measurements. We present a person identification task that uses machine learning algorithms on a set of biomarkers collected from 30 subjects carrying out a cycling experiment. We compared an SVM and a gated recurrent neural network (RNN) for real-time accuracy using different window sizes of the measured data. Results show that using all biomarkers gave the best results from any of the models. With all biomarkers, the gated RNN model achieved ~90% accuracy even in a 30s time window; and ~92.3% accuracy in a 150s time window. Excluding any of the biomarkers leads to at least 7.4% absolute accuracy drop for the RNN model. The RNN implementation on the Jetson Nano incurs a low latency of ~45 ms per inference.

**C3L-B4 14:15—14:30**

### Classification of Activated Microglia by Convolutional Neural Networks

Chao-Hsiung Hsu{3}, Artur Agaronyan{3}, Raffensperger Katherine{1}, Micah Kadden{1}, Hoai T. Ton{1}, Frank Wu{3}, Yu-Shun Lin{3}, Yih-Jing Lee{2}, Paul C. Wang{3}, Michael Shoykhet{1}, Tsang-Wei Tu{3}
{1}Children's National Hospital, United States; {2}Fu-Jen Catholic University, Taiwan; {3}Molecular Imaging Laboratory, Howard University, United States

Microglia are the macrophages in the central nervous system. The morphology of microglia is notably diverse and a prominent manifestation of activation in brain injuries. In this study, we propose to classify activated microglia from the cortex and midbrain of control and cardiac-arrest rat brains. Results were compared between CNNs with different architectures, including Resnet18, Resnet50, Resnet101, and support vector machine. The highest model accuracy was found by Resnet18, trained after 120 epochs with 95.5-98.8 percent. The findings indicate a potential application for using CNN in the quantitative analysis of microglial morphology over regional differences in a large brain section.

**C3L-B5 14:30—14:45**

A One-Shot Lung 4D-CT Image Registration Method with Temporal-Spatial Features

Yu Ji, Zhenyu Zhu, Ying Wei
Shandong University, China

For lungs 4DCT registration methods, conventional pairwise methods ignore the temporal information of the periodic motion of lungs which could have been useful for registration and tracking. Although some groupwise methods take that into consideration, a clear approach has not yet emerged. We proposed a novel temporal-spatial method for lung 4D-CT registration. Through the hybrid architecture of CNN and ConvLSTM, we realize modeling of images\' temporal motion. And the periodic motion constraint was applied into the temporal model with an effectively dual-stream way. We train model in one-shot style on DIRLAB dataset. In comparison, proposed method has achieved better registration accuracy in terms of TRE than current deep learning-based unsupervised methods and is comparable with supervised methods.

**C3L-B6 14:45—15:00**

Super Acoustic Resolution Photoacoustic Microscopy Imaging Enhancement

Zhengyuan Zhang, Haoran Jin, Zesheng Zheng, Yuanjin Zheng
Nanyang Technological University, Singapore

In this paper, the hardware modules of the system are specifically analyzed, then the typical AR-PAM system and its miniaturized counterparts have also been demonstrated. Furthermore, optical Monte Carlo simulation and acoustic k-wave simulation have been proposed to quantitatively characterize the imaging system's sensitivity, meanwhile the degradation model of the imaging results has also been obtained with mathematical derivation. With the acquired degradation model, both learning based and model based algorithms are proposed to enhance the resolution, contrast and signal to noise ratio of the raw AR-PAM imaging results.

## Lecture Session (8) - C5L-B October 15, 2022 | 16:00-17:30

### Grand Challenge on Respiratory Sound Classification

Session Chair(s):
Yongfu Li / Shanghai Jiao Tong University, China
Li-Wei (Leo) Ko / National Yang Ming Chiao Tung University, Taiwan

**C5L-B1 16:00—16:15**

Grand Challenge on Respiratory Sound Classification for SPRSound Dataset

Qing Zhang{9}, Jing Zhang{6}, Jiajun Yuan{5}, Huajie Huang{9}, Yuhang Zhang{9}, Baoqin Zhang{5}, Gaomei Lv{4}, Shuzhu Lin{1}, Na Wang{3}, Xin Liu{2}, Mingyu Tang{7}, Yahua Wang{7}, Hui Ma{7}, Lu Liu{7}, Shuhua Yuan{7}, Hongyuan Zhou{10}, Jian Zhao{9}, Yongfu Li{9}, Yong Yin{6}, Liebin Zhao{8}, Guoxing Wang{9}, Yong Lian{9}
{1}Fengcheng Hospital, China; {2}Fifth Affiliated Hospital of Harbin Medical University, China; {3}Linyi City Maternal and Child Health Hospital, China; {4}Linyi City People Hospital, China; {5}Sanya Maternity and Child Care Hospital, China; {6}Shanghai Children's Medical Center, China; {7}Shanghai Children's Medical Center, Shanghai Jiao Tong University, China; {8}Shanghai Engineering Research Center of Intelligence Pediatrics, China; {9}Shanghai Jiao Tong University, China; {10}Shanghai Tuoxiao Intelligent Technology Co., Ltd, China

It is important to continuously monitor our respiratory system to prevent us from suffering respiratory-releated diseases. This demands for an automatic respiratory sounds software to speed up diagnosis and to reduce the workload of physicians. In the IEEE BioCAS 2022 conference, we have organized the first grand challenge on respiratory sound classification using the paediatric respiratory sound (SPRSound). This event has invited 45 teams with more than 100 open source entries and the top 5 teams are invited to present their works in the IEEE BioCAS 2022.

**C5L-B2 16:15—16:30**

An Effective Lung Sound Classification System for Respiratory Disease Diagnosis Using DenseNet CNN Model with Sound Pre-Processing Engine

Wei-Bang Ma, Xiang-Yuan Deng, Yang Yang, Wai-Chi Fang
National Yang Ming Chiao Tung University, Taiwan

Respiratory disease is one of the most common and serious diseases in the world. Its symptoms seriously affect the lives of patients, and some respiratory diseases are contagious. After the pre-processing steps, we train a set of weights with CNN structure, which can be used to make judgments on the lung sound data. Our system then classifies the lung sound wave files into several types.

**C5L-B3 16:30—16:45**

### Improving the ResNet-Based Respiratory Sound Classification Systems with Focal Loss

Jun Li{2}, Xiao Wang{3}, Xiaoqin Wang{1}, Shushan Qiao{1}, Yumei Zhou{1}
{1}Institute of Microelectronics of the Chinese Academy of Sciences, China; {2}Nanjing Institute of Intelligent Technology, China; {3}University of Chinese Academy of Sciences, China

Automated respiratory sound classification aims to provide a rapid and reliable diagnosis of respiratory disease. However, the database used to develop a lung sounds classification system usually suffers from class imbalance issues, resulting in a lower recall of adventitious sounds compared to the normal class. In this paper, we adopt the focal loss for the ResNet-based systems to solve class imbalance issues. The experiments are conducted on the SPRSound dataset. At the event level, with ResNet18 of 11.3M parameters as the backbone, when trained with class-balanced methods, the best binary and multi-class scores of the validation set are 0.933 and 0.879, and those of the test set are 0.889 and 0.82. While at the record level, contributing to the focal loss, the best ternary score of the validation set is 0.833, achieved by TC-ResNet of 12.2M parameters, and the multi-class score is 0.673 with ResNet18. The ternary and multi-class scores of the test set are 0.718 and 0.533 with TC-ResNet.

**C5L-B4 16:45—17:00**

### Multiclass Categorisation of Respiratory Sound Signals Using Neural Network

Naseem Babu, Jyoti Kumari, Jimson Mathew, Udit Satija, Arijit Mondal
Indian Institute of Technology Patna, India

Respiratory diseases have seriously impacted human life in the last couple of years; as Covid 19 arrived, many lost their beloved ones. Since respiratory diseases directly attack the patient's lungs, it is becoming risky day by day for human life and doctors because a confined number of resources are available in hospitals to detect these respiratory diseases, and detection of these diseases is a difficult job to the doctors. Therefore early-stage diagnosis can help the doctor in saving human lives. Researchers are continuously trying to help doctors by designing efficient and more accurate tools for detecting different types of respiratory diseases. This paper uses a convolution-based deep learning model to classify these respiratory diseases using patient respiratory sound signals with Mel frequency cepstral coefficients (MFFCs) as a feature vector. In this paper, we have tried to keep our neural network model as simple as possible with less trainable parameters and good classification accuracy. The model performance is measured in terms of sensitivity, specificity, average score, and harmonic score.

**C5L-B5 17:00—17:15**

### Classify Respiratory Abnormality in Lung Sounds Using STFT and a Fine-Tuned ResNet18 Network

Zizhao Chen, Hongliang Wang, Chia-Hui Yeh, Xilin Liu
University of Toronto, Canada

We propose and evaluate a software solution for detecting traits of respiratory diseases in lung sounds. Our solution extracts spectral features with STFT and classifies spectrograms with a fine-tuned ResNet18 Network

## C5L-B6 17:15—17:30

### A Feature Polymerized Based Two-Level Ensemble Model for Respiratory Sound Classification

Lin Zhang, Yangxin Zhu, Shikui Tu, Lei Xu
Shanghai Jiao Tong University, China

Accurate analysis and classification of respiratory sound play an important role in the diagnosis of respiratory diseases. Most of the current methods for classifying respiratory sounds use deep neural networks to classify the spectrograms generated from the audio. In this paper, we propose a Feature Polymerized (FP) based Two-Level Ensemble Model (TLEM) for respiratory sound detection, shortly called FP-TLEM to make effective use of auscultation recordings. In FP-TLEM, considering the expiration and inspiration or the steady and non-steady stage in signal, we divide the signals to conquer and aggregate rather than extract from the whole breathing process or the whole signal. Instead of using just spectrogram features, FP extract various features such as mfccs, spectrogram, chromagram features from each segment. We also use the technique of oversampling to solve the problem of unbalanced sample size between normal and adventitious samples. Considering gender is essential in data distribution and is the main factor influencing building the modeling, a two-level ensemble model technique is adopted to build a robust and promising classifier.

# Live Demonstrations

## Live Demonstrations - A2P-A October 13, 2022 | 19:30-21:00

Session Chair(s):
Andrew J. Mason / Michigan State University, USA
Herming Chiueh / National Yang Ming Chiao Tung University, Taiwan

### A2P-A1

A Portable Four-Lenses Panoramic-Stereo Endoscope System Development

Ching-Hwa Cheng, Don-Gey Liu
Feng Chia University, Taiwan

A four-lenses endoscopic put on a Trocar side-by-side and the wide-angle stitching image can produce any viewing angle between the two sets of lenses. This work proposes a combination of two techniques of image stitching and view synthesis to a three-dimensional view.

### A2P-A2

Pupil Tracking System Development for Electronystagmography

Wei-Han Chang{2}, Ching-Hwa Cheng{1}, Don-Gey Liu{1}
{1}Feng Chia University, Taiwan; {2}University of Southern California, United States

An Electronystagmography evaluation can also be useful in ruling out potential causes of dizziness. A convenient tool is required for quick screen purpose. This proposed pupil tracking can be real-time, accurate operated, and less prone to interference due to reflection-glasses.

### A2P-A3

Live Demonstration: A BLE Wireless Neural-Recording Headstage on Freely-Moving Rat

Junhong Sun, Changgui Yang, Yunshan Zhang, Zhuhao Li, Huan Gao, Chaonan Yu, Yuxuan Luo, Kedi Xu, Gang Pan, Bo Zhao
Zhejiang University, China

We demonstrate a BLE wireless headstage system based on an 8-channel neural-recording chip. A kickback-reduction technique is proposed to realize low power and miniature size. The chip is implemented in 65nm CMOS process with measured results: 1) The AFE achieves a 43.3dB gain and a 9.68uVrms IRN in 0.9Hz-7.2kHz, as well as an 82.75dB CMRR. 2) The ADC achieves a 9.66-bit ENOB with 315nW power. 3) The neural-recording chip consumes totally 249uW. In the demonstration on a Sprague-Dawley rat, the 2.6g headstage induces little impact to the freely-moving activities and transfers the in-vivo neural signals to a cellphone through BLE.

## A2P-A4

### Live Demonstration: A Stimulation Senseless Based Visual Brain-Computer Interface for Shopping Scenarios

Fangkun Zhu, Zicheng Zhang, Shanshan Chen, Qian Guo, Xiaochen Ye, Xiaojun Liu, Xiaoan Wang, Chengdong Lin, Junwen Luo
BrainUp Research Lab, China

A novel visual brain-computer interface interactive technology for shopping scenarios is presented in this work. As shown in Figure 1, the system consists of an EEG recorder, soft dry electrodes, and a desktop software. The software involves with comfortable visual stimulus patterns, application materials and decoding algorithms.. The system can successfully translate user's visual attentions to digital commands of selecting products. Therefore, it brings a brand new immersion shopping experience to the user.

## A2P-A5

### Live Demonstration: Wireless Device for Clinical Pulse Wave Velocity Evaluations

Andrea Valerio{1}, Irene Buraioli{1}, Alessandro Sanginario{1}, Dario Leone{2}, Giulia Mingrone{2}, Alberto Milan{2}, Danilo Demarchi{1}
{1}Politecnico di Torino, Italy; {2}University of Turin, Italy

This Live Demonstration presents a low-cost wireless integrated device for clinically evaluating Pulse Wave Velocity (PWV). The system comprises two pen-shaped probes with a high-precision MEMS force sensor on their tips and a base/recharge station. The two probes are placed on the femoral and carotid arterial sites and send the pulse wave signals to the base/recharge station via Bluetooth. A PC GUI displays the signals and calculates in real-time the PVW value. The visitors can see a real PWV measurement on a dedicated test subject or experience, in the first person, the arterial pulse assessment on their carotid after proper probe sterilization.

## A2P-A6

### Live Demonstration: A Real-Time Bio-Mimetic System for Multichannel FES Control

Fabio Rossi, Andrea Prestia, Andrea Mongardi, Nicolò Landra, Paolo Motto Ros, Danilo Demarchi
Politecnico di Torino, Italy

This demonstration presents a bio-mimetic system for the real-time multichannel control of Functional Electrical Stimulation (FES). The intensities of the FES profiles are directly mapped by processing surface ElectroMyoGraphic (sEMG) signals detected from synergistic muscles, thus achieving a user-comfortable stimulation that follows the monitored physiological patterns. Furthermore, a user-dedicated calibration routine and multiple versatile operating configurations allow the system to be integrated into standard rehabilitation protocols to enhance the restoration of motor functionalities.

### A2P-A7

#### Live Demonstration: Neuromorphic Robot Goalie Controlled by Spiking Neural Network

Nicola Russo{2}, Haochun Huang{1}, Konstantin Nikolic{2}
{1}Imperial College London, United Kingdom; {2}University of West London, United Kingdom

This demonstration shows an implementation of the Robot Goalie using neuromorphic hardware and a Spiking Neural Network (SNN) to control the goalkeeper position. The system consists of four main components: a Dynamic Vision Sensor (DVS128) used as an ”eye”, a SpiNNaker SpiNN-3 board to run a SNN to predict the final position of the ball and intercept it, an actuator (Futaba S9257) and an Arduino Due microcontroller (MCU), linked by a previously developed PCB board. The system represents a real-time (fast reaction) and low-power solution for the task of intercepting incoming objects.

