2025 Eighteenth International Conference on Sensing Technology (ICST2025)

Utsunomiya, Tochigi, Japan | December 1-3, 2025

Programme & Abstract Book

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CONTENTS

WELCOME MESSAGE

We would like to take this great opportunity to welcome you all to the 2025 Eighteenth International Conference on Sensing Technology, ICST2025, held from December 1 – 3, 2025. The conference is being jointly organized by the Utsunomiya University, Japan and Macquarie University, Australia. The conference is held at the Tochigi Prefectural Cultural Center (Tochigi-ken Sogo Bunka Center), a multi-purpose cultural facility located in Utsunomiya City, Tochigi Prefecture of Japan. This is the 18th conference of the series. In terms of the history of the ICST, the first two (2005, 2007) were held at Massey University, New Zealand, Palmerston North campus, the third (2008) one was held at National Cheng-Kung University, Tainan, Taiwan, the fourth (2010) one was held at the University of Salento, Lecce, Italy. Then the fifth (2011) one was held at Massey University, New Zealand, Palmerston North campus and the sixth (2012) was held at Kolkata, India. The seventh (2013) one was held at the Wellington campus of the Massey University, New Zealand and the eighth (2014) one was held at Liverpool John Moore University, Liverpool, United Kingdom. The Ninth one was held in Auckland (2015) and the Tenth one was held at Nanjing, China (2016). Then we have the ICST2017 held in Sydney, Australia and the ICST2018 was organized by the University of Limerick, Limerick, Ireland during December 2018. Due to pandemic we did not have any conference during 2020 and 2021. The fourteenth one ICST2022 was held on line and organized by Indian Institute of Technology Madras, India during January 2022. The fifteenth one was held at Macquarie University, Sydney in 2022, the 16th one was held in Hyderabad, India during December 2023. The last one, the 17th ICST was held at Macquarie University, Sydney during December 9 to 11, 2025. This conference will have 76 papers presented over three days. We would like to congratulate all the authors and share this happiness with you all.

The applications of Sensing Technology ranging from medical diagnostic to industrial manufacturing and to defense, national security, prevention of natural disaster and terrorism. The proper detection of events by high performance sensors and appropriate analysis of sensor signals can lead to early warning of phenomena like the bridge collapse at Mississippi river and many other countries and help to prevent deaths from these types of catastrophic accidents. There is a need for interaction between researchers across technologically advanced and developing countries working on design, fabrication and

development of different sensors. We sincerely hope ICST2025 provides a forum for that.

On behalf of the organizer we would like to extend our sincere thanks to many organizations and individuals. Firstly we would like to thank all the authors as they are the key people for any conference to succeed. The Technical programme committee has done a tremendous and wonderful job. We are very much indebted to everybody in the Technical Programme committee for accepting the invitation and for lending their help, support, time and effort to make this conference a great success. Our special thanks to our keynote speakers Prof. Homei Miyashita of Meiji University, Japan, Prof. Yoko Yamanishi of Kyushu University, Japan and Prof. Olga Korostynska of Oslo Metropolitan University, Norway for their time and support.

The conference is being organized by the School of Engineering, Utsunomiya University, Japan. We thank the Semiconductor Portal Inc for organizing all conference related services.

We do sincerely belief that the conference will provide a platform for discussion on the advancement of technical and scientific issues of different sensing technological problems and interaction among the participants will be stimulating, productive and encouraging.

We wish you all a pleasant stay during the conference at Utsunomiya and enjoy your time while you are in Japan.

T. Azuma, S. C. Mukhopadhyay, K. P. Jayasundera, S. Ikezawa,
K. Mitsubayashi, O. Postolache, N. K. Suryadevara

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KEYNOTE SPEAKER

From Taste Sensing to Food Futures: Media Technologies for the 22nd Century

Professor Homei Miyashita

Abstract:

Recent advances in technologies now allow not only the measurement but also the reproduction of taste sensations. Building on this, the emerging fields of taste media, olfactory media, and nutritional media go beyond traditional food engineering: enabling flavors to be shared remotely, scents to be replayed in immersive dining, and nutrition to be digitally tailored to individual needs.
Looking ahead, these technologies make it possible to re-create rare flavors, design foods that overcome allergies, and generate meals optimized for health and pleasure. With the aid of generative AI, flavor creation becomes a collaboration between human imagination and machine creativity, opening new possibilities far beyond conventional food production.
This keynote will explore not only the frontiers of sensing and reproduction, but also the visions of food in the 22nd century—a future in which eating becomes customizable, shareable, and playful. I will share these ideas through an engaging talk enriched with videos and demonstrations, inviting the audience to experience the joy and imagination behind the science of food

***Author's Short Biography*:**

Homei Miyashita, Ph.D. is a Professor, Department Chair of Frontier Media Science, School of Interdisciplinary Mathematical Sciences, Meiji University.

In 2020, his project "Taste the TV (TTTV)," which embodies the concepts of "taste media," "tele-taste," and "tele-eat" that he had been promoting, was selected for the INNO-vation program of the Ministry of Internal Affairs and Communications. In collaboration with NTT DOCOMO and H2L, he developed the "FEEL TECH" taste sharing technology integrated with the human augmentation platform.

In collaboration with Kirin Holdings, he developed the "Electric Salt" spoon, which use electricity to enhance the saltiness of low-salt foods. This product is now available for purchase. The "Electric Salt" products also won two awards at the 2025 CES Innovation Awards® in the Digital Health and Accessibility & AgeTech categories.