### A2P-A8

#### Live Demonstration: Cyber Attack Against an Ingestible Medical Device

Alperen Yasar, Qijun Liu, Matthew Mao, David Starobinski, Rabia Yazicigil
Boston University, United States

Ingestible medical devices (IMD) are gaining attention as they are capable of transforming the monitoring and treatment procedures to a remote process. These devices raise a concern for security. A successful attack can cause leakage of confidential data, wrong diagnosis, or wrong treatment which can be lethal. This work will demonstrate a cyber attack against an (IMD) to impersonate the device and send false data to the server. Visitors will experience the step-by-step unfolding of the attack through the eyes of a hacker. It\'s aimed to attract attention to the security of medical systems with this demonstration.

# Poster Sessions

## Poster Session I - A1P-A

October 13, 2022 | 16:10-17:00

Session Chair(s):
Wouter Serdijn / Delft University of Technology, Netherlands
Hsiao-Chin Chen / National Taiwan Universityof Science and Technology, Taiwan

### A1P-A01

**Deep Spiking Neural Network with Ternary Spikes**

Congyi Sun{1}, Qinyu Chen{2}, Yuxiang Fu{1}, Li Li{1}
{1}Nanjing University, China; {2}University of Zurich, Switzerland

In SNNs, the neurons communicate with each other with binary spikes. However, the coding efficiency for the rate coding scheme is low, and a long time window is usually required for the training and inferencing of SNNs. In this paper, we propose a hardware-friendly ternary spikes scheme to achieve higher efficiency of information transfer, and an SCNN with ternary spikes is trained using backpropagation. The proposed SCNN achieves competitive performance on MNIST dataset and Fashion-MNIST dataset with a short window, thus the latency and the computations of the SCNN can be greatly reduced.

### A1P-A02

**MorphBungee: An Edge Neuromorphic Chip for High-Accuracy On-Chip Learning of Multiple-Layer Spiking Neural Networks**

Tengxiao Wang{1}, Haibing Wang{1}, Junxian He{1}, Zhengqing Zhong{1}, Fang Tang{1}, Xichuan Zhou{1}, Shuang-Ming Yu{2}, Liyuan Liu{2}, Nanjian Wu{2}, Min Tian{1}, Cong Shi{1}
{1}Chongqing University, China; {2}University of Chinese Academy of Sciences, China

In this work, we present a digital edge neuromorphic chip for real-time high-accuracy on-chip multi-layer SNN learning in visual recognition tasks. It employs a hierarchical multi-core architecture, a dynamically reconfigurable array parallelism and a quasi-event-driven scheme to improve processing speed. A prototype chip with a core area of 10.39 mm2 was fabricated using a 65-nm 1P9M CMOS process, and typically achieved a real-time speed of 87 frames/s and a power dissipation of 106 mW at an 83 MHz clock rate when training a 4-layer fully-connected SNN. Our chip attained comparably high recognition accuracies of 96.29% on the MNIST dataset, with an energy efficiency of 97 pJ/SOP for learning and 30 pJ/SOP for inference.

### A1P-A03

#### Wave Digital Emulation of a Bio-Inspired Circuit for Axon Growth

Sebastian Jenderny, Karlheinz Ochs
Ruhr-University Bochum, Germany

Even though artificial neural networks and corresponding hardware implementations are already very powerful, they are still far away from the efficiency of biological neuronal networks. It is hence useful to better understand and model biological principles shaping these networks besides synaptic changes, such as axon growth. As the few existing implementations focus on technical abstractions of the latter aspect, in this work, we aim for a bio-inspired circuit implementing axon growth well comparable to biological processes. For this purpose, we utilize Morris-Lecar oscillators as nodes of Ranvier and memristors for the growth mechanism. In order to emulate this circuit, we derive a wave digital model, which is well scalable and runtime efficient. Emulation results show the circuit successfully mimics axon growth principles observed in mammalian visual cortex and motor cortex neurons.

### A1P-A04

#### A Differential Difference Amplifier with a Combined Input Pairs for Neural Signal Recordings

Longbin Zhu, Zhijun Zhou, Qiao Meng, Xiao-Ying Lü, Zhi-Gong Wang
Southeast University, China

This paper presents a differential difference amplifier with a combined symmetrical and complementary input pairs for neural signal recording. It has three input transconductors, the first one is connected to the target neural signal, to ensure a high input impedance. The second one stabilizes the dc quiescent point and determines the cut-off frequency. The third one provides the common mode feedback (CMFB) and gain calibration. The circuits are targeted at IC realization, designed in a 0.18-μm CMOS technology. The post simulation achieves an input impedance of circa 1GΩ at 100 Hz, a CMRR of 128 dB. The proposed CIP-DDA (two channels) with a system CMFB achieves a die area of 0.23 mm2 and consumes a power consumption of 51 μW (single channel of DDA consumes 3.6μW).

### A1P-A05

#### A 6.78MHz Mid-Range Wireless Power Charging System for Milliwatt-Power-Level Long-Term Biomedical Sensing Applications

Zhiqiang Xu, Esther Rodriguez-Villegas
Imperial College London, United Kingdom

This paper presents a methodology and system architecture to supply power over mid-distance, in the context of bio-sensors for long-term vital monitoring purposes. The first part introduces a novel non-coupling coil system with a beamforming-control algorithm to enhance the power transfer efficiency, regardless of the receiver's position. In the second part a system-on-chip wireless power charger with high efficiency and trimming function to charge the mAh-level NiMH battery and provide stabilized power supply to devices, is presented. Overall, the system achieves 0.74% power efficiency up to 25cm (0.86% from the beamforming-control system and 86% from the wireless power charger system).

## A1P-A06

### Case-Study on Visible Light Communication for Implant Monitoring

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The focus of this paper is the feasibility of Visible Light Communication (VLC) for the monitoring of implants in rodents by example of two approaches. One of the VLC variants is intended for manually triggered transmission and takes advan- tage of the CMOS sensor rolling shutter principle. The second approach is designed mainly for autonomous monitoring. Trials with freely moving animals have shown that the first approach provides a throughput of 148 bit/s. For the automatic monitoring a transmission every 6 hours is suffcient for a reliable daily update of the implant status. VLC exhibits limited range and channel capacity in com- parison to radio frequency (RF) based telemetry. However, the advantage of VLC solutions is the minimal space requirement as only a single LED is needed in addition to the microcontroller on the transmitter side.

## A1P-A07

### Direct Digital Sensing Potentiostat Targeting Body-Dust

Roberto Rubino{2}, Sandro Carrara{1}, Paolo Crovetti{2}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Politecnico di Torino, Italy

In this paper, an innovative Direct Digital Sensing Potentiostat integrated circuit for enzymeless blood glucose sensing and direct digitization is proposed to address the requirements of Body Dust. The circuit occupies a silicon area of 460 um2 in 180nm CMOS and operates down to 0.4V power supply voltage with 4.7nW power consumption. The functionality of the proposed circuit and its performance under typical conditions and under process and temperature variations is tested by postlayout simulations.

## A1P-A08

### Effects of Broadband, Bandstop, and Amplitude-Modulated Alternating Current Stimulation on a Neural Mass Model

Alexander Pei, Barbara Shinn-Cunningham
Carnegie Mellon University, United States

Transcranial alternating current stimulation (tACS) is a neuromodulation technique that investigates the functions of neural oscillations in the brain. We investigated three alternative stimulation protocols in a computational model of the brain. We investigated broadband stimulation, as opposed to single-peak stimulation near the networks eigenfrequency. In a similar fashion, stimulation bandstopped near the peak eigenfrequency of the model was also investigated. We found no difference between broadband and single-peak stimulation, but found that bandstopped stimulation was able to desynchronize the network. Additionally, ampltide-modulated tACS was not able to entrain the network at the modulation frequency.

### A1P-A09

**A Wirelessly Powered, Batteryless Bipolar Biphasic Costant Current Stimulator for Gastric Application**

Chia-Ching Hung, Chen-Hao Hung, Dao-Han Yao, Po-Hung Chen
National Yang Ming Chiao Tung University, Taiwan

This paper presents a wirelessly powered, batteryless bipolar biphasic constant current stimulator (CCS) for gastric application. The proposed current stimulator employs a 0X/1X regulating rectifier to realize voltage rectification and regulation in one stage. Thus, an additional dc-dc converter for internal controller voltage generation, which occupies a large volume and reduces receiver efficiency, is eliminated. A positive voltage charge pump and a bipolar biphasic constant-current stimulator are integrated together to demonstrate bipolar biphasic stimulation with a maximum stimulation current of 6 mA and a step of 0.2 mA. The chip was fabricated in a 0.18-µm HV CMOS technology. A measured maximum rectifier PCE is 84.8%, and peak charge pump PCE is 60%.

### A1P-A10

**A Resonant Capacitive Wireless Power and Data Transfer Link with 52% PTE and 6.5 Mbps Data Rate for Biomedical Implants**

A N M Shahriyar Hossain, Pedram Mohseni, Hossein Miri Lavasani
Case Western Reserve University, United States

This paper presents a highly-efficient and high-speed capacitive wireless power and data transfer (C-WPDT) link for biomedical implants. Series-resonant capacitive wireless power and data transfer scheme involving external tuning inductors has been used for power transfer to biomedical implants. The same link has also been utilized for high-speed data transmission using simple amplitude-modulated signals. Ex vivo measurements are performed using beef muscle for a characteristic example. The series-resonant links show up to 52% power transfer efficiency (PTE) in a test case, which is comparable with the state-of-the-art power transfer schemes for implantable bioelectronics. The same link features a maximum of 6.5 Mbps data rate, which is the highest among tuned capacitive links with two pairs of metallic patches around body tissue.

### A1P-A11

**Automatically Controlled Flow and Pressure Conditions in a Bioreactor System for Medium- to Large-Sized Tissue-Engineered Vascular Grafts**

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Tissue engineering of medium- to large-sized vascular grafts requires specialized bioreactors and fluid circuits to provide sufficient static and dynamic cultivation in vitro. This paper describes the implementation and evaluation of a fluid circuit for automatically controlled flow and pressure conditions for vascular grafts with an inner diameter of up to 8 mm. The presented research includes CFD simulations of fluid characteristics, appropriate sizing of a pump, and the development of custom sensors and actuators. Compared to other published bioreactor systems for vessel maturation, the system presented here establishes sufficient hemodynamic conditions even for large-sized tissue-engineered vascular grafts.

## A1P-A12

### A 180 nm CMOS Integrated System Based on a Multilevel Synchronized Pulsed Modulation for High Efficiency Implantable Optical Biotelemetry

Guido Di Patrizio Stanchieri{2}, Andrea De Marcellis{2}, Marco Faccio{2}, Elia Palange{2}, Timothy G. Constandinou{1}
{1}Imperial College London, United Kingdom; {2}University of L'Aquila, Italy

This paper reports on the design of a fully integrated UWB-inspired optical biotelemetry system for high efficiency implantable devices in biomedical applications. The communication link implements a multilevel data coding combined to a synchronized pulse position modulation technique operating with serial bitstreams having data rates from 60 Mbps to 240 Mbps, symbols composed by 1 up to 6 bits (configurable operating modes) and pulse width of 300 ps. The proposed system has been designed in TSMC 180 nm standard CMOS technology requiring a total Si area of about 0.044 mm^2. Post-layout simulations demonstrate the correctness of the system functionalities and operations for transmission data rates up to 240 Mbps, symbol lengths up to 6 bits, and overall energy efficiencies lower than 22 pJ/bit. The comparison with results of similar solutions in the Literature demonstrates that the proposed system achieves the best performances in terms of data rate and energy efficiency.

## A1P-A13

### FPGA Implementation of an Event-Driven Saliency-Based Selective Attention Model

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{1}University of Groningen, Netherlands; {2}University of Zurich and ETH Zurich, Switzerland

Artificial vision systems of autonomous agents are required to process vast amounts of information in real time. Event-based vision sensors greatly reduce the amount of data produced, however, even then, fast and efficient vision remains an open challenge. An effective strategy for solving this problem is to divide the visual field into small sub-regions and process them sequentially, starting from the ones of highest saliency. This strategy is typically referred to as ``selective attention\'\'. Here we present a digital architecture implementing a saliency-based selective visual attention model for processing event-based data received from a DVS. We describe the architecture block diagram and demonstrate experimental results measured from the FPGA interfaced to the DVS.

### A1P-A14

#### Pre-Filtering of Stimuli for Improved Energy Efficiency in Electrical Neural Stimulation

Francesc Varkevisser, Amin Rashidi, Tiago L. Costa, Vasiliki Giagka, Wouter A. Serdijn
Delft University of Technology, Netherlands

This work proposes a guideline for designing more energy efficient electrical stimulators by analysing the frequency spectrum of the stimuli. It is shown that the natural low-pass characteristic of the neuron's membrane limits the energy trans- fer efficiency from the stimulator to the cell. Thus, to improve the transfer efficiency, it is proposed to pre-filter the high-frequency components of the stimulus. The method is validated for a Hodgkin-Huxely (HH) axon cable model using NEURON v8.0 software. To this end, the required activation energy is simulated for rectangular pulses with durations between 10 μs and 5 ms, which are low-pass filtered with cut-off frequencies of 0.5-50 kHz. Simulations show 51.5% reduction in the required activation energy for the shortest pulse width (i.e. 10 μs) after filtering at 5 kHz. It is also shown that the minimum required activation energy can be decreased by 11.04% when an appropriate pre- filter is applied. Finally, we draw a perspective for future use of this method to improve the selectivity of electrical stimulation.

### A1P-A15

#### An Open-Loop VCO-Based ADC with Quasi-Chopping and Non-Linearity Cancellation for Bio-Sensor Applications

Chien-Liang Chen, Tsung-Hsien Lin
National Taiwan University, Taiwan

An open-loop VCO-based ADC with quasi-chopping for bio-sensor applications is reported in this paper. The VCO is implemented as a trans-conductor (Gm) stage followed by a current-controlled oscillator (CCO). The proposed Gm circuit is designed to accommodate a large input range. This work also adopts a quasi-chopping technique that suppresses low-frequency noise while performs demodulation in the digital domain. The non-linearity cancellation (NLC) algorithm further improves the overall linearity. The proposed chip is fabricated in the TSMC 180-nm process. The core chip area of the circuit is 0.26 mm2. The total power consumption is 0.65 mW. With an input of 1.52 Vpp, the ENOB is 9.3 with a 100-kHz bandwidth. The ADC achieves an FoMs of 140 dB and FoMw of 5.1 pJ/conv.

### A1P-A16

**Freeform Stimulator (FS) Implant Control System for Non-Pulsatile Arbitrary Waveform Neuromodulation**

Grace Foxworthy, Gene Fridman
Johns Hopkins University, United States

Conventional neurostimulators deliver charge-balanced biphasic current pulses through metal electrodes implanted near a neural target to excite neurons and achieve a therapeutic goal. This type of stimulation avoids accumulating charge on the electrodes so that adverse electrochemical reactions are eliminated or minimized. However, these devices are mostly limited to generating phase-locked, excitatory neural activity. In contrast, direct ionic current can excite, inhibit, and control neural sensitivity. For this reason, we developed a Freeform Stimulator (FS) neural implant. It uses a microfluidic system to convert charge-balanced current waveforms through the electrodes embedded in the device into ionic current waveforms at the output ports to provide arbitrary non-pulsatile waveforms for neuromodulation without harmful electrochemical reactions. Here, we describe and model the closed-loop control system used to operate the device.

### A1P-A17

**Miniaturized Wireless Potentiostat for Intraoral Sensing of Glucose and Lactate**

Ella Thomson, Cheng Chen, Joonseok Yang, Siavash Kananian, Rayhan Lal, Justin Annes, Ada Poon
Stanford University, United States

A wireless dual-channel potentiostat is fabricated in CMOS and integrated in a mouthguard format for continuous salivary biosensing of glucose and lactate. Continuous glucose monitoring is required for closed-loop insulin dosing in Type 1 Diabetes. Continuous lactate sensing could improve closed-loop control, by serving as a biomarker of exercise. Saliva is readily and non-invasively available for biosensing. Glucose sensing range is < 0.6 mM with sensitivity of 2.4 µM and lactate sensing range is < 2 mM with sensitivity of 1.6 µM. Data from both channels is packetized for simultaneous transmission over the 902–928 MHz ISM band.

### A1P-A18

**A Low-Power Sensing System of VEGF Concentration with Monolithic Electrodes and an All-Digital Sub-Sampling Delay-Locked Loop**

Tsung-Wen Sun{1}, Ren-Wei Cheng{1}, Tsung-Heng Tsai{2}
{1}National Chung Cheng University, Taiwan; {2}National Yang Ming Chiao Tung University, Taiwan

A low-noise sensing system using the sub-sampling technique to suppress the interface noise is presented. The biomarker is vascular endothelial growth factor (VEGF). The proposed sensing system converts the capacitance variations caused by the VEGF concentration at the transducer into digital codes with a low-power SAR-assisted time-to-digital converter (TDC). CMOS MEMS interdigitated electrodes are adopted as the transducer. Post-process etching and Au plating are applied on the surface of the electrodes. Experimental results show that a capacitive resolution of 28.3 fF and a sensing range of VEGF concentration from 1 to 1000 pg/ml are achieved. The power consumption of the sensing front-end is 18 µW and overall sensing system is merely 60.65 µW. The FOM of the proposed low-power VEGF sensing system is 587.8 pJ/conv.-step.

### A1P-A19

#### Experimental Validation of a High-Voltage Compliant Neural Stimulator Implemented in a Standard 1.8V/3.3V CMOS Process

David Palomeque-Mangut, Ángel Rodríguez-Vázquez, Manuel Delgado-Restituto
Seville Institute of Microelectronics, Spain

This paper describes a neural stimulator with high compliance voltage, delivering up to 2.08 mA, and implemented in a standard 180 nm 1.8V/3.3V CMOS Process. The wide range of stimulation currents and high compliance voltage make it suitable for stimulation applications both in rodents and mammals. Besides, it can be configured both as electrical and optical stimulator. Stacked transistor cells with dynamic gate biasing have been used for withstanding voltages well above the nominal supply. An on-chip programmable high-voltage generator supplied the stimulator front-end. The system has been fabricated and experimentally tested by connecting it to a custom $\\upmu$electrode array which was immersed into a phosphate-buffered saline solution.

### A1P-A20

#### Design of 256-ch Neurochemical MEA Probe

Brian Kim, Kevin White
University of Central Florida, United States

Dopamine constitutes a significant portion of the catecholamine content in the brain and plays a distinct role in neuromodulation including directing motor control, motivation, reward, and cognitive function. For future neuroprobe technology, not only is simultaneous high-density neurochemical recording vital, temporal resolution plays a key part in the roles of the spatiotemporal distributions of catecholamines in the brain. In this work, we present a new probe design that contains a 256 microelectrode array with an integrated 256 transimpedance amplifier array capable of both amperometry and fast-scan cyclic voltammetry. The new probe enables a high-resolution spatiotemporal mapping of neurochemicals in the brain.

### A1P-A21

#### A Pressure-Sensitive Oscillator for Neuromorphic Applications

Bharath Kumar Singh Muralidhar, Rafael Ashkrizzadeh, Hermann Kohlstedt, Adrian Petraru, Robert Rieger
Kiel University, Germany

A post-CMOS compatible pressure sensor and associated readout electronic circuits are presented, which in combination yield a pressure sensitive artificial neuron with spike-frequency coded output. The transducers consist of a custom made metal-oxide-semiconductor field effect transistor, comprising a piezoelectric aluminum scandium nitride layer inside the gate stack (piezo-FET). They can operate in either a diode configuration or as current mirror pairs. The operating regime is CMOS compatible. The pressure dependent output current feeds a CMOS ring oscillator, varying its output frequency. The neuron is designed for off-chip coupling into a neural spiking network. Measured results are shown for the piezo-FET, readout setup, and oscillator, confirming the capability of encoding the mechanical quantity into a series of frequency-modulated spikes.

## A1P-A22

### A 9.03 μW Low Noise Highly Tunable Analog Front-End for Fully Implantable Cochlear Prosthesis

Berkay Özbek{1}, Haluk Külah{2}
{1}Imperial College London, United Kingdom; {2}Middle East Technical University, Turkey

This paper presents a low-noise, low-power and highly-programmable analog front-end that can interface with an implantable acoustic sensor of a fully implantable cochlear implant. Capable of processing outputs from a sensor higher than 20 μVrms as in the speech processors of conventional cochlear implants, the system mimics the filtering in the cochlea with 12 channels (85-6500 Hz) while consuming only 9.03 μW. Despite operating in analog domain, the system is highly reconfigurable in terms of center frequency, bandwidth and signal amplitude of the channels so that the system becomes compatible with different sensors and maximizes the hearing for each patient.

## A1P-A23

### The Impact of Signal Quality in Dielectrophoresis Experiments

Niklas Boldt{2}, Jana Späth{2}, Stephan Hartmann{2}, Mario Birkholz{1}, Roland Thewes{2}
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The impact of signal quality on dielectrophoresis experiments is investigated. Three frequencies providing a positive, a negative, and a vanishing real part of the Clausius Mossotti factor are compared using different signal resolutions. Sinusoidal signals are applied with 3 to 10 bit resolution, a total harmonic distortion of -60 to -20 dB, and a spurious free dynamic range from 27 to 65 dB. An experiment is performed with carboxyl functionalized 4.5 um polystyrene microspheres in deionized water using an electrode pair in a microfluidic channel. Signal qualities with resolutions smaller than 7 bit induce unwanted DEP forces or lower the net force.

## A1P-A24

### Power-Efficient and Accurate Texture Sensing Using Spiking Readouts for High-Density e-Skins

Mark Daniel Alea, Ali Safa, Jonah Van Assche, Georges Gielen
Katholieke Universiteit Leuven, Belgium

Fine-grain tactile sensing has recently gained much attention in robotics applications where the manipulation of potentially fragile objects must be provided. This has led to the emergence of electronic skin (e-skin) sensors, usually implemented with conventional frame-based acquisition chains. In addition, prosthetics applications require e-skins with human-level, sub-millimeter spatial resolution. This paper proposes to study two types of spike-based e-skin readout circuits, based on conventional and neuromorphic level crossing architectures. Compared to prior frame-based, coarse spatial resolution readout schemes, a sub-millimeter spiking e-skin scheme is modeled and compared to its frame-based counterpart in terms of power consumption and texture classification accuracy, using a Spiking Neural Network. Our analysis shows that the sparsity-inducing spike-based solutions achieve one order of magnitude lower power consumption while reaching a higher classification accuracy (87.92%) compared to the frame-based readout (74.58%).

### A1P-A25

#### Cortical-Inspired Placement and Routing: Minimizing the Memory Resources in Multi-Core Neuromorphic Processors

Vanessa Rodrigues Coelho Leite{1}, Zhe Su{1}, Adrian M. Whatley{1}, Giacomo Indiveri{2}
{1}Institute of Neuroinformatics, University of Zürich and ETH Zürich, Switzerland; {2}University of Zurich and ETH Zurich, Switzerland

Brain-inspired event-based neuromorphic processing systems have been emerging as a promising technology in particular for bio-medical circuits and systems. However, both neuromorphic and biological implementations of neural networks have critical energy and memory constraints. To minimize the use of memory resources in multi-core neuromorphic processors, we propose a hardware-software co-design approach that takes inspiration from biological neural networks. We use this approach to design a new routing scheme optimized for small-world networks and, at the same time, to present a hardware-aware placement algorithm that optimizes the allocation of resources for small-world network models. We validate the algorithm with a canonical small-world network and present preliminary results for other networks derived from it.

### A1P-A26

#### Neuromorphic Implementation of ECG Anomaly Detection Using Delay Chains

Stefan Gerber, Marc Steiner, Maryada Maryada, Giacomo Indiveri, Elisa Donati
University of Zurich and ETH Zurich, Switzerland

A major challenge pf spiking neural networks on neuromorphic hardware lies in the processing of spatio-temporal signals that last longer than the time constants present in the network synapses and neurons. There is no possibility of storing large amounts of data in buffers. We propose to extend the memory capacity of a spiking neural network by using parallel delay chains. We show the possibility to map temporal signals of seconds into spiking activity distributed across multiple neurons. We show that temporal information is properly preserved, and that this architecture can be used to detect anomalies in ECG signals.

### A1P-A27

#### Audio Mapping Using LiDAR to Assist the Visually Impaired

Benjamin Hofflich, Irene Lee, Alan Lunardhi, Nitesh Sunku, Jason Tsujimoto, Gert Cauwenberghs, Akshay Paul
University of California, San Diego, United States

Visually impaired individuals lack spatial awareness of obstacles in their environment. Traditional aids such as white canes and seeing-eye dogs allow users to navigate while understanding a very small spatial area around themselves. Light-to-audio conversion that is accomplished via two single-point LiDAR (light detection and ranging) sensors that output distance values that are converted into audio feedback, provides a sense of depth perception and warns the user of any impending obstacles. Through testing of this device, it was found that the device could successfully increase a user's ability to detect obstacles at a distance and take evasive action to avoid them. It was also determined that the double coding audio feedback system is intuitive for first time users and creates an artificial depth perception.

### A1P-A28

#### Flexible Design Methodology for Spike Encoding Implementation on FPGA

Clémence Gillet, Adrien Francis Vincent, Bertrand Le Gal, Sylvain Saïghi
CNRS - IMS - Laboratoire de l'Intégration du Matériau au Système, France

Inherently event-based sensors able to feed Spiking Neural Networks (SNNs) are few and using conventional sensors instead requires to encode their outputs into spikes. Dedicated algorithms have been studied in the literature but are often restricted to specific contexts and to software demonstrations, which can significantly increases energy consumption or latency. Here we introduce a flexible design methodology for implementing a generalized spike-encoder on Field Programmable Gate Array through High-Level Synthesis, allowing to quickly optimize the architecture. This could accelerate the development of lower power and latency smart sensors by combining conventional sensors with hardware SNNs.

### A1P-A29

#### Brain-Inspired Multi-Level Control of an Assistive Prosthetic Hand Through EMG Task Recognition

Alisha Menon, Laura I. Galindez Olascoaga, Niki Shakouri, Jennifer Ruffing, Vamshi Balanaga, Jan M. Rabaey
University of California, Berkeley, United States

Brain-inspired hyperdimensional computing (HDC) has shown promise for highly accurate EMG-based gesture recognition owing to its few-shot learning capabilities, and robustness to noise and electrode placement variability. The simplistic paradigm is also ultra low-power and low latency, potentially enabling local and fast closed-loop control of assistive prosthetic devices. In this work, we propose a novel fully HDC multi-level sensor fusion prosthetic control scheme. While prior work has only utilized HDC for recognition of static gestures held for 5 seconds, prosthetic control depends on task recognition with continuously changing EMG signals. To achieve this, we collect a multi-sensor dataset for 6 activities of daily living with feedback sensors, detailed sub-tasks and two levels of timing complexity. Finally, we demonstrate task recognition accuracy of 91% on the continuously changing EMG data, contributing a basis on which higher levels of control can be designed.

### A1P-A30

#### High-Dimensional Time-Series Gait Analysis Using a Full-Body Wireless Wearable Motion Sensing System and Convolutional Neural Network

Brandon Gresham{1}, Juan Torres{3}, Jonathan Britton{3}, Ziwei Ma{2}, Anita Parada{3}, Michelle Gutierrez{3}, Mark Lawrence{1}, Wei Tang{1}
{1}New Mexico State University, United States; {2}University of Tennessee at Chattanooga, United States; {3}University of Texas at El Paso, United States

This paper reported a high-dimensional time-series data analysis for a real-time full-body wearable motion-sensing system in conjunction with a convolutional neural network to classify gait patterns. The results show that the combination of hardware and algorithm is able to accurately classify different gait tasks and evaluate the interlimb coordination through correlation coefficient between left and right joint angles. The ultimate goal of future research is to detect the subtle abnormalities of patients with mild traumatic brain injury to determine the need for earlier intervention.

### A1P-A31

#### Ultra-Sensitive 2D Cancer Screening Based on Parity-Time-Symmetric Spoof Plasmonic Wave

Xixi Wang, Yu Luo, Yuanjin Zheng
Nanyang Technological University, Singapore

A parity-time (PT)-symmetric spoof plasmonic meta-waveguide (SPMW) is constructed to realize ultra-sensitive temperature sensing. This feature is owing to the ingenious configuration based on spoof plasmonic meta-waveguide and material characteristics. The PT-symmetric SPMW can be sensitively transferred from the unbroken phase to the broken phase by only varying a few percent (<3%) of ε\' value of polymer-based wave-transparent material, which leads to an asymmetric transmission of the plasma wave. More importantly, compared with other devices, this sensor affords 2D visual temperature imaging, which provides the precise monitoring of large-area body temperature. The combination of 2D material, graphene, further provides impressive flexibility and robustness for the practical applications of the whole system. This finding opens an unexpected horizon for the field of ultrasensitive sensing, that points out the promising way for flexible portable wearable temperature detectors

### A1P-A32

#### Real-Time, Dynamic Sensory Feedback Using Neuromorphic Tactile Signals and Transcutaneous Electrical Nerve Stimulation

Yucheng Tian, Ariel Slepyan, Mark Iskarous, Sriramana Sankar, Christopher Hunt, Nitish Thakor
Johns Hopkins University, United States

The development of upper limb prosthetics with sensory feedback has been a hot research topic. However, the real-time dynamics of the tactile information and sensory feedback have not yet been addressed. In this work, we developed a neuromorphic closed-loop system that integrates tactile sensing and transcutaneous electrical nerve stimulation in real time. We demonstrate the dynamic characteristics of the sensory stimulation pulses that change in response to real-time neuromorphic tactile information, which is the foundation of enhanced perception of touch and dexterous motor control in upper limb amputees.