In 2025, he began a new collaboration with the Asahi Group Japan, combining their expertise in flavor design and materials with his lab's research on taste media. This project resulted in technologies that reproduce flavor and texture for personalized nutrition, as well as aroma-blending systems that create diverse beverage experiences. These efforts aim to overcome dietary constraints, provide optimized eating experiences, and pioneer a world where health, pleasure, and diverse tastes can coexist.

In 2023, he received the Ig Nobel Prize (Nutrition).

KEYNOTE SPEAKER

Emergent Functions of Electrically Induced Bubbles in Micro/Nano-Scale Fluid Engineering for Biomedical Applications

Professor Yoko Yamanishi

Abstract:

Cell poration technologies provide powerful tools not only for exploring the behavior of biological molecules but also for advancing genetic manipulation. However, delivering large molecules that carry extensive genomic information remains a significant challenge.

In this presentation, I introduce a novel electromechanical poration technique utilizing a core–shell microbubble generator. This device features a fine microelectrode encased in a dielectric material, with a microcavity at its tip that concentrates the electric field upon pulse application. This configuration enables the generation of microbubbles that stimulate cells electromechanically.

Remarkably, this method allows for the transfection of extremely large molecules—on the order of thousands of kilodaltons—into cell types traditionally considered difficult to manipulate, such as osteoblasts and Chlamydomonas. Furthermore, we discovered that adjusting the viscosity of the cell suspension significantly improves transfection efficiency, likely due to cytoskeletal remodeling at the membrane level.

The versatility of this approach across diverse cell types opens exciting possibilities for emerging applications in gene engineering. I will discuss the underlying mechanism of electrically induced bubble formation and highlight its broad potential in electromechanical poration.

Author's Short Biography:

Professor **Yoko Yamanishi** earned her Ph.D. from Imperial College London in 2003. She has held academic positions at Tohoku University, Nagoya University, and Shibaura Institute of Technology, focusing on BioMEMS, microbubble injectors, and biomedical fluid engineering. Since 2016, she has been a Professor (Distinguished Prof. since 2024) at Kyushu University, leading research on bubble-based gene delivery. She currently serves as Principal Investigator for CREST JST and Program Manager for the Moonshot R&D initiative.

KEYNOTE SPEAKER

Intelligent Sensors for Measuring Mechanisms and Effects of Art Therapy

Professor Olga Korostynska

Abstract:

Art therapy is a psychosocial health intervention that promotes emotional and physical well-being. It is used to manage various disorders, including somatic or psychosomatic pain and could offer cost-effective pain management without the side effects that medications often have. Integrating art therapy into public healthcare services can decrease the financial burden on the system and make it more sustainable.
But how does it work? Is it for everyone? How can mechanisms and effects of art therapy be objectively measured? This talk will focus on intelligent sensors that can be used to answer these questions. This will help to understand the extent to which non-pharmacological interventions, such as art therapy, can alleviate pain. Ultimately, the findings may provide valuable justification for the long-term use of such interventions in pain regulation and their correlation with physiological and neural responses.

Author's Short Biography:

Olga Korostynska is a Professor in Biomedical Engineering at Oslo Metropolitan University (OsloMet), Oslo, Norway. She has a B.Eng and M.Sc in Biomedical Engineering from the National Technical University of Ukraine (KPI), PhD in Electronics and Computer Engineering and LLB from the University of Limerick, Ireland. She was doing research on sensors and lecturing in six universities and four countries: Norway (OsloMet and NMBU), England (LJMU), Ireland (DIT and UL) and Ukraine (NTUU). She has been part of various research projects funded by EU FP7 and Horizon, MSCA, IRCSET, Enterprise Ireland, Cancer Research UK, Daiwa foundation and Norwegian Research Council. Her research interests include sensors for biomedical applications, smart tools and electromagnetic wave sensors, including for real-time water quality monitoring. Prof. Korostynska has co-authored 2 books, 15 book chapters, 5 patents and over 300 scientific papers in peer-reviewed journals and conference proceedings.

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SPECIAL TALK

Next Generation of Smart Devices, IoT and Drones

Professor Dr. Subhas Mukhopadhyay

Abstract:

The advancement of sensing technologies, embedded systems, wireless communication technologies, nano-materials, miniaturization, vision sensing and processing speed makes it possible to develop smart mechatronics and machine systems. This seminar will discuss recent research and developmental activities on different sensors and sensing system, Mechatronics, including robotics and drones, IoT along with machine visions at Macquarie University as applicable to medical science, biology and environmental monitoring.

Author's Short Biography:

Subhas holds a B.E.E. (gold medalist), M.E.E., Ph.D. (India) and Doctor of Engineering (Japan). He has over 35 years of teaching, industrial and research experience. Currently he is working as a Professor of Mechanical/Electronics Engineering, Macquarie University, Australia and is the Discipline Leader of the Mechatronics Engineering Degree Programme. His fields of interest include Smart Sensors and sensing technology, instrumentation techniques, wireless sensors and network (WSN), Internet of Things (IoT), Robotics, Mechatronics and Drones etc. He has supervised over 60 postgraduate students and over 180 Honours students. He has examined over 80 postgraduate theses.