### A1P-A33

#### Towards a Miniaturized, Low Power, Batteryless, and Wireless Bio-Potential Sensing Node

Roshan Pathitharayil Mathews, Hamid Jafari Sharemi, Iman Habibagahi, Jaeeun Jang, Arkaprova Ray, Aydin Babakhani
University of California, Los Angeles, United States

This paper presents a miniaturized (7.5mm radius), low power (8.8μW) sensing device capable of recording biopotentials in applications utilizing ECG (electrocardiogram), EMG (electromyography), and EOG (electrooculogram) while operating as a battery-less and wireless device. The sensing node utilizes wireless power transfer (WPT) in the ISM band of 40.68MHz enabling battery less operation and a wireless data uplink is performed in the ISM band utilizing short pulses of 915MHz. The sensing IC (integrated circuit) consists of a rectifier, power management unit, clock recovery unit, amplifier, ADC (analog-to-digital converter) and a transmitter. The IC is integrated into the sensing node through a specially designed miniaturized loop antenna for WPT and a co-designed dipole antenna for the uplink transmit. The sensing node is fabricated in the 180nm CMOS process and is successfully verified for recording bio-potential signals like ECG, EMG and EOG.

## Poster Session II - B4P-A

October 14, 2022 | 15:00-16:00

Session Chair(s):
Mohamed Atef / United Arab Emirates University, United Arab Emirates
Nien-Tsu Huang / National Taiwan University, Taiwan

### B4P-A01

**Design, Development and Validation of a Portable Visual P300 Event-Related Potential Extraction System**

Rathin K. Joshi, Manu K S, Hari R S, Mahesh Jayachandra, Hardik Jeetendra Pandya
Indian Institute of Science, India

P300 is an involuntary Event Related Potential (ERP) elicited in response to a novel stimulus. A non-invasive, cost-effective P300 extractor system was designed, developed and validated for Attention and Working Memory assessment. Standard P300 three-event visual stimuli were generated and presented using a head-mounted display. P300 responses were acquired using an Open BCI Cyton from young adults (n=5) and validated using an FDA-approved, CE-certified Neuroelectric Enobio 8 reference system. The extracted biopotential patterns from Cz and Pz electrodes matched in both developed and reference systems. Furthermore, ERP imaging confirmed P300 fatigue phenomenon during the experiment.

### B4P-A02

**Modeling and Analysis of a Wirelessly Powered Closed-Loop Implant for Epilepsy**

Mohammad Javad Karimi, Keyvan Farhang Razi, Catherine Dehollain, Alexandre Schmid
École Polytechnique Fédérale de Lausanne, Switzerland

A system-level model of a wireless power and data transmission system with a closed-loop epileptic seizure detector and suppressor device for low-power implantable applications is proposed using the MATLAB Simulink software. The proposed system transmits power and bidirectional data through a single inductive link with a monitoring unit, and records high-resolution intracranial-EEG (iEEG) signals by multiple electrode channels. The recording signals are processed in the analog domain and feed a digital signal processing block to extract five time-domain features to detect the seizure onsets, using datasets from Inselspital Bern. Subsequently, a current-mode multi-channel electrical stimulator is activated according to the seizure detection signal and delivers the electrical pulses to the brain.

**B4P-A03**

### A 16-Channel High-Voltage ASIC with Programmable Delay Lines for Image-Guided Ultrasound Neuromodulation

Ardavan Javid{2}, Chenyuan Zhao{1}, Mehdi Kiani{2}
{1}Jinan University, China; {2}Pennsylvania State University, United States

Ultrasound neuromodulation (USN) systems utilize bulky electronics to drive an ultrasonic (US) transducer. To achieve large-scale USN within a given tissue volume, a US transducer array should electronically be driven in a beamforming fashion to steer focused US beams towards different neural targets. This paper presents a 16-channel high-voltage ASIC (with 4-channel US imaging frontend) for driving a 16-element piezoelectric transducer array suitable for image-guided USN applications. In measurements, the performance of drivers with programmable delay lines in generating 50 V peak-peak pulses at 2 MHz with the total delay range of 32.05 μs and fine tuning has been demonstrated.

**B4P-A04**

### An Onchip Electrode Impedance Estimation Achieving 1.2 dB 3σ-Accuracy with Minimum Hardware Overhead

Stefan Reich, Peter Ammann, Markus Sporer, Maurits Ortmanns
University of Ulm, Germany

Neuromodulation has rapidly evolved in recent years and is evaluated for therapeutic treatment of various neurological ailments, including epilepsy and Parkinson's disease. When transitioning from a measurement laboratory prototype to a biomedical circuit for chronic implantation in humans, safety features and regulations are of utmost importance. One example for a safety-related feature is built-in electrode impedance estimation. Monitoring the electrode condition is crucial for early detection of electrode aging and decay, and allows to adapt stimulation parameters to the changes in the electrodetissue interface. Prior implementations used time domain analysis or transfer function estimations, which are both bound to a predefined model and vulnerable against noise and disturbers. In this paper, we present an electrode impedance estimation procedure that relies on a simple tone-based estimation to achieve about 1.2 dB accuracy. The estimation is applicable over a wide frequency range with minimum hardware overhead. Compared to our previous implementation, processing complexity is reduced by >100x, and accuracy is improved by 1.6x.

## B4P-A05

### An 11V-Tolerant, High-Density Neurostimulator Using Time-Domain Calibration in 65 nm CMOS

Maxime Feyerick, Wim Dehaene
Katholieke Universiteit Leuven, Belgium

Safe neurostimulation requires accurate charge balancing of the stimulation waveform to avoid charge build-up on the electrode-tissue interface. This work presents a novel time-domain calibration scheme to reduce the on-chip area per channel: control in the amplitude domain is loosened in exchange for corrections in the time domain, relieving analog matching constraints. A 16-channel stimulator was implemented in 65 nm CMOS to validate the principle, requiring only 0.0141 $mm^2$ area/channel. Despite being implemented in a standard CMOS technology, 10.4 V compliance has been achieved for compatibility with high-impedant microelectrode arrays typical for high-resolution neurostimulators. Measurements after calibration show the DC error is successfully reduced below 60 nA on every channel. Static power consumption is 22.4 μW per channel.

## B4P-A06

### Micro Cuff Electrode Manufacture for Vagus Nerve Monitoring in Rats

Javier Chávez Cerda{3}, Elena Acedo Reina{2}, Lars Stumpp{2}, Romain Raffoul{3}, Louis Vande Perre{3}, Macarena Díaz Cortés{3}, Pascal Doguet{1}, Jean Delbeke{2}, Riëm El Tahry{2}, Antoine Nonclercq{3}
{1}Synergia Medical SA, Belgium; {2}Université Catholique de Louvain, Belgium; {3}Université Libre de Bruxelles, Belgium

This work describes the fabrication of a homemade cuff electrode intended for rat vagus nerve electroneurography. The cuff electrode is built around 50 μm platinum wires contacts in tripolar configuration, 4 mm contact spacing. The body is made of silicone rubber and four surgical threads. In vivo validation allowed to record respiration and cardiac related activity from the vagus nerve. The results show that our electrodes are a suitable low-cost alternative for our preclinical studies.

## B4P-A07

### Programmable Electrochemical Stimulation on a Large-Scale CMOS Microelectrode Array

Pushkaraj Joshi{2}, Kangping Hu{2}, Joseph Larkin{1}, Jacob Rosenstein{2}
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In this paper we present spatio-temporally controlled electrochemical stimulation of aqueous samples using an integrated CMOS microelectrode array with 131,072 pixels. We demonstrate programmable gold electrodeposition in arbitrary spatial patterns, controllable electrolysis to produce microscale hydrogen bubbles, and spatially targeted electrochemical pH modulation. Dense spatially-addressable electrochemical stimulation is important for a wide range of bioelectronics applications.

## B4P-A08

### Telehealth Data-Derived Visual Analytics for Health Informatics Applications in Coordinated Care of Patients with Multiple Comorbidities

Chih-Yuan Chen{1}, Hsin-Hung Huang{2}, Chiu-Yeh Wu{2}, Li-Ting Kuo{2}, Siou-Yu Shih{2}, Por Lai{3}
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We describe telehealth data-derived visual analytics (VA) approaches aiming to deliver better healthcare outcomes to our telehealth service users with multiple comorbidities through enhanced real-time and real-world clinical decisions. In addition to the continuous vital sign data acquired from years of telemonitoring, the telehealth datasets also contain large amounts of unstructured service data including intervention notes and lifestyle-related information. These data are analyzed by our natural language processing (NLP) program for extracting coded data and subsequent machine learning. We develop a Gantt chart-based approach to interactively visualizing these complex analytics results in order to perform insightful examinations of users' health status. To our knowledge, this is the first case of using Gantt chart model for analyzing telehealth datasets and the integrated health information of both providers- and users-generated sources.

## B4P-A09

### Assessment Method of Balance Ability of Older Adults Using an In-Shoe Motion Sensor

Chenhui Huang, Fumiyuki Nihey, Kenichiro Fukushi, Hiroshi Kajitani, Yoshitaka Nozaki, Zhenwei Wang, Kazuki Ihara, Kentaro Nakahara
NEC Corporation, Japan

Falls rank as the second main cause of accidental death and injury in older adults. In this study, as the first stage of this study, by using in-shoe motion sensor (IMS), we aim to develop an assessment method for dynamic balance ability that is an important factor for fall risk. Statistical parametric mapping was used to find important predictors from IMS signals. We successfully constructed the model that achieved \excellent\" agreement between true and estimated clinical score of dynamic balance ability assessment."

### B4P-A10

#### A Setup for Conduction Velocities and Temperature Gradients Measurements During Infrared Neurostimulation

Louis Vande Perre{3}, Joaquin Cury{3}, Javier Chávez Cerda{3}, Maxime Verstraeten{3}, Romain Raffoul{3}, Pascal Doguet{1}, Jean Delbeke{2}, Riëm El Tahry{2}, Simon-Pierre Gorza{3}, Antoine Nonclercq{3}
{1}Synergia Medical SA, Belgium; {2}Université Catholique de Louvain, Belgium; {3}Université Libre de Bruxelles, Belgium

Infrared Neural Stimulation (INS) is a novel neuromodulation technique involving a rapid temperature increase of the neuron membrane, resulting in action potential triggering. This paper describes an experimental setup developed to measure the spatiotemporal temperature gradients at the surface of an ex vivo sciatic nerve. The setup is also designed to measure the conduction velocity of the nervous fibers excited by INS, with the aim of determining the type of fibers activated during optical stimulation. Two animal experiments successfully validated the setup and provided encouraging results on (1) the impact of heat accumulation on INS and (2) the difference in nerve fibers excited by optical and electrical nerve stimulation.

### B4P-A11

#### Optimal Pressure Sensor Locations in Smart Insoles for Heel-Strike and Toe-Off Detection

Diliang Chen{2}, Nozhan Ghoreishi{2}, Femi Olugbon{2}, Stella Ansah{2}, Ming-Chun Huang{1}, Qiaoyan Yu{2}
{1}Duke Kunshan University, China; {2}University of New Hampshire, United States

Heel-strike and toe-off are important gait events for gait analysis. Smart insoles with pressure sensors in different locations have been proposed to detect these two gait events. However, there is no research to reveal optimal sensor locations for heel-strike and toe-off detection. To address this problem, a novel method based on the mechanism of heel-strike and toe-off detection was proposed to find out the optimal sensor locations. The results showed that two sensor locations, one in the heel area and another at the front edge of the metatarsal bones area, were enough to detect heel-strike and toe-off with good accuracy.

### B4P-A12

#### Dual-Site Photoplethysmography Sensing for Noninvasive Continuous-Time Blood Pressure Monitoring Using Artificial Neural Network

Anas Rababah, Moien Ab Khan, Falah Awwad, Mohamed Atef
United Arab Emirates University, U.A.E.

In this work, we propose dual site Photoplethysmography (PPG) sensing for blood pressure monitoring using Artificial Neural Network (ANN). The method was implemented on a microcontroller for real-time BP monitoring. The models were evaluated on 15 volunteers and the ANN model achieved a MAE±SD 0.29 ± 4.49 mmHg for SBP and 0.5±2.4 mmHg for DBP. The proposed dual PPG site ANN model exhibited superior performance and robustness in real-time tests compared to the classical ANN single-site PPG model.

## B4P-A13

### A Hardware Accelerator for Long Sequence Alignment with the Bit-Vector Scoring Scheme and Divide-and-Conquer Traceback

Chuan-Yu Chen, Shih-Hao Huang, Yi-Chang Lu
National Taiwan University, Taiwan

Sequence alignment plays an important role in bioinformatics. We propose an ASIC design for the pairwise sequence alignment using Levenshtein distance based on the Myers Bit-Vector algorithm. We also design an accelerator of the divide-and-conquer-based Hirschberg\'s Algorithm to reduce memory usage, so that the on-chip traceback function can be supported. The hardware is implemented with TSMC 40 nm technology and the maximum input sequence size of the aligner is 10,240 X 5,242,880 bps. Our hardware accelerator can achieve 3,992 GCUPS, which speeds up the pairwise alignment by 147X when compared with the software counterpart for the sequences of 90% similarity.

## B4P-A14

### Zero-Weight Aware LSTM Architecture for Edge-Level EEG Classification

Seungjae Yoo, Geunchang Seong, Jaeseong Park, Chul Kim
Korea Advanced Institute of Science and Technology, Korea

In the electroencephalograph (EEG) brain-computer interface field, the classification of EEG signals with neural networks is an emerging research topic. However, previous works mainly focused on choosing appropriate networks and implementing them in a software fashion. For edge-level EEG classification, this paper proposes a Zero-Weight (ZW) aware long short-term memory (LSTM) based EEG classifier implemented on field-programmable gate array (FPGA). ZW-aware LSTM network optimizes the matrix-vector multiplication (MxV) not only using the sparse weight of the LSTM layer itself but also considering the sparse weights of the following layers. Public BCI competition data are used for the evaluation of the proposed ZW-aware LSTM network EEG classifier. Our hardware-implemented EEG classifier shows x9.53 speedup compared to the software classifier implemented on CPU @3.40GHz and achieves accuracy up to 81%.

### B4P-A15

**Design and Simulation of a Low Power 384-Channel Actively Multiplexed Neural Interface**

Gabriella Shull{2}, Thomas Jochum{2}, Kyung Jin Seo{1}, Yieljae Shin{1}, James Morizio{2}, Hui Fang{1}, Jonathan Viventi{2}
{1}Dartmouth College, United States; {2}Duke University, United States

Brain computer interfaces (BCIs) provide clinical benefits including partial restoration of lost motor control, vision, speech, and hearing. A fundamental limitation of existing BCIs is their inability to span several areas (> cm2) of the cortex with fine (< 100 µm) resolution. One challenge of scaling neural interfaces is output wiring and connector sizes as each channel must be independently routed out of the brain. Time division multiplexing (TDM) overcomes this by enabling several channels to share the same output wire at the cost of added noise. This work leverages a 130-nm CMOS process and transfer printing to design and simulate a 384-channel actively multiplexed array, which minimizes noise by adding front end filtering and amplification to every electrode site (pixel). The pixels are 50 µm × 50 µm and enable recording of all 384 channels at 30 kHz with a gain of 22.3 dB, noise of 9.57 µV rms, bandwidth of 0.1 Hz – 10 kHz, while only consuming 0.63 µW/channel. This work can be applied broadly across neural interfaces to create high channel-count arrays and ultimately improve BCIs.