He has been co-inventor of 14 patents and published over 450 papers in different international journals and conference proceedings, written ten books and sixty two book chapters and edited twenty conference proceedings. He has also edited forty five books with Springer-Verlag and thirty five journal special issues. He has organized over 20 international conferences as either General Chairs/co-chairs or Technical Programme Chair. He has delivered 458 presentations including keynote, invited, tutorial and special lectures. As per

Scholargoogle, his total citation is 28782 and h-index is 87.
He is a Fellow of IEEE (USA), a Fellow of IET (UK), a Fellow of IETE (India). He is a Topical Editor of IEEE Sensors journal, an associate editor of IEEE Transactions on Instrumentation and Measurements and IEEE Reviews in Biomedical Engineering (RBME). He is EiC of the International Journal on Smart Sensing and Intelligent Systems. He was a Distinguished Lecturer of the IEEE Sensors Council from 2017 to 2022. He chairs the IEEE Instrumentation and Measurement Society NSW chapter.

ICST 2025 PROGRAMME AT A GLANCE

SUNDAY, 30th NOVEMBER

Time	Event
16:00-18:00	Registration and Welcome Reception [room 3]

MONDAY, 1ST DECEMBER

Time	Event	
8:30-9:00	Registration [room 3]	
9:00-9:30	S0: ICST 2025 Opening Ceremony [room 1]	
9:30-10:00	Morning Tea [room 3]	
10:00-11:30	S1A: Bio-sensors [room 2]	S1B: Optical Sensors [room 1]
11:30-11:45	Break Time	
11:45-13:00	S2A: Sensors for Environmental Monitoring [room 2]	S2B: Magnetic, Inductive and Capacitive Sensors [room 1]
13:00-13:30	Lunch [room 3]	
13:30-14:15	S3: Keynote #1 [room 1]	
14:15-15:00	S3: Special talk [room 1]	
15:00-15:30	Afternoon Tea [room 3]	
15:30-17:20	S4A: Bio-med Applications and Medical Devices [room 2]	S4B: WSN and IoT [room 1]
17:30-20:00	Reception 1 [Utsunomiya Downtown]	

TUESDAY, 2ND DECEMBER

Time	Event	
8:30-9:00	Late Registration [room3]	
9:00-10:30	S5A: Chemical and Gas Sensors [room 1]	S5B: Sensors for Robots and Vehicle Monitoring [room 2]
10:30-11:00	Morning Tea [room 3]	
11:00-12:30	S6: Keynote #2 Keynote #3 [room 1]	
12:30-13:30	Lunch [room 3]	
13:30-15:00	S7A: Acoustic Sensors [room 1]	S7B: Sensors Applications in Challenging Environment [room 2]
15:00-15:30	Afternoon Tea [room 3]	
15:30-17:00	S8A: Image Sensors [room 1]	S8B: Sensors for Robotics and Autonomous Vehicles [room 2]
17:30-19:00	Reception 2 [Futaarayama Jinja Shrine]	
19:30-22:00	Banquet Dinner at Utsunomiya Tobu Hotel Grande	

WEDNESDAY, 3RD DECEMBER

Time	Event	
9:00-10:30	S9B: Sensors Data Processing with ML and AI [room 1]	S9A: Sensors for Novel Applications [room 2]
10:30-11:00	Morning Tea [room 3]	
11:00-12:30	S10B: Sensors Signal Processing [room 1]	S10A: Mechanical MEMS and Vibration Sensors [room 2]
12:30-13:30	Lunch Time [room 3]	
13:30-15:00	Closing Ceremony and Award [room 1]	

VENUE

ICST 2025 will be held at:

Tochigi Prefectural Culture Center(Gallery Building 3rd Floor)

Address: 1-8 Honmachi, Utsunomiya 320-8530, Tochigi, Japan

RECEPTION 1

Evening tours in Utsunomiya Downtown:

Date: Monday, December 1st, 2025
Time: 18:00 - 21:00

3 courses are offered to participants of ICST2025 by Utsunomiya city center.

1. **The Art & Culture of Gyoza – Tour with Hands-On Culinary Workshop**

Begin your evening on Utsunomiya's famous Gyoza Street, where you'll discover why this city is celebrated as Japan's "Gyoza Capital." Together with a local gyoza master, you'll roll up your sleeves to learn the delicate art of crafting these perfect dumplings. The highlight of the night is sitting down to savor the flavors of your very own handmade gyoza. A memorable experience that blends culinary fun with cultural discovery. This hands-on workshop is an excellent and engaging activity, perfect for foodies, families, couples, and colleagues seeking a shared cultural experience.

2. The Flavors of Utsunomiya – Gyoza & Izakaya Hopping Tour

Begin your evening by discovering why Utsunomiya is known as Japan's "Gyoza Capital." After a brief look at the history and culture of this beloved dish, you'll visit three izakayas and gyoza shops on a guided journey through the city's lively nightlife. Taste different styles of gyoza, enjoy popular Japanese dishes, and savor drinks in authentic local settings. A memorable experience that blends food, culture, and the vibrant atmosphere of Utsunomiya after dark.

3. The Spirit of Utsunomiya – Sake Discovery & Tasting Tour

Begin your evening by exploring why Utsunomiya is celebrated as a hidden gem for sake. The city is home to three renowned breweries, including one of only two in Japan to have won the International Wine Challenge (IWC) Champion title twice, and another that has earned an IWC Trophy. Thanks to pure water flowing from the Nikko mountains, Utsunomiya's sake is known for its exceptional quality.