### B4P-A16

**Electronic System Design for a Next-Generation Laser-Driven Portable Photodynamic Therapy Medical Device**

Eric Yeh{3}, Joe Harling{3}, Sean Spencer{3}, Tayyaba Hasan{1}, Jonathan Celli{2}, Filip Cuckov{3}
{1}Harvard University, United States; {2}University of Massachusetts Boston, United States; {3}Wentworth Institute of Technology, United States

Photodynamic Therapy (PDT) is a promising method for treating oral cancer using photosensitizers in conjunction with a moderately powered red light. This paper details the electronic circuit design for a new prototype of a PDT cancer treatment device. A microcontroller interfaces with a current driver to run a 300-mW laser. Safety interlocks and a touchscreen are in place for users to interface with and control the device during operation. Additionally, the device is made portable with an internal battery. A power switching circuit allows for efficient swap over from an external source in case of loss of power.

## B4P-A17

### A Miniaturized Prototype for Continuous Noninvasive Transcutaneous Oxygen Monitoring

Burak Kahraman{2}, Vladimir Vakhter{2}, Ian Costanzo{2}, Guixue Bu{1}, Foroohar Foroozan{1}, Ulkuhan Guler{2}
{1}Analog Devices Inc., United States; {2}Worcester Polytechnic Institute, United States

Luminescent oxygen sensing is employed for measuring the partial pressure of oxygen diffusing through the skin, named transcutaneous oxygen. Two well-known approaches are intensity- and lifetime-based measurement for assessing transcutaneous oxygen. The lifetime-based technique is preferable as it offers lower sensitivity to optical path changes and reflections compared to the intensity-based method. High-resolution lifetime capturing is critical to accurate transcutaneous oxygen measurements from the human body. This study proposes a miniaturized prototype based on a specialized analog front end, ADPD4101, with a 14-bit ADC and a developed firmware. We have demonstrated that the prototype could detect small changes in the lifetime with high resolution, showing its suitability for future human subject tests. We implemented the prototype on a 68 mm × 43 mm printed circuit board (PCB) and consumes the power of 39 mW.

## B4P-A18

### A CMOS Microelectrode Array Integrated Into an Open, Continuously Perfused Microfluidic System

Raziyeh Bounik{1}, Jihyun Lee{1}, Vijay Viswam{2}, Fernando Cardes{1}, Mario M. Modena{1}, Andreas Hierlemann{1}
{1}ETH Zürich, Switzerland; {2}ETH Zürich & MaxWell Biosystems, Switzerland

A monolithic device is presented that features a CMOS microelectrode array system integrated into an open microfluidic device. The system includes two microelectrode arrays, each featuring 1024 microelectrodes arrayed within a 1.6 × 1.6 mm2 sensing area. It enables label-free in vitro impedance and electrophysiology recordings from cells and tissues. The open microfluidic system provides oxygenation and perfusion capabilities, as well as controllable liquid handling, which makes the device a versatile tool for long-term experiments and compound development studies.

**B4P-A19**

### Body-Channel Wireless Power Transfer Employing Transmitter-Side Received Power Monitoring and Maximum Point Tracking

Yabin Zheng{1}, Tao He{1}, Xu Liang{1}, Zhen Kong{2}, Longyang Lin{2}, Jian Zhao{1}
{1}Shanghai Jiao Tong University, China; {2}Southern University of Science and Technology, China

This paper proposes a power-boosted wireless energy transfer system for wearable devices through human body channels (BC-WPT). The BC-WPT system enables monitoring the received power at the transmitter side and tracking the maximum power point by a tunable LC network. The proposed system has three advantages: First, the system uses the voltage across the insertion resistor between the transmitter and the body electrode to estimate the received power, and the soundness is verified by theoretical analysis; Second, a maximum power point tracking (MPPT) system based on LC resonance is also designed at the transmitter side to maximize the received power under dynamic variations; Finally, the technology does not introduce any extra overhead for miniaturized and low-power sensor nodes, and realizes power boosting. The simulation results show a 17 dB improvement compared to the uncompensated case, and a worst-case improvement of 1.2 times than the traditional method of maximizing transmitter power.

**B4P-A20**

### Towards a Wireless Micropackaged Implant with Hermeticity Monitoring

Arthur Jaccottet, Peilong Feng, Katarzyna Szostak-Lipowicz, Lewis Keeble, Timothy G. Constandinou
Imperial College London, United Kingdom

This paper presents an implantable micropackaging concept to protect a microelectronic system-on-chip. A hermetic chamber is formed by bonding the active CMOS chip to a silicon cover, using a gold-tin eutectic sealant. A humidity sensor inside the chamber monitors its humidity to assess its permeability. To power the sensor and read its data, interconnections in the chip itself have been designed; these metal tracks pass underneath the cover creating a connection between the inside and outside of the cavity. As an alternative to these connections, an on-chip wireless power management and data communication system is also presented with simulated results.

**B4P-A21**

### In-Vitro Experiment of Magnetoelectric Wireless Power Transfer System on Human Tissue Mimicking Phantom

Dibyajyoti Mukherjee, Simran Rainu, Neetu Singh, Dhiman Mallick
Indian Institute of Technology Delhi, India

A miniaturized, low-frequency magnetoelectric wireless power transfer (WPT) system is reported for powering implantable medical devices while addressing the trade-off between miniaturization, power generation, and bio-compatibility. The device's bio-compatibility is confirmed by the cytotoxicity tests after encapsulating using conformal parylene coating. Experimentally, the device generates 0.4V under an alternating magnetic field of 0.4Oe. The maximum power transferred by the device is 6.66μW and 5μW in air and tissue-mimicking phantom medium, respectively. A battery-less power management circuit enabling synchronous electric charge extraction is also demonstrated that can suitably regulate input voltage from 0.5-10V to 2.5V DC, limiting the intrinsic power consumption.

## B4P-A22

### FAST: FPGA-Based Acceleration of Genomic Sequence Trimming

Behnam Khaleghi{2}, Tianqi Zhang{2}, Niya Shao{2}, Ameen Akel{2}, Ken Curewitz{1}, Justin Eno{1}, Sean Eilert{1}, Niema Moshiri{2}, Tajana Rosing{2}
{1}Micron Technology, Inc., United States; {2}University of California, San Diego, United States

We propose the first FPGA-based framework called FAST to accelerate the sequence trimming step of bioinformatics pipelines, in particular adapter and primer removal. FAST supports a comprehensive set of functionalities and is convenient to use by operating on standard genomics data formats. FAST is fully configurable and supports variety of runtime settings. It surpasses the widely-used adapter trimmer by up to 29.4× speed-up, with up to 54.9× less energy. For clipping primers, which with the current existing softwares accounts for ~50% of COVID analysis pipeline, FAST achieves up to 62× speed-up in trimming the virus sequences.

## B4P-A23

### A Dual Resonant Frequencies Tuning Circuit Based on FSK Modulation for Wireless Power and Data Transmission in Medical Implants

Anning Liu, Qiang Wang, Wending Qi, Songping Mai
Shenzhen International Graduate School, Tsinghua University, China

In this paper, we propose a dual resonant frequencies tuning circuit (DRFTC) to improve the PTE of the WPDT system for medical implants. The PTE and PDL of the proposed DRFTC-WPDT system are measured to be 65.50% and 69.11 mW, respectively. The data transmission rate reaches 564 Kbps. The transmitter SoC is fabricated by 0.18-μm CMOS technology and occupies 1.8 mm2. Experimental results have verified the function and demonstrated the potential of the proposed DRFTC-WPDT system to be utilized in medical implants.

## B4P-A24

### Implementation of Light and Dark Adaptation Function for High QOL 3D-Stacked Artificial Retina Chip

Kohei Nakamura{2}, Yaogan Liang{2}, Bang Du{2}, Shengwei Wang{2}, Yuta Aruga{2}, Bunda Inoue{2}, Hisashi Kino{2}, Takafumi Fukushima{2}, Koji Kiyoyama{1}, Tetsu Tanaka{2}
{1}Nagasaki Institute of Applied Science, Japan; {2}Tohoku University, Japan

The increase in the number of visually impaired people has led to active research on artificial retinas. In our laboratory, we are studying a fully implantable 3D stacked retinal prosthesis using a 3D stacked retinal chip, which provides highly visible visual information with edge enhancement and binarization functions. However, since the visibility of objects can be significantly reduced when the ambient illumination is low, a light and dark adaptation (LDA) function is needed to provide the same visibility regardless of the ambient illumination. However, conventional LDA functions have problems in operability, comfort, and circuit area. In this study, we proposed a small-area LDA function that provides visual information with high quality of life, and evaluated a prototype circuit.

## B4P-A25

### A Low-Noise Ex-Vivo CMOS MEA with 4K Recording Sites, 4K Recording Channels, and 1K Stimulation Sites

Timo Lausen, Stefan Keil, Norman Dodel, Mathias Schulz, Andrea Corna, Günther Zeck, Andreea-Elena Cojocaru, Roland Thewes
Technische Universität Berlin, Austria; Technische Universität Berlin, Germany

This paper presents a Multi-Electrode-Array (MEA) in a 180nm CMOS-Technology with 4225 recording sides and 1024 stimulation sites. Two versions of the Chip provide an active area of 2.3mm x 2.3mm and 4.1mm x 4.1mm respectively with a spacial resolution of 36µm and 64µm. It is capable of full imaging at a high frame rate of 25kHz at an input referred noise of 13.1µVrms in the AP band (300Hz to 10kHz), 10µVrms in the AP band (300Hz t0 6kHz) and 15.1µVrms in the LFP band (1Hz to 300Hz). To reach these noise levels the electrodes are routed out of the array to dedicated low noise amplifiers. Crosstalk between individual pixels is reduced by individual actively shielded traces significantly.

## B4P-A26

### A Nucleotide-Position-Based Data Format for Fast Variant Calling and its Hardware Analyzer Design

Hao-Wei Liu, Zhe-Wei Shen, Yang-Ming Yeh, Yi-Chang Lu
National Taiwan University, Taiwan

In this paper, we propose a file format, vBAM, to improve the performance of variant calling tasks. The vBAM format removes data irrelevant to variant calling and compresses base/quality information by positions to reduce data bits. Thus, the vBAM format takes shorter variant calling time and is smaller in size when compared to the conventional BAM/pileup files. Our C++ software supports BAM to vBAM conversion, vBAM decoding, and variant calling. We also implement an accelerator to shorten the computing time of decoding and calling stages. The hardware can achieve at least a 7.2X speed-up when compared to its software counterpart.

## B4P-A27

### Accelerated Testing of Electrode Degradation for Validation of New Implantable Neural Interfaces

Vichaya Manatchinapisit, Adrien Rapeaux, Ian Williams, Timothy G. Constandinou
Imperial College London, United Kingdom

Implanted electrode degradation monitoring systems for neural prostheses were proposed in many works of literature. However, validating those systems requires a long time to generate electrode degradation. This paper presents an experimental design for accelerated electrode degradation by increasing temperature and electrical stimulation. Electrochemical Impedance Spectroscopy (EIS) was measured hourly to observe electrochemical properties related to electrode degradation. Microscopy images show tungsten wire electrodes\' morphology changes before and after testing. The minimum accelerated testing to create electrode failure was 6 hours. Additionally, EIS plots illustrate the slight impedance increase over time due to the decline of the electrode surface area.

### B4P-A28

#### Prediction of Protein-Protein Interactions Through Deep Learning Based on Sequence Feature Extraction and Interaction Network

Nguyen Quoc Khanh Le, Quang Hien Kha
Taipei Medical University, Taiwan

Protein-protein interaction (PPI) is an important molecular process in the cell, which is vital to the function of the cell in the biochemical process. This study uses protein information and the relationship of protein interaction network structure to predict PPI. Deep neural network model is implemented to realize PPI prediction. Through different evaluation processes, high prediction performance is produced (92.45% accuracy). To further evaluate the performance of our method, we compared it with other machine learning algorithms and previously published works. The experimental results show that our model is significantly better than the others on the same dataset.

### B4P-A29

#### A High SNR, Low-Latency Dry EMG Acquisition System for Unobtrusive HMI Devices

Victor Javier Kartsch Morinigo{2}, Simone Benatti{3}, Luca Benini{1}
{1}Integrated Systems Laboratory, ETH Zürich, Switzerland; {2}Università di Bologna, Italy; {3}University of Modena and Reggio Emilia, Italy

Gel-based electrodes are at the core of clinical and HMI applications, given their excellent signal quality. Still, their intrusiveness, preparation times, and non-reusability limit their usage, most notably when scaling up the number of EMG channels. This work introduces a low-cost, zero-preparation, highly dense, unobtrusive dry EMG bracelet system that offers a competitive signal-to-noise ratio and achieves 95% classification accuracy on eight hand gestures. The dry electrodes are coupled with BioWolf16, an HMI device for embedded signal processing. The system was validated in the HMI context to control a nano-drone, with the complete processing chain running on the embedded device.

### B4P-A30

#### Digitally Controllable ASIC for Tri-Color Wireless Photometry

Ravi Kirschner{2}, Amin Hazrati Marangalou{2}, Yusuke Tsuno{1}, Ulkuhan Guler{2}
{1}Kanazawa University, Japan; {2}Worcester Polytechnic Institute, United States

In this work, we propose a tri-color wireless photometry application-specific integrated circuit to measure multiple neurotransmitters simultaneously. The proposed optical excitation channel is fully time-multiplexed and can provide an excitation pulse of between 100 uA and 4 mA with a nominal pulse length of 6.66 Hz, whereas our optical recorder is a fully-differential chopping integrator with three separate channels designed for a 250 $\\mu$s integration window with a 10 nA current input before resetting as well as 2.21 pA$_R_M_S$ of input-referred noise integrated from 0.5 Hz to 10 kHz. The presented chip is simulated in TSMC 180 nm standard CMOS.

## Poster Session III - C4P-A

October 15, 2022 | 15:00-16:00

Session Chair(s):
Sohmyung Ha / New York University Abu Dhabi, United Arab Emirates
Chia-Hsiang Yang / National Taiwan University, Taiwan

### C4P-A01

#### Various Distance Metrics Evaluation on Neural Spike Classification

Shengpeng Guo, Liyuan Guo, Seyed Mohammad Ali Zeinolabedin, Christian Mayr
Technical University Dresden, Germany

State-of-the-art neuroscience applications require the classification of action potential activities (or spikes) recorded by multi-channel electrodes, named spike sorting. A typical spike sorting algorithm involves three parts: detection, feature extraction, and training/classification. Training/classification stages are mainly based on distance-based algorithms like k-means. For the classification, in particular, the accuracy depends highly on the distance metric performance. In this paper, we analyze several distance metrics to classify various datasets with different noise levels using the F1 score. This includes Manhattan, Euclidean, and, Mahalanobis distance metrics. As a result, the Mahalanobis distance metric outperforms other metrics in noisy conditions by an average of 10% in the presence of the noise.