RECEPTION 2

Special Pre-Banquet Event in Futaarayama jinja shine:

Date: Tuesday, December 2nd, 2025
Time: 17:30 - 19:00

This free event is offered to all participants of ICST2025 by Utsunomiya city before the banquet. A traditional Japanese art is performed in Futaarayama Jinja shrine.

BANQUET

Utsunomiya Tobu Hotel Grande

Address: 5-12 Honmachi, Utsunomiya 320-0033, Tochigi, Japan

TECHNICAL PROGRAMME

MONDAY, DECEMBER 1st

9:00AM to 9:30AM S0: ICST 2025 OPENING CEREMONY

Chairs: Takehito Azuma (Utsunomiya University, Japan),

Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

10:00AM to 11:30AM S1A: BIOSENSORS

Room: room2

Chair: Krishanthi Jayasundera (University Technology Sydney, Australia)

10:00 An Ultrasensitive Fluorescent Biosensor for Acetaldehyde by an Enzymatic Recycling Reaction

Yi Jiang, Zhang Geng, Yuki Maeno, Kenta Ichikawa and Kenta Iitani (Institute of Science Tokyo, Japan); Koji Toma (Shibaura Institute of Technology, Japan); Takahiro Arakawa (Tokyo University of Technology, Japan); Yasunari Miyazaki and Kohji Mitsubayashi (Institute of Science Tokyo, Japan)

Accurate detection of transcutaneous emitted acetaldehyde (AcH), a metabolic byproduct of ethanol (EtOH), is essential for monitoring an individual's alcohol metabolism. However, the extremely low concentrations of AcH in transcutaneous gas pose significant challenges for real-time monitoring. To address this issue, here we develop a highly sensitive fluorometric biosensor based on an enzyme recycling reaction of alcohol dehydrogenase (ADH) and alcohol oxidase (AOD). The core principle of the system is based on the ADH-catalyzed reduction of AcH to EtOH. This process is accompanied by the oxidation of reduced nicotinamide adenine dinucleotide (NADH) and a corresponding decrease in its fluorescence signal (excitation at 340 nm, emission at 490 nm). The resulting EtOH is then oxidized back to AcH

by AOD, enabling a cyclic reaction that increases NADH consumption triggered by AcH. In the experiment, key sensor parameters such as buffer pH, NADH concentration, and the attachment order of enzyme-immobilized membranes were optimized. Experimental results showed that the AcH biosensor incorporating the ADH-AOD recycling system exhibited significantly amplified fluorescence change. Compared to sensors utilizing only the ADH-catalyzed reaction, it showed a 10.3-fold and 4.4-fold increase when applying AcH concentrations of 10 and 100 nM, respectively. These findings highlight the significant potential of enzyme recycling strategies in sensing AcH in transcutaneous gas.

10:18 Biofluorometric Imaging of Acetone Vapor Using Secondary Alcohol Dehydrogenase Immobilized on Laser Cutting Polytetrafluoroethylene Meshe

Jihu Lim, Naoki Mizukoshi, Kenta Ichikawa and Kenta Iitani (Institute of Science Tokyo, Japan); Koji Toma (Shibaura Institute of Technology, Japan); Takahiro Arakawa (Tokyo University of Technology, Japan); Kohji Mitsubayashi (Institute of Science Tokyo, Japan)

Lipid metabolism can be monitored by measuring acetone in human-derived gaseous samples. Additionally, imaging the spatial and temporal changes in acetone vapor concentration would be useful for identifying optimal measurement sites in transcutaneous vapor. Here, we developed an acetone vapor imaging system based on secondary alcohol dehydrogenase (S-ADH) by measuring the decrease in fluorescence intensity of reduced nicotinamide adenine dinucleotide (NADH), which is consumed during the reduction of acetone. First, laser-cutting conditions of hydrophilic polytetrafluoroethylene (H-PTFE) membrane were optimized to produce H-PTFE meshes used as substrate material for S-ADH immobilization. Then, the effects of membrane thickness and pore size on NADH fluorescence stability were evaluated. Next, we optimized the immobilization amount of S-ADH within a honeycomb-patterned H-PTFE mesh using the biocompatible polymer PMEH. As a result, acetone vapor was successfully imaged with an immobilized amount of 0.5 units/cm2. In

the future, we aim to apply this system to measure transcutaneous acetone vapor emission with further characterization.

10:36 Development of a Reference Electrode Integrated Ir/IrOx Thin Film pH Sensor for microRNA Detection

Kazuya Suzuki (Tokyo University of Technology, Japan); Miyuki Tabata (Tokyo University of Agriculture and Technology, Japan); Yuji Miyahara (Tokyo Medical and Dental University, Japan); Takahiro Arakawa (Tokyo University of Technology, Japan)

Liquid biopsy is a minimally invasive diagnostic method that detects disease markers in body fluids, offering advantages over traditional biopsy such as faster testing and reduced patient burden. Among potential biomarkers, microRNA (miRNA) is promising due to its stability in blood and disease-specific expression. In this study, we developed a reference electrode integrated Ir/IrOx thin film pH sensor to detect miRNA using hydrogen ions released during nucleic acid amplification. Ir/IrOx films were fabricated via reactive sputtering, and the sensor formed under Ar: O_2=0:100 showed a pH sensitivity of -58.5 mV/pH, close to the theoretical value. For reference integration, AgCl was deposited on Ag thin films using 3-diaminopropane-tetraacetic acid ferric ammonium salt monohydrate (PDTA·Fe(III)). The AgCl electrode formed with 10 mM PDTA and 5-minute immersion showed the best Cl^- sensitivity of -51.9 mV/log[Cl^-] and stable performance in the Cl^- range typical of isothermal amplification. The integrated sensor exhibited a pH sensitivity of -59.5 mV/pH, indicating its potential for real-time miRNA detection in point-of-care testing.

10:54 Stem-Based Electrical Impedance Spectroscopy for Assessing Nutrient Concentration Effects on Early Growth of Hydroponic Zea Mays

Jonathan Jr O. Marcelino, Ronnie Concepcion II and Edwin Sybingco (De La Salle University, Philippines)

Corn is a globally important crop, requiring balanced concentrations of potassium (K), nitrogen (N), and phosphorus (P) for healthy and balanced plant growth. In hydroponic systems, where plants grow in nutrient solutions rather than soil, managing nutrient levels is challenging as imbalances can severely impact plant health and yield. This study addresses these challenges by utilizing electrical impedance spectroscopy (EIS), a non-invasive technique, to evaluate the effects of nutrient concentrations on the early growth stages of corn (Zea mays). The experiment evaluated the growth responses of corn seedlings under varying NPK treatments (control, high nitrate, high phosphate, high potassium) using metrics such as plant height, leaf count, and electrical properties such as impedance and capacitance. Results showed that potassium-rich treatments significantly enhanced growth, emphasizing potassium's critical role in water regulation and enzymatic functions. Conversely, nitrogen-dominant treatments were less effective without balanced nutrient profiles. The findings demonstrate the potential of EIS as a cost-efficient tool for monitoring plant health, paving the way for improved nutrient management in hydroponic crop systems.

11:12 Multi Sensory Video-Odor Stimuli Boost EEG-Based Emotion Recognition

Hemant Ghayvat (Linnaeus University, Sweden); Rebakah Geddam (Karnavati University, India & Linnaeus University, Sweden); Muhammad Awais (Physics Memorial Sloan Kettering Cancer Center, USA)

In several applications, Brain Computer Interface is used in detecting emotions, yet the visual-aural stimuli does not very often produce a strong, quantifiable emotional responses. Participants EEG signals were recorded after they were exposed to four different experimental conditions: Early-stage olfactoryenhanced videos (OVEP), late-stage olfactory-enhanced videos (OVLP), early-stage traditional videos (TVEP), and late-stage traditional videos (TVLP). The purpose of classifying emotions, differential entropy (DE) features were acquired

from the EEG signals in the Delta, Theta, Alpha, Beta, and Gamma frequency bands. A voting classifier, Random Forest, Support Vector Machine (SVM), Logistic Regression, and Gradient Boosting were among the machine learning classifiers we used. With the OVEP condition obtaining the highest emotion classification accuracy, the results showed that the olfactory-enhanced conditions performed better than the conventional conditions. The findings indicate that odor integration in the early phases increases emotional encoding, since the OVEP condition produced a considerable increase in identification accuracy (51%) comparing to TVEP (40%), whereas OVLP and TVLP showed no substantial difference. Notably, films with added scents were particularly successful at evoking unpleasant emotions. Furthermore, there were notable differences in the neuronal patterns of response at Fp1, Fp2, and F7 between odor and non-odor circumstances. The current study advances the expanding field of EEG signal analysis and opens the door for further investigation into improving categorization methods using cutting-edge machine learning algorithms.

10:00AM to 11:30AM SESSION S1B: OPTICAL-SENSORS

Room: room1

Chairs: Satoshi Ikezawa (Waseda University, Japan)
Tadao Matsunaga (Tottori University, Japan)

10:00 Development of Optical Gas Sensor Using Deep Ultraviolet Plasmon Resonance on 2D Grating

Mayu Sekiguchi, Yui Tsukamoto and Ryo Matsuda (Tokyo University of Agriculture and Technology, Japan); Yuji Ogawa, Kenichiro Matsushita and Keita Sasaki (Meidensha Corporation, Japan); Kentaro Iwami (Tokyo University of Agriculture and Technology, Japan)

This study presents the fabrication and characterization of an optical gas sensor based on deep ultraviolet (DUV) plasmon resonance. A

plasmonic metasurface was constructed using a two-dimensional (2D) metallic grating of aluminum (Al) deposited on a glass substrate. The 2D grating structure was fabricated via electron beam lithography followed by Al deposition using a sputtering technique. The fabricated structures were characterized by scanning electron microscopy (SEM). Furthermore, reflection spectra were measured after fabrication, confirming the presence of a resonance dip in the UV region.

10:18 Development of Circular Polarization Separating Metalens for Digital Holography

Ryosei Ito and Ayaka Yamazaki (Tokyo University of Agriculture and Technology, Japan); Tatsuki Tahara (National Institute of Information and Communications Technology, Japan); Kentaro Iwami (Tokyo University of Agriculture and Technology, Japan)

In this study, we fabricated and evaluated a circular polarization-separating meta-lens for use in the optics of digital holography. Metalens consisting of silicon nitride nanocolumns were fabricated on a glass substrate coated with silicon nitride. The metalens nanostructure was drawn by electron beam lithography, followed by mask deposition and etching. The structure of the completed metalens was evaluated using scanning electron microscopy (SEM). Furthermore, the metalenses were evaluated with respect to their polarization separation function and its efficiency, as well as their degree of circular polarization (DoCP), which indicates the conversion efficiency of circular polarization, using an optical system.