### C4P-A02

#### Divergent Functional Connectivity Patterns of Brain Network in Patients with or Without Post-Stroke Dementia : A Resting-State fMRI Study

Xiaoyu Li{2}, Mengru Xu{2}, Huaying Cai{1}, Yu Sun{2}
{1}Sir Run Run Shaw Hospital, China; {2}Zhejiang University, China

Considering the high-risk mortality in patients with post-stroke dementia (PSD), efforts could be made to further expound the neural mechanisms from a brain network perspective. This study quantitatively compared the topological properties of brain network among health subjects, patients without PSD, and patients with PSD. Significantly decreased global properties (global efficiency, local efficiency, and small-world properties), and nodal efficiency in specific regions related with cognitive functions indicated the altered functional connectivity patterns in PSD patients. These findings would promote the technical developments of premorbid prevention, clinical diagnosis and neural treatment of PSD in the future.

### C4P-A03

#### CMOS-Based Ion Image Sensors for Eliminating Optical Contamination

Runa Honjo, Kenta Sembo, Yoshiko Noda, Daisuke Akai, Takeshi Hizawa, Yasuyuki Kimura, Yong-Joon Choi, Kazuhiro Takahashi, Kazuaki Sawada, Toshihiko Noda
Toyohashi University of Technology, Japan

In the case of ion image sensor which has been developed, ion measurement was strongly fluctuated by light incident to the sensor. Therefore, this study proposed and approached two methods to eliminate contamination of the optical signal. One is to design two pixels with different characteristics and compare them to eliminate the influence of light. The other is to subtract from the output. As a results of functional validation, both approaches achieve ion measurement under the light irradiation without fluctuation by optical contamination. It was eliminated without degrading the spatial resolution of ion sensing.

### C4P-A04

#### A 43.6 TOPS/W AI Classifier with Sensor Fusion for Sepsis Onset Prediction

Sudarsan Sadasivuni{3}, Sumukh Prashant Bhanushali{1}, Imon Banerjee{2}, Arindam Sanyal{1}
{1}Arizona State University, United States; {2}Mayo Clinic, Arizona State University, United States; {3}State University of New York at Buffalo, United States

This work presents an artificial intelligence (AI) framework for real-time, personalized sepsis prediction four hours before onset through fusion of electrocardiogram (ECG) and patient electronic medical record. An on-chip classifier combines analog reservoir-computer and artificial neural network to perform in-sensor classification at 43.6 TOPS/W (normalized efficiency of 528 TOPS/W) which reduces energy by 155 compared to conventional sensors and 4 compared to stateof- the-art bio-medical AI circuits. The proposed AI framework predicts sepsis onset with state-of-the-art 92.9% accuracy on patient data from MIMIC–III. The proposed framework is noninvasive and does not require lab tests which makes it suitable for at-home monitoring.

### C4P-A05

#### Fast High-Resolution Disparity Estimation for Laparoscopic Surgery

Jan Müller{2}, Reuben Docea{1}, Matthias Hardner{2}, Katja Krug{2}, Paul Riedel{2}, Ronald Tetzlaff{2}
{1}National Center for Tumor Diseases Dresden, Germany; {2}Technische Universität Dresden, Germany

An intraoperative Image Guidance System (IGS), facilitating the localisation of pathological tissue or vasculature, could enormously support medical decisions during minimally invasive interventions. In our IGS for laparoscopic surgery, the 3D reconstruction of the abdominal organs requires fast and accurate depth information from stereo images. To this end we employ a state-of-the-art algorithm for dense disparity estimation. To cope with low processing performance, previous solutions used only downscaled images, and hence produced disparities of low quality. In this contribution we present methods and implementations to improve and accelerate disparity estimation, to work with FullHD resolution images at full camera framerate.

## C4P-A06

### A Laparoscopic Liver Navigation Pipeline with Minimal Setup Requirements

Reuben Docea{1}, Micha Pfeiffer{1}, Jan Müller{2}, Katja Krug{2}, Matthias Hardner{2}, Paul Riedel{2}, Martin Menzel{1}, Fiona Kolbinger{1}, Laura Frohneberg{2}, Jürgen Weitz{2}, Stefanie Speidel{1}
{1}National Center for Tumor Diseases Dresden, Germany; {2}Technische Universität Dresden, Germany

In the case of liver tumour resections, Minimally Invasive Surgery (MIS) poses several benefits over open surgery. However, MIS makes navigating the surgical scene considerably more challenging and consequently hampers the realisation of its full potential. Many Image Guidance Navigation Systems (IGS) have been proposed to overcome these challenges. The majority of these depend on optical tracking systems, whose additional setup overhead is a barrier to clinical translation. In this paper we put forward an IGS which eliminates the need for optical tracking, and additionally incorporates a user-oriented camera calibration method which is more reliable and faster than typical checkerboard methods. We lastly make publicly available the core system modules for 3D reconstruction and rigid registration.

## C4P-A07

### A Firing Rate Independent Threshold Estimation for Neuronal Spike Detection Methods

Mattia Tambaro{2}, Stefano Vassanelli{1}
{1}Padova Neuroscience Center, University of Padua, Italy; {2}University of Padua, Italy

Setting the threshold for a spike detection method is always challenging. In this work we demonstrate how common approach to automatic threshold estimation are highly affected by changes in the firing rate of neurons, causing the threshold to become an unreliable yardstick of evaluation between different channels and even within the same recording. For this reason, we propose a noise estimation method suitable for the automatic setting of a firing-rate independent threshold for spike detection methods. We compare its performances against other widely used statistical variability indices both qualitatively and quantitatively.

## C4P-A08

### Blood Pressure Estimation Using Pulse Transient Time Derived from Photoplethysmogram and Seismocardiogram in Smartphone

Dongrae Cho, Kwang Jin Lee, Jongin Kim
Deepmedi Corp., Korea

Recently, with the advance of technology, it is possible to extend of functions of smartphone extremely. Accordingly, there have been growing number of people who want to receive healthcare services using smartphone. In particular, the smartphone has a variety of sensors and the photoplethysmogram(PPG) signal and seismocardiogram (SCG) signal which are reflected in cardiac functions can be acquired easily. In this paper, we came up with the algorithm measuring the bio-signals using the sensors of smartphone and estimating the blood pressure without transitional blood pressure gauge. As a result, the averages of root mean square error obtained by proposed method and reference values (systolic pressure and diastolic pressure) were 9.6mmHg and 5.8mmHg, respectively.

### C4P-A09

#### Chronic Setup System for Continuous Monitoring of Epileptic Rats

Javier Chávez Cerda{3}, Elena Acedo Reina{2}, Hugo Smets{3}, Maxime Verstraeten{3}, Louis Vande Perre{3}, Macarena Díaz Cortés{3}, Pascal Doguet{1}, Jean Delbeke{2}, Riëm El Tahry{2}, Antoine Nonclercq{3}
{1}Synergia Medical SA, Belgium; {2}Université Catholique de Louvain, Belgium; {3}Université Libre de Bruxelles, Belgium

This work presents a setup for chronic monitoring of spontaneous epileptic seizures in rats under kainic acid. The system allows to record the vagus nerve electroneurogram at 40 kS/s and the electroencephalogram at 250 S/s using an USB-6212 multifunction I/O-device. The system includes a video channel (20 fps) controlled by a Raspberry Pi 4 Model B. A slipring allows the rat to move freely. Quick cage cleaning is possible through a movable base. The chronic setup was tested on a Wistar rat after status epilepticus induction, using kainic acid. The system appears to be robust and reliable enough to record status epilepticus, making it suitable for more extended experiments in epileptic rats.

### C4P-A10

#### Event-Driven ECG Classification Using Functional Approximation and Chebyshev Polynomials

Maryam Saeed{3}, Olev Märtens{1}, Benoit Larras{2}, Antoine Frappé{2}, Deepu John{3}, Barry Cardiff{3}
{1}Tallinn University of Technology, Estonia; {2}Université Lille, Polytechnic University of Hauts-de-France, France; {3}University College Dublin, Ireland

Level-crossing ADCs reduce the size of data streams in wearable devices. However, in the context of electrocardiogram (ECG) signals, such an event-driven data source results in a variable length two-dimensional (time-amplitude tuples) data vector for each ECG beat. It is difficult to apply many standard signal processing techniques to this data making classifiers more complex. In this paper we resolve these difficulties by mapping the variable length 2D vectors to a fixed length feature vector comprising the first 80 coefficients of a Chebyshev polynomial expansion of the ECG beat. We show that, by using these 80 coefficients, the average percentage root-mean-square error is only ≈3.08%. Using this feature set we constructed a simple three-layered ANN binary (Normal / Abnormal) ECG classifier and we demonstrate 98.15% average accuracy and 96.07% average sensitivity. We also constructed a 4-class ANN, using the same ANN structure and we achieved 98.80% average accuracy and 91.5% average sensitivity. Both these networks have only 20k parameters and outperform the state-of-the-art classifiers, enabling low-power edge computing.

## C4P-A11

### All Attention U-Net for Semantic Segmentation of Intracranial Hemorrhages in Head CT Images

Tian Sheuan Chang{2}, Chia Shuo Chang{2}, Jiun Lin Yan{1}, Li Ko{1}
{1}Chang Gung Memorial Hospital, Taiwan; {2}National Yang Ming Chiao Tung University, Taiwan

Intracranial hemorrhages in head CT scans serve as a first line tool to help specialists diagnose different types. However, their types have diverse shapes in the same type but similar confusing shape, size and location between types. To solve this problem, this paper proposes an all attention U-Net. It uses channel attentions in the U-Net encoder side to enhance class specific feature extraction, and space and channel attentions in the U-Net decoder side for more accurate shape extraction and type classification. The simulation results show up to a 31.8\\% improvement compared to baseline, ResNet50 + U-Net, and better performance than in cases with limited attention.

## C4P-A12

### Single-Channel EEG Completion Using Cascade Transformer

Chao Zhang{2}, Siqi Han{1}, Milin Zhang{2}
{1}Beijing University of Posts and Telecommunications, China; {2}Tsinghua University, China

The recorded electroencephalogram (EEG) signal is easy to be incomplete due to packet loss, electrode falling off, etc. This paper proposed a Cascade Transformer architecture and a loss weighting method for the single-channel EEG completion, which reduced the Normalized Root Mean Square Error (NRMSE) by 2.8% and 8.5%, respectively. With the percentage of the missing points ranging from 1% to 50%, the proposed method achieved a NRMSE from 0.026 to 0.063, which aligned with the state-of-the-art multi-channel completion solution. The proposed work shows it\'s feasible to perform the EEG completion with only single-channel EEG.

## C4P-A13

### FlowMorph: Morphological Segmentation of Ultrasound-Monitored Spinal Cord Microcirculation

Denis Routkevitch, Andrew Hersh, Kelley Kempski, Max Kerensky, Nicholas Theodore, Nitish Thakor, Amir Manbachi
Johns Hopkins University, United States

Here, we present FlowMorph, a morphological image processing algorithm to segment and analyze rat spinal cord microvasculature as recorded by non-contrast ultrasound. Individual perforating vessels are automatically isolated and single-vessel flow parameters such as flow velocity, radius, and flow rate are automatically extracted. The segmentation outlines vessels well with little extraneous labeling, and cardiac cycles are visible in the single-vessel parameters through time. This technique will be used in future work on probing the microvascular physiology of spinal cord injury in rats and can be expanded to other species as well.

### C4P-A14

**A Resource-Efficient and Data-Restricted Training Method Towards Neurological Symptoms Prediction**

Shiqi Zhao{2}, Di Wu{1}, Jie Yang{1}, Mohamad Sawan{1}
{1}Westlake University, China; {2}Zhejiang University, Westlake University, China

In this work, we propose a novel transformer based on-device training framework to tackle the aforementioned issues. The proposed framework adopts direct feedback alignment (DFA) for hardware and computation efficient model training and semi-supervised learning with customized augmented techniques to ease the data labeling process. The effectiveness of the proposed framework is validated on seizure prediction task using electroencephalogram (EEG), experimental results indicated that the proposed framework yields an average improvement of 6.39% and 0.05/h in prediction sensitivity and false positive rate respectively under various label rates.

### C4P-A15

**In-Vivo pH Imaging System for Hydrogen Ion Dynamics Observation in the Brain of a Freely-Moving Mouse**

Mai Madokoro{2}, Hiroshi Horiuchi{1}, Tomoko Kobayashi{1}, Tomoko Horio{2}, Yasuyuki Kimura{2}, Hideo Doi{2}, Yong-Joon Choi{2}, Kazuhiro Takahashi{2}, Toshihiko Noda{2}, Junichi Nabekura{1}, Kazuaki Sawada{2}
{1}National Institute for Physiological Sciences, Japan; {2}Toyohashi University of Technology, Japan

By studying ionic changes in the brain of freely-moving animals, we can better understand disease states. We developed a sensor for in-vivo real-time monitoring of spatiotemporal pH in brain of freely-moving mice. The sensor has a pixel size of 5.65 × 4.39 μm2 and a high spatiotemporal resolution (pH resolution 0.016 pH, temporal resolution 62 fps). The range of motion of the mice was secured by reducing the sensor weight and fabricating a reference electrode. We succeeded for the first time in the world in real-time monitoring of spatiotemporal pH changes in awake and unrestrained mice .

### C4P-A16

**Improvement of Stability in Long-Term Motor Decoding Forelimb Movement with a Sequence Imputation of Temporal-Based Spike Patterns**

Yun-Ting Kuo{2}, Shih-Hung Yang{1}, Chin-Yu Chou{2}, Hao-Cheng Chang{2}, Kuan-Yu Chen{2}, You-Yin Chen{2}
{1}National Cheng Kung University, Taiwan; {2}National Yang Ming Chiao Tung University, Taiwan

Instability of neural signals is a vital issue in intracortical brain machine interface (iBMI) systems which caused by missing neuron day by day. This study proposed mean-perturbation to impute missing neural spike train during rat forelimb movement. Our results showed that the proposed mean-perturbation for sequence imputation of missing neural spikes was used to enhance the long-term decoding performance.

## C4P-A17

### Prediction of the Extubation Outcome Through Electrical Impedance Tomography Measurements

Vincent Janiak{2}, Vincent Joussellin{3}, Gwendoline Tallec{1}, Christophe Marsala{2}, Umar Saleem{1}, Martin Dres{3}, Andrea Pinna{2}
{1}BioSerenity, France; {2}LIP6, CNRS, UMR7606, Sorbonne Université, France; {3}Sorbonne Université, URMS 1158 Inserm, France

Extubation failure can occur in 10 to 25% of patients who were successfully separated from their ventilator. In which case, patients need to be re-intubated. To reduce the extubation failure rate, we monitor patients during 48h after extubation using Electrical Impedance Tomography (EIT). In total, we recruited 34 patients from which 8 failed their extubation in the ICU ward. Prediction of extubation success or failure using only non-invasive EIT data show a sensitivity of 0.80 and a specificity of 0.73. The prediction for the 8 extubation failures was accurate for most right after the extubation and achieved 100% accuracy for the measurement set preceding the failure.