10:36 Revealing Absorption Shadows Through Emission Inversion in Crystal Analysis by Axicon-Focused Laser-Induced Breakdown Spectroscopy

Satoshi Ikezawa (Waseda University, Japan); Kentaro Iwami (Tokyo University of Agriculture and Technology, Japan); Eiji Iwase (Waseda University, Japan)

The paper reports a novel optical phenomenon observed during laser-induced breakdown spectroscopy (LIBS) of crystalline materials using an axicon and plano-convex lens focusing system. By combining emission and absorption profiles, we demonstrate the emergence of shadow-like absorption features corresponding to the Na D-line doublet (D1 and D2) under specific focusing conditions. The spatial-spectral separation enabled by the axicon-generated Bessel-like beam allows for unprecedented clarity in distinguishing these lines, as confirmed by streak camera imaging and spectral integration. This study opens a pathway toward a new methodology for absorption-assisted LIBS diagnostics in structured media.

10:54 Light Detector System for Analyzing Plant Cultivation Utilization of Reflected Light from Ground Surfaces

Takashige Kaihatsu, Jo Kitada, Toshihiko Kinugasa, Daiju Taketoshi, Yusuke Miyazaki, Sang-Seok Lee and Tadao Matsunaga (Tottori University, Japan)

The objective of this study is to elucidate plants' use of reflected light and develop a light detection system for the associated measurements and analysis. The light environment was measured using different types of ground surfaces. In addition, the differences between the intensities of upward and downward incident light, as well as changes in reflected light according to the ground surface type, were effectively compared.

11:12 Image Processing Approach for Inspecting Nanoscale Defects on Patterned Wafers Based on Darkfield Optical Imaging Method

Jiaqi Hu, Yihong Huang, Tao Liu, Yuanyang Yao and Wenze Wang (Xi'an Jiaotong University, China); Wei Li (Center for Advanced Measurement Science, National Institute of Metrology, China); Yurang Liu and Jiaqi Ye (Xi'an Jiaotong University, China)

A laser scattering-based darkfield imaging method is used to inspect nanoscale defects on patterned wafers. Noise contamination and background pattern residue in images can weaken or even obscure defect signals. In this paper, an image processing approach for scattering signals in the darkfield optical inspection system is described. By constructing an inspection framework that integrates spatial and frequency domain feature analysis, we effectively suppress noises and enhance defect features. Various patterned wafer defects with a line width of 55 nm are successfully extracted from optical scattered darkfield images, demonstrating an improved signal-to-noise ratio. The image processing approach achieves mapping from the raw scattering light intensity distribution to a high-contrast defect feature spectrum, providing an efficient image information processing solution for nanoscale defect inspection in semiconductor manufacturing.

11:45AM to 12:57PM S2A: SENSORS FOR ENVIRONMENTAL MONITORING

Room: room2

Chair: Md Eshrat E Alahi (Shenzhen Institutes of Advanced Technology Chinese Academy of Sciences, China)

11:45 Adaptive Neuro-Fuzzy-Based Environment Sensing and Control of a Fogponics System Under Simulated Partial Gravity

Newton John O. Suganob and Ronnie Concepcion II (De La Salle University, Philippines)

The advancement of astrobotany has driven the development of innovative plant cultivation techniques for extraterrestrial environments. Fogponics, an advanced aeroponic method, provides an efficient alternative to soil-based cultivation, which poses challenges in partial gravity due to particle dispersion and pathogen risks. However, maintaining optimal environmental conditions in a fogponics system is complex, especially under simulated partial gravity, where fluid dynamics are altered. This study addresses these challenges by

integrating an Adaptive Neuro-Fuzzy Inference System (ANFIS) into precise environmental control in a fogponics-based germination system. The proposed ANFIS-based controller regulates critical parameters such as temperature, humidity, and nutrient properties, ensuring stable conditions for plant growth. The system dynamically adjusts fogger activation and thermoelectric cooler (TEC) operations using real-time sensor data. MATLAB was used to train and evaluate the model, with performance assessed through root mean square error (RMSE), mean squared error, and mean absolute error. Results demonstrated the ANFIS model's high predictive accuracy, achieving an RMSE of 0.00932 for TEC voltage prediction and 0.303 in validation tests. A 24-hour analysis confirmed the system's ability to maintain stable nutrient solution temperatures, preventing fluctuations that could hinder plant growth. These findings highlight the potential of ANFIS-based control for space agriculture, offering a reliable, adaptive approach to environmental regulation in fogponics systems. The study lays the groundwork for resource-efficient cultivation techniques in long-duration extraterrestrial missions, advancing controlled-environment agriculture for space and terrestrial applications.

12:03 A PCB Sensor for Monitoring the Residual Effects of the 2020 Wildfires on the Loch Vale Watershed in Rocky Mountain National Park

Isabella A. Oleksy (University of Colorado, USA); Timothy Weinmann (Colorado State Government, USA); Daniel Bowker (Coalition for the Poudre River Watershed, USA); Robert N Dean (Auburn University, USA & University of Waikato, New Zealand)

Rocky Mountain National Park in Colorado, USA is a precious natural resource that is threatened by disasters such as overly large wildfires. The Park was adversely affected by two large wildfires in 2020. To assist with monitoring the residual effects from these wildfires, a low-cost PCB electrical conductivity sensor was developed and demonstrated over an eight-year measurement period in four alpine and subalpine lakes in the Loch Vale Watershed inside the Park. The data

showed that the wildfires resulted in a large increase in electrical conductivity in all four lakes, with an overall peak two years after the fires. Samples taken during the third year after the wildfires showed a decrease in electrical conductivity, but with levels still above the pre-fire levels.

12:21 Development & Validation of a Portable Electrochemical System for Soil NPK Detection in Precision Agriculture

Sahil Rajadhyaksha, Preksha Koli, Shrut Patil, Durgesh Dere, Sanskruti Sankhe and Sheetal Vilas Mapare (Vidyalankar Institute of Technology Mumbai, India)

India's agricultural sector is at a turning point, serving as the backbone of the country. Millions of farmers are burdened with deteriorating soil fertility, falling yield trends, and rising costs of cultivation, while the plots of land they depend on are becoming smaller. Most farmers lack inexpensive and timely access to soil testing, so the majority resort to ineffective guesswork to inform their fertilizer application decisions. This uncertainty leads to both overuse and underuse of crop nutrients, wastage of resources, and long- term land degradation. For small and marginal farmers, most of this cycle not only jeopardizes seasonal productivity but also poses a threat to livelihood security. In this situation, sustainable agriculture will secure food production for the future. In pursuit of this vision, we have developed a low-cost, in-situ electrochemical sensor system to facilitate real-time assessment of the three macronutrients in soil: Nitrate (N), Phosphate (P), and Potassium (K). The sensors are outfitted with selective acoustic coating and are based on the methodology of electrochemical impedance spectroscopy, wherein ion interactions in soil lead to negligible resistance and reactance movement, resulting in measurable responses. The sensors are calibrated to standard solutions and tested with soil extracts from previous assessments, exhibiting low-cost, high sensitivity, high accuracy, and reliability. It would provide farmers with an immediate tool to comprehend their soil space, evaluate their fertilizer footprint, and implement precision farming.

12:39 The Impact of Missing Value Imputation on Low-Cost Air Quality Sensor Calibration: Case Study on Ozone Sensors

Prabath Badullahewage and Liwan Liyanage (Western Sydney University, Australia)

Low-cost sensors are practical and cheap solution for air quality monitoring. It is mandatory to calibrate them before deploying them in the field to ensure their accuracy, as their readings are prone to measurement errors. One of the requirements before any calibration is to have a complete sensor dataset. However, due to sensor mis operations, the presence of missing values in data is inevitable and it could result in large gaps in the data that may hinder the proper sensor calibration. Hence, addressing the problem of missing values is an important step in the context of low-cost sensor calibration. This research is focused on finding effective imputation methods that would improve the accuracy of low-cost sensor calibration in the presence of missing values. We applied and evaluated the performance of seven missing value imputation methods. The performance of each imputation method is evaluated using simulated missing values at different proportions ranging from 10% to 50%. The data for the study is provided by a low-cost air quality sensor network deployed in Sydney, Australia. The Missforest method gave the best imputation accuracy at different missingness rates and Linear Interpolation also had similar performance. After the imputation phase, Support Vector Regression, Random Forest, and Multiple Linear Regression models were trained on the imputed data at 10% missingness rate to obtain the sensor calibration models. The best calibration performances were obtained from the Random Forest model for the dataset that was treated under the Complete Case Analysis. The results from the calibration phase show that unlike in the imputation phase, the multiple imputation methods do not have a significant impact or advantage over the Complete Case Analysis method in the Low-cost Ozone sensor calibration process.

11:45AM to 12:57PM S2B: MAGNETIC, INDUCTIVE AND CAPACITIVE SENSORS

Room: room1

Chairs: Hiroaki Kikuchi (Iwate University, Japan),
K. Tashiro (Shinshu University, Japan)

11:45 Effects of Meander Configuration and Joule Heating on Thin-Film Magnetoimpedance Properties

Hiroaki Kikuchi and Yuta Tanaka (Iwate University, Japan)

In the miniaturization of thin-film magnetoimpedance elements, the application of a meander structure is considered effective for efficient in-plane space utilization. To suppress the demagnetizing field distribution inherent in such structures, a design incorporating extended ferromagnetic parts was proposed, and its effectiveness was demonstrated. Furthermore, a simple method for controlling magnetic anisotropy was applied to the meander structure, and its usefulness was also confirmed.

12:03 Stress-Magnetic Response of API 5L Pipeline Steels for Deepwater Risers Using Metal Magnetic Memory Technique

Gang Tong (CNOOC Research Institute Ltd, China); Jianchun Fan (China University of Petroleum - Beijing, China); Renjun Xie (CNOOC Research Institute Ltd, China); Wenlan Chen (China University of Petroleum (Beijing), China); Yingjun Wang (CNOOC Research Institute Ltd, China)

This study examines the stress-magnetic response of API 5L X80, X65, and X60 pipeline steels, focusing on deepwater risers, using the metal magnetic memory (MMM) method. Experimental results highlight distinct differences between loading and unloading phases. During unloading, a consistent demagnetization pattern emerges, linked to material anisotropy and residual stress, contrasting with the loading phase. Higher coercivity steels show greater sensitivity to these changes. Numerical simulations with the Jiles-Atherton model confirm

that higher saturation magnetization enhances the stress-magnetic effect, with minimal impact from geomagnetic fluctuations. These findings support MMM as a reliable non-destructive testing method for assessing stress states in deepwater riser steels.

12:21 Developing the Eddy Current Testing System for the Corrosion Evaluation of Steel Rebar and Steel Cable

Li He (The University of Tokyo, Japan); Dongfeng He (National Institute for Material Science, Japan); Makoto Watanabe (National Institute for Materials Science, Japan)

We developed a compact system to evaluate the corrosion of steel rebar or steel cable using the eddy current testing method. In this system, an 80kHz current was sent to the excitation coil to produce the AC magnetic field; a detection coil was used to detect the signal produced by the eddy current induced by the AC magnetic field in the steel rebar or steel cable. A differential-type detection coil was used to reduce the influence of the environmental noise and the background signal produced by the excitation coil. A lock-in amplifier was used to get the same phase signal and 90-degree phase difference signal, and X-Y graph was plotted using the two signals. From the slope of the X-Y graph, the corrosion of steel rebar or steel cable can be evaluated. To make the system portable, the excitation coil, the detection coil, the amplifier, the lock-in amplifier, and the AD converter were all put in a small box with a length of about 17 cm, a width of about 8.5 cm, and a height of about 6 cm. The probe was connected to a single-board computer of the Raspberry Pi 4 Model B for the data acquisition, data procession, and results displaying. Some indoor measurements and field experiments of corrosion detection and steel cable corrosion evaluation of cable-stayed bridges were done using the system.

12:39 Evaluation of Metal Detection Performance for Metal Discrimination Using an Optical Probe Current Sensor

Ren Tajika (Shinshu University); K. Tashiro and Hiroyuki Wakiwaka

(Shinshu University, Japan); Kazutoshi Machida, Shuhei Saito and Yoshihiro Nakamura (Fuji Electric Co., Ltd., Japan)

This paper investigates a metal identification sensor that achieves high spatial resolution. The sensor measures the magnetic flux density between a magnetic flux density coil and a metal plate using a compact optical probe current sensor, and integrates this detection sensor with an excitation coil. First, magnetic flux density distributions were measured for copper, aluminum, nickel, and iron plates facing the coil, and the optimal sensor orientation and installation position were determined. The optimum detection point was found to be 1 mm from the coil center along the radial axis, where the flux changes relative to the coil-only condition reached 121 % for copper, 55 % for aluminum, -29 % for nickel, and -65 % for iron. The proposed method was then benchmarked against conventional inductance-based impedance measurements. The flux-based output exhibited contrasts 17 times (copper), 9 times (aluminum), 15 times (nickel), and 9 times (iron) larger than those from inductance. These results suggest that the method could be effective for non-destructive inspection of small metallic components and dissimilar metal joints.

13:30PM to 15:00PM S3: KEYNOTE #1 AND SPECIAL TALK

Room: room1

Chair: Satoshi Ikezawa (Waseda University, Japan)

Keynote #1:

13:30 From Taste Sensing to Food Futures: Media Technologies for the 22nd Century

Homei Miyashita(Meiji University, 2023 Ig Nobel Prize Winner, Japan)

Recent advances in technologies now allow not only the measurement but also the reproduction of taste sensations. Building on this, the emerging fields of taste media, olfactory media, and nutritional media go beyond traditional food engineering: enabling flavors to be shared remotely, scents to be replayed in immersive dining, and nutrition to be

digitally tailored to individual needs. Looking ahead, these technologies make it possible to re-create rare flavors, design foods that overcome allergies, and generate meals optimized for health and pleasure. With the aid of generative AI, flavor creation becomes a collaboration between human imagination and machine creativity, opening new possibilities far beyond conventional food production. This keynote will explore not only the frontiers of sensing and reproduction, but also the visions of food in the 22nd century-a future in which eating becomes customizable, shareable, and playful. I will share these ideas through an engaging talk enriched with videos and demonstrations, inviting the audience to experience the joy and imagination behind the science of food.

Special talk:

14:15 Next Generation of Smart Devices, IoT and Drones

Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

The advancement of sensing technologies, embedded systems, wireless communication technologies, nano-materials, miniaturization, vision sensing and processing speed makes it possible to develop smart mechatronics and machine systems. This seminar will discuss recent research and developmental activities on different sensors and sensing system, Mechatronics, including robotics and drones, IoT along with machine visions at Macquarie University as applicable to medical science, biology and environmental monitoring.

15:30PM to 17:18PM S4A: BIO-MED APPLICATIONS AND MEDICAL DEVICES

Room: room2

Chair: Kohji Mitsubayashi (Tokyo Medical and Dental University, Japan)

15:30 Real-Time Physiological Monitoring Strap for Enhanced Diver Safety

Cheng Huan Lu, Derek Orbaugh and Xavier Vrijdag (Auckland

University, New Zealand); Iain Anderson (University of Auckland, New Zealand)

Ensuring diver safety during underwater activities remains a critical challenge due to the limited ability to monitor physiological conditions in aquatic environments. This study presents a novel wearable strap capable of real-time, dual parameter monitoring of heart rate and respiration during diving. Featuring waterproof sensors and a compact, hydrodynamic form factor, the system ensures minimal drag and high comfort. Signals are wirelessly transmitted to a surface receiver for real-time analysis and early warning. Integrated experiments validate its reliability and usability in real-world scenarios, including dynamic trials in fresh and seawater and public diving demonstrations in a 4 m deep pool. Designed for scalability, the platform supports expansion to additional sensors and integration with motion capture systems, offering a promising tool for enhancing underwater safety and performance.

15:48 Standalone Device for Measurement of Distribution and Fluctuation of Weak Finger Force for Using in a Patient