## C4P-A18

### Semi-Automatic A-Line Detection and Confidence Scoring in Lung Ultrasound

Oriane Thiery{2}, Garance Martin{2}, Isabelle Bloch{2}, Martin Dres{4}, Umar Saleem{1}, Andrea Pinna{3}
{1}BioSerenity, France; {2}LIP6, CNRS, Sorbonne Université, France; {3}LIP6, CNRS, UMR7606, Sorbonne Université, France; {4}Sorbonne Université, URMS 1158 Inserm, France

Weaning a patient from mechanical ventilation is a critical task in Intensive Care Units, but it can be made safer by using Lung Ultrasound scoring. This scoring is currently done visually by specialists based on Lung Ultrasound artifacts among which are A-lines. Automating this scoring may help standardizing results and saving time for clinicians. In this paper, we propose a method to automatically detect A-lines from a manual delineation of the pleural line, and by using both the intensity profile of the LUS image and morphological operations. A score is then assigned to significant lines and represents the possibility of them being A-lines. The proposed method shows promising results in differentiating A-lines from other elements with an Area Under the Curve of 0.95; furthermore, using a threshold at 0.5 to detect A-lines leads to very good performances with an accuracy of 95% and a F0.5-score of 0.84.

## C4P-A19

### EEGformer: Transformer-Based Epilepsy Detection on Raw EEG Traces for Low-Channel-Count Wearable Continuous Monitoring Devices

Paola Busia{2}, Andrea Cossettini{1}, Thorir Mar Ingolfsson{1}, Simone Benatti{3}, Alessio Burrello{3}, Moritz Scherer{1}, Matteo Antonio Scrugli{2}, Paolo Meloni{2}, Luca Benini{1}
{1}Integrated Systems Laboratory, ETH Zürich, Switzerland; {2}Università degli Studi di Cagliari, Italy; {3}Università di Bologna, Italy

Leveraging the ability of transformers in capturing long-term raw data dependencies in time series, we present in this work EEGformer, a compact transformer model for seizure detection, that can be executed in real-time on tiny MicroController Units and operates on the raw electroencephalography (EEG) signal acquired by the 4 temporal channels. Our proposed model is able to detect 73\\% of the examined seizure events, with an average onset detection latency of 15.2s. The False Positive/hour (FP/h) rate is equal to 0.8 FP/h, although 100\\% specificity is obtained in most tests, with 5/40 outliers that are mostly caused by EEG artifacts.

## C4P-A20

### Multi-Resolution Medical Image Registration with Dynamic Convolution

Zhenyu Zhu, Yu Ji, Ying Wei
Shandong University, China

Recent deep learning medical image registration (DLMIR) methods based on static convolutional neural network (CNN) have achieved advanced registration performance with feature representation and learning ability of CNN. To further improve the registration accuracy, the common practice is to increase the depth or width of the network, which increases the computational overhead. To address this problem, in this paper, we utilize dynamic convolution instead of static convolution to perform the registration task, where Dynamic convolution kernels are formed by the nonlinear aggregation of several parallel and input-dependent convolution kernels. We evaluate the proposed method on a public Magnetic Resonance (MR) brain scan dataset. The results demonstrate that the proposed method outperforms existing methods in terms of registration accuracy without increasing the depth and width.

## C4P-A21

### Estimating Intrinsic Manifold Dimensionality to Classify Task-Related Information in Human and Non-Human Primate Data

Zachary Bretton-Granatoor, Hannah Stealey, Samantha Santacruz, Jarrod Lewis-Peacock
University of Texas at Austin, United States

Feature selection, or dimensionality reduction, has become a standard step in reducing large-scale neural datasets into usable signals for brain-machine interface and neurofeedback decoders. Current techniques in fMRI data reduce the number of voxels (features) by performing statistics on individual voxels or using traditional dimensionality techniques that utilize linear combinations of features. However, these methods often do not account for the cross-correlations found across voxels and do not sufficiently reduce the feature space to support efficient real-time feedback. To overcome these limitations, we propose using factor analysis on fMRI data, a technique that has become increasingly popular for extracting a minimal number of latent features to explain high-dimensional data in non-human primates.

## C4P-A22

### Action Potential Detection Algorithm Adaptable to Individual Nerve and Recording Setup

Romain Raffoul{3}, Javier Chávez Cerda{3}, Elena Acedo Reina{2}, Hugo Smets{3}, Maxime Verstraeten{3}, Louis Vande Perre{3}, Rami Taheri{3}, Pascal Doguet{1}, Jean Delbeke{2}, Riëm El Tahry{2}, Jacques Deviere{3}, Antoine Nonclercq{3}
{1}Synergia Medical SA, Belgium; {2}Université Catholique de Louvain, Belgium; {3}Université Libre de Bruxelles, Belgium

This work presents an automated analysis algorithm to detect action potentials (APs) in a nerve and quantify its activity. The algorithm is based on template matching. The templates are automatically adapted to individual AP shapes that vary depending on the nerve fibers from which the AP originates, and the recording setup used. The algorithm was validated by quantifying vagus nerve activity recorded during in vivo experiments in a rat model. The MATLAB version of the code is available in open access on GitHub.

## C4P-A23

### Binary Compressed Sensing of ECG by Neural Matrix Optimization and Support Oracle

Filippo Martinini{2}, Andriy Enttsel{2}, Alex Marchioni{2}, Mauro Mangia{2}, Riccardo Rovatti{2}, Gianluca Setti{1}
{1}Politecnico di Torino, Italy; {2}Università di Bologna, Italy

Compressed Sensing is a lightweight compression method, it is very effective for ECG signals, permitting the design of simple binary encoders. To further reduce the size of the encoded signal, Deep Neural Networks (DNNs) have been recently successfully proposed, which however still struggle with the training of binary encoders. In our work we propose a strategy to jointly tailor the binary encoder with a DNN based decoder. The proposed method can either automatically find a suitable density of ones in the sensing matrix, or let one fix a predefined value.

## C4P-A24

### Training Binary Layers by Self-Shrinking of Sigmoid Slope: Application to Fast MRI Acquisition

Filippo Martinini{2}, Andriy Enttsel{2}, Alex Marchioni{2}, Mauro Mangia{2}, Fabio Pareschi{1}, Riccardo Rovatti{2}, Gianluca Setti{1}
{1}Politecnico di Torino, Italy; {2}Università di Bologna, Italy

Deep Neural Networks (DNN) have become popular and widespread because they combine computational power and flexibility, but they may present critical hyper-parameters that need to be tuned before the model can be trained. Recently, the use of trainable binary masks in the field of Magnetic Resonance Imaging (MRI) acquisition brought new state-of-the-art results, but with the disadvantage of introducing a bulky hyper-parameter, which tuning is usually time-consuming. We present a novel callback-based method that is applied during training and turns the tuning problem into a triviality, also bringing non-negligible performance improvements. We test our method on the fastMRI dataset.

## C4P-A25

### Performance Assessment of Automatic Sleep Stage Classification Using Only Partial PSG Sensors

Iksoo Choi, Wonyong Sung
Seoul National University, Korea

a simple, readily accessible sleep stage classification technology is strikingly at need. conventional sleep stage classification relies on electroencephalogram, electrooculogram, and electromyogramsensors. however, such sensors are costly and exceedingly inconvenient to utilize. we studied how much loss in accuracy was incurred when eliminating specific signals in polysomnography. the performance with the transformer was compared with those of fully connected deep neural network and recurrent neural network models. we aim to eliminate electroencephalogram sensors as they are the most cumbersome. This experiment demonstrates the possibility and limitations of simple sleep stage classification that does not rely on electroencephalogram signals

### C4P-A26

#### A Sub-μW Intracranial EEG Integrated Preamplifier

Carolina Cabrera, Julián Oreggioni
Universidad de la República, Uruguay

This work presents an amplifier targeting the acquisition of intracranial electroencephalography signals with low power consumption, low voltage supply, low noise, and high common-mode rejection ratio (CMRR). A prototype was designed in a 180 nm FD-SOI CMOS technology and characterized by simulations. It presents an input noise of 3.2 uVrms, a current consumption of 0.5 uA, and it operates from a 1.8 V voltage supply, which represents a power consumption of 0.9 uW. The bandwidth ranges from 0.1 Hz to 1 kHz, the gain is 40 dB, the CMRR is greater than 79.4 dB, and the Noise Efficiency Factor (NEF) is 2.7.

### C4P-A27

#### Toward Writing Skill Acquisition Support System for People with Dysgraphia: Evaluation of Alphabet Writing Dexterity in Healthy Early Twenties

Tomohiko Igasaki{1}, Naoki Itasaka{1}, Kazuharu Hashitsume{2}
{1}Kumamoto University, Japan; {2}Shimane University, Japan

As a pilot study for a writing skill acquisition support system for people with dysgraphia, we proposed a set of features to be extracted to evaluate writing dexterity in the English alphabet. For healthy early twenties, we tested whether we could find differences in writing dexterity between dominant/non-dominant hands. As a result, we observed that subjects whose dominant hand had remained unchanged since childhood showed significant writing dexterity in their dominant hand. On the other hand, for subjects whose dominant hand had been corrected in childhood, there was no difference between dominant and non-dominant hands.

### C4P-A28

#### Efficient Ultrasound Image Enhancement Using Lightweight CNNs

Farid Anjidani, Daler Rakhmatov
University of Victoria, Canada

Given the widespread use of plane-wave ultrasound imaging in biomedical diagnostics applications, it is important to have a highly efficient mechanism for image reconstruction and enhancement. This work demonstrates how one can enhance 2D ultrasound envelope data (produced by a fast Fourier-domain beamforming method) using lightweight convolutional neural networks (CNNs). These CNNs are based on a well-known and highly efficient network targeting single-image superresolution tasks. Using three experimental datasets, we show that our approach leads to better-quality ultrasound images compared to conventional delay-and-sum beamforming.

## C4P-A29

### Cuffless Blood Pressure Estimation from Finger PPG and ECG Signals Verified by the AAMI Protocol

Yu-Chuan Li{1}, Jia-Wei Guo{1}, Jia-Yu Yang{1}, Pei-Yun Tsai{1}, Hung-Ju Lin{2}, Tzung-Dau Wang{2}
{1}National Central University, Taiwan; {2}National Taiwan University Hospital, Taiwan

Cuffless blood pressure (BP) estimation attracts much attention for its convenience and capability of long-term health monitoring. The BP estimation derived from finger photoplethysmography (PPG) and electrocardiographic (ECG) signals and validated by the AAMI protocol is presented in this paper. PPG morphological features, pulse decomposition features, and demographic features were extracted. Combined feature strategy was used for feature compensation and normalization. Interpolation-based synthetic oversampling was adopted to improve the balance of training sample distribution. Hierarchical regression is proposed to refine BP estimation by ensemble average and range shrinkage. From the experiments, the mean absolute errors (MAEs) of systolic BP and diastolic BP were 8.02 mmHg and 5.96 mmHg, respectively, with the calibration-free and subject-split criterion. The study first presents the cuffless BP estimation results from PPG and ECG under the AAMI validation protocol.

## C4P-A30

### A Multimode Markerless Gait Motion Analysis System Based on Lightweight Pose Estimation Networks

Weining Li{4}, Shimeng Wang{4}, Jiaxin Lei{4}, Xuecheng Wang{4}, Liu Wang{1}, Kuntao Chen{4}, Tieyuan Zhang{3}, Yanjun Guan{3}, Zhe Zhao{2}, Lan Yin{4}, Milin Zhang{4}
{1}Beihang University, China; {2}Being Tsinghua Changgung Hospital, Tsinghua University, China; {3}Institute of Orthopedics, Chinese PLA General Hospital, China; {4}Tsinghua University, China

Gait motion analysis for animal models plays an important role in experimental medical science to better study neurological disorders. To perform a quantitative assessment of neural diseases, this paper proposed a multi-mode markerless gait motion analysis with synchronous acquisition of neural signals and dual-view gait video recording. To achieve the goal of real-time online data analysis and on-device implement, the design of lightweight pose estimation networks was presented with the output of nine anatomical features related to gait motion patterns. Fusion analysis method for collected multimode information of gait parameters and EMG/ENG signals was introduced. The proposed gait motion analysis system workflow was verified by experiments upon two groups of rats including normal rats and rats of nerve injury.

### C4P-A31

#### Resource Efficient Gas Classifier Based on 1.5-Bit Quantization of Sensing Channel Difference for Electronic Nose

Nan Wu{2}, Ning Pu{2}, Xinpeng Liu{2}, Siqi Zhang{2}, Hanjun Jiang{2}, Hong Chen{2}, Wen Jia{1}, Zhihua Wang{2}
{1}Research Institute of Tsinghua University in Shenzhen, China; {2}Tsinghua University, China

A resource efficient neural network based gas classifier using the 1.5-bit quantization of sensing channel difference as the feature extraction is proposed in this paper, which is designated for unattended electronic noses for long-term surveillance. The feature rate of proposed method is as low as 48 bits per second (bps), significantly reducing the computational complexity of the classifier compared with state-of-the-art works. Based on the simple and identifiable features, a slight fully connected neural network (SFCN) is proposed as a gas classifier. The parameters and floating-point operations per second (FLOPs) are reduced 41X and 624X than state-of-the-art gas classifiers, respectively. A self-recorded gas dataset with 9 types of gases and 64413 samples is used to validate the performance of the proposed feature extraction method and classifier. Simulation results show that this method can classify 9 different gases with an accuracy of 97.2%, which is comparable to the state-of-the-art works. Meanwhile, the parameters and the computation complexity are greatly reduced, which makes it suitable for long-term electronic noses with computation resource constraint.

### C4P-A32

#### sEMG Neural Spikes Reconstruction for Gesture Recognition on a Low-Power Multicore Processor

Mattia Orlandi{3}, Marcello Zanghieri{3}, Victor Javier Kartsch Morinigo{3}, Francesco Conti{3}, Davide Schiavone{1}, Luca Benini{2}, Simone Benatti{4}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Integrated Systems Laboratory, ETH Zürich, Switzerland; {3}Università di Bologna, Italy; {4}University of Modena and Reggio Emilia, Italy

Automated recognition of hand movements is a very active research domain for developing Human-Machine Interfaces. The surface electromyographic (sEMG) signal is a versatile data source for intuitive control of machines, robots, or prostheses based on gesture classification, but the mapping is non-trivial. Algorithms for Blind Source Separation (BSS) can retrieve the sEMG\'s Motor Unit signals, which are the originary format of physiological information, and can be forwarded to a Machine Learning classifier. However, implementation of BSS algorithms for execution on resource-constrained hardware is still in its infancy. In this work, we propose a parallelized version of the FastICA BSS method ported on the Mr.Wolf microcontroller based on PULP, achieving latency <50ms and energy consumption <1mJ. In an end-to-end approach, we fed the reconstructed neural signals to an SVM and an MLP classifier, obtaining accuracy >92% on 5 classes (rest and 4 gestures). These results prove that our setup is suitable for running in real-time on the limited resources of embedded hardware, while guaranteeing the same accuracy as black-box state-of-the-art solutions lacking any physiological insight.

## C4P-A33

### Design of a Wireless Distributed Real-Time Muscle Fatigue Detection System

Yahao Song{3}, Handi Yin{3}, Xuecheng Wang{3}, Chao Sun{1}, Yuan Ma{3}, Yuwei Zhang{1}, Xiong Zhong{1}, Zhe Zhao{2}, Milin Zhang{3}
{1}Beijing Ningju Technology Co., Ltd, China; {2}Being Tsinghua Changgung Hospital, Tsinghua University, China; {3}Tsinghua University, China

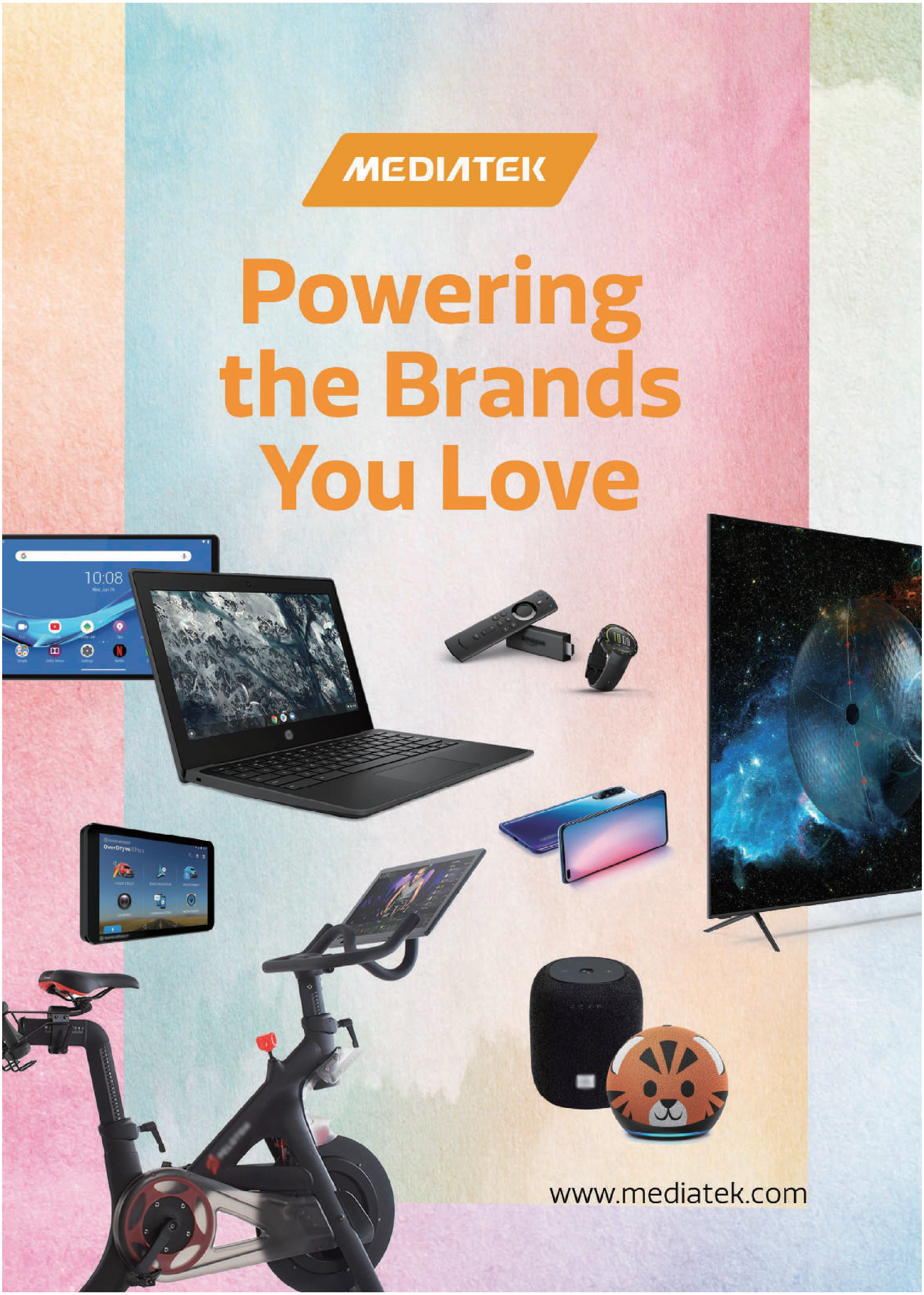
This paper proposed a muscle fatigue detection system based on a distributed low-power neural signal acquisition system. The central plant wirelessly collected EMG signals from multiple locations. The wireless communication features low effect to the movement of the subject. A fatigue evaluation algorithm based on time-frequency feature analysis was proposed. A muscle fatigue database was built including 3.4 hours recording on 10 subjects.

## C4P-A34

### Design of CMOS Analog Front-End Electroencephalography (EEG) Amplifier with ±1-V Common-Mode and ±10-mV Differential-Mode Artifact Removal

Chi Wei Huang, Jian Jun Wang, Chung Chih Hung, Chung Yu Wu
National Yang Ming Chiao Tung University, Taiwan

This paper presents a 0.18μm CMOS analog front-end amplifier (AFEA) applied to EEG recording. A capacitively-coupled chopper instrumentation amplifier (CCCIA) is used in the AFEA to suppress flicker noise. To avoid the stimulation artifact from saturating the AFEA, the artifact cancellation loop is employed and enables the AFEA fast recover to normal operation after stimulation. The input referred noise within the bandwidth is 0.839μVrms. The measured THD is 0.155% under no artifact and 4.5% with 150mV DC offset, ±1V common-mode artifact (CMA), and ±10mV differential-mode artifact (DMA) under 2 kHz and 2.01 kHz of temporally interfering stimulation (TIS).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# Conference Information

## Conference Date

October 13-15, 2022

## Conference Venue

CHANG YUNG-FA FOUNDATION International Convention Center (CYFF)

TEL: +886-2 2351-6699 #6199

Address: No.11, Zhongshan S. Rd., Taipei City 10048, Taiwan (R.O.C.)

(台北市中正區中山南路 11 號)

## Registration

The Registration Reception will open at the 8F Lobby as follows:

| | |
|---|---|
| Thursday, October 13 | 08:00-18:00 |
| Friday, October 14 | 07:30-16:30 |
| Saturday, October 15 | 07:30-16:30 |

## Conference Badge

Participants are requested to wear the Conference badges for all the lectures, social events and the exhibition. All staff will have the right to refuse entry if without a proper name badge.

## Language

The official language of the Conference is English, which will be used in all presentations and printed materials.

## Coffee Break & Poster Sessions

The poster session and light refreshments will take place at 810B, 8F.

## Lunch

Lunch will be served at 810A.

## Proceedings Download

There will be no hardcopy and USB/CD/DVD publication for the 2022 BioCAS. Please download Proceedings from the virtual platform with your registration account email and password

## Social Programs

*Welcome Reception & Live Demonstrations*

- Date/Time: Oct 13 19:30~21:00
- Venue: 810B, 8F, CYFF

*Banquet*

- Date/Time: Oct 14 18:30~20:30
- Venue: Dragon Hall, 3F, The Howard Plaza Hotel Taipei
- Shuttle Bus:
  18:00 **CFYY** to **Howard Plaza Hotel Taipei**
  20:30 **Howard Plaza Hotel Taipei** to **CFYY** and **Taipei Main Station**

*Farewell Party*

- Date/Time: Oct 14 18:30~20:30
- Venue: Rosa Room, 2F, Taipei Garden Hotel
- Shuttle Bus:
  18:00 **CFYY** to **Taipei Garden Hotel**
  20:30 **Taipei Garden Hotel** to **CFYY** and **Taipei Main Station**

## Wi-fi Access

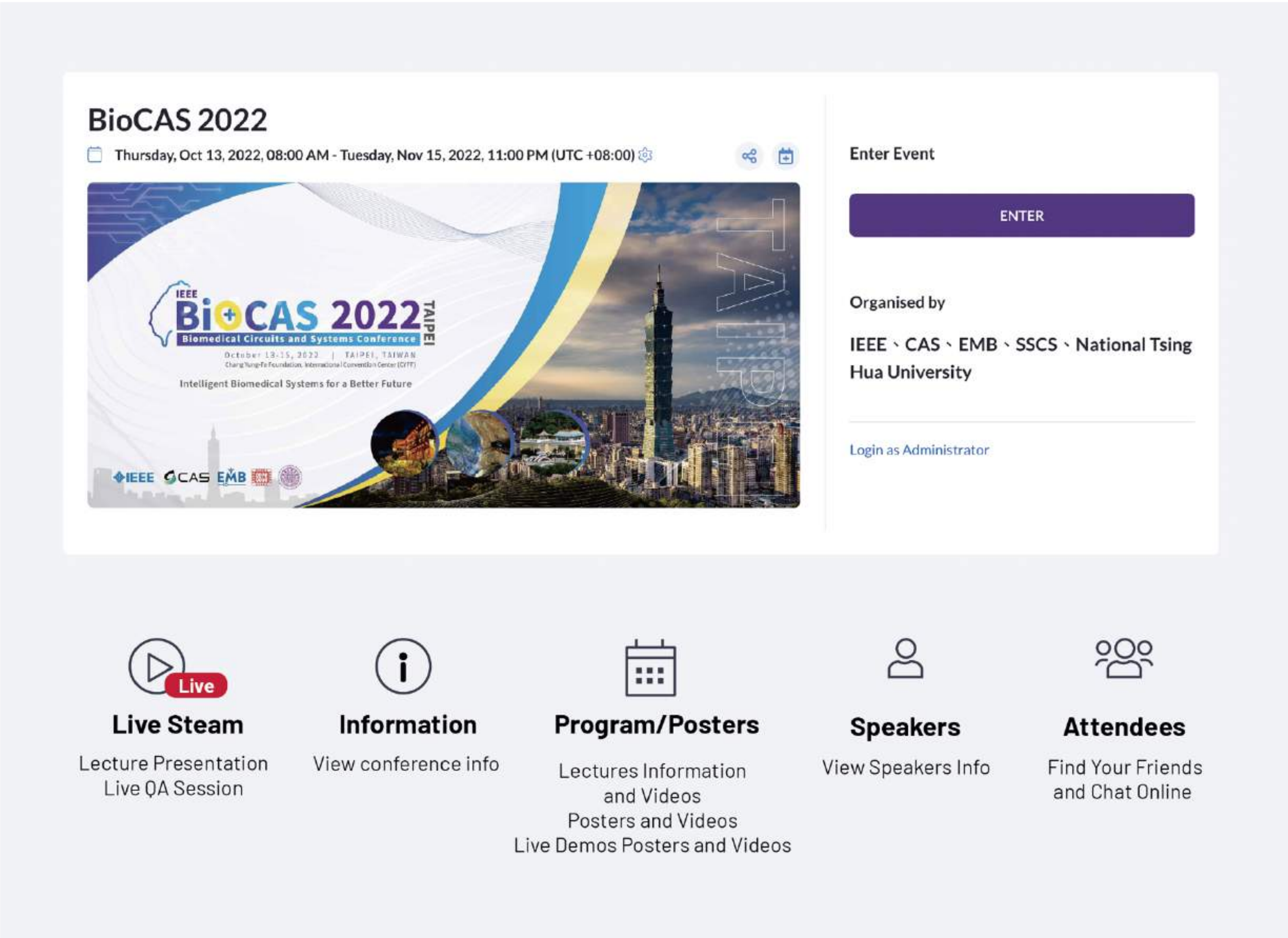
Wi-Fi Network: Chang Yung-Fa foundation

## Conference Virtual Platform

Login Period: October 13, 00:00am (GMT+8)~November 15 24:00 (GMT+8))

Website: https://2022.ieee-biocas.org/

Account: Please login with your registered account email, you can setup your own password, personal photo...etc. at the platform.



# Floor Plan


Poster No
A19~A26
810B
Poster No
A27~A34
Coffee Break
Coffee Break / Poster
Welcome Reception / Live Demo
Neurotech
VIP
Secretariat
Preview Room
Poster No. A01~A18
Live Streaming
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# Acknowledgements

The BioCAS 2022 organizing committee extends its warmest thanks to the following organizations and sponsors for their generous contributions and efforts.

## Organizational Sponsors

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# Author Index

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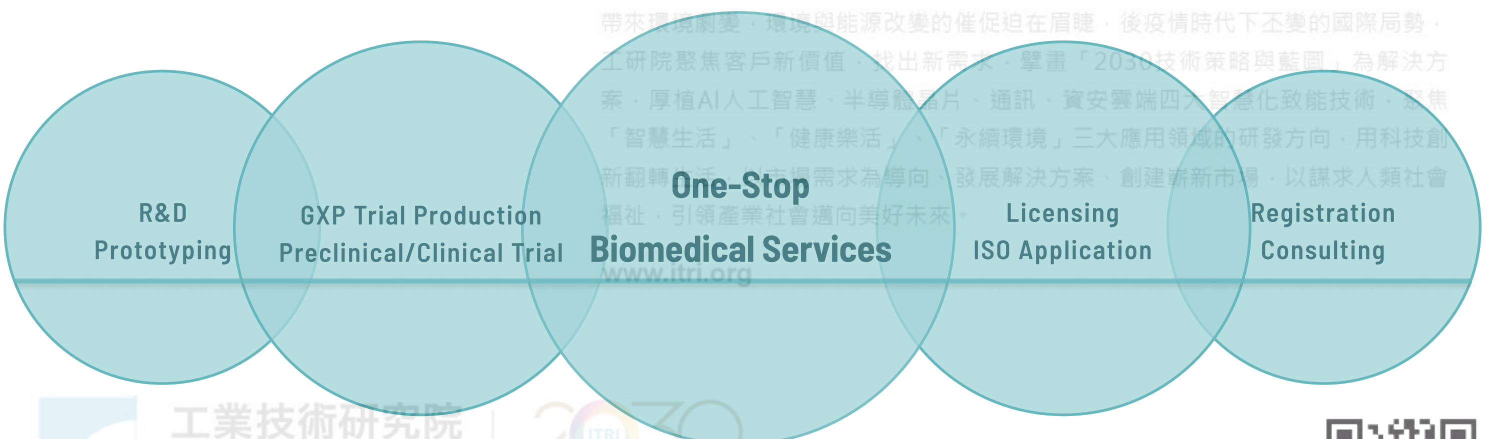
## X


## Biomedical Technology and Device Research Laboratories

ITRI is committed to driving the development of various industries with its outstanding technology and research abilities in hopes to create economic values and promote social well-being. In addition to playing a role of researcher and developer in the fields of medicine as well as medical devices, it has also established a complete structure of CRO (Contract Research Organizations) and CDMO (Contract Development & Manufacturing Organization) services.

The one-stop biomedical services platform of ITRI provides assistance in a wide range of scopes, including research and development, prototyping, GXP trial production, pre-clinical / clinical trial, post-marketing consultation, etc. This mechanism makes it possible for domestic manufacturers to lower their initial cost of investment, and accelerate their research and development.

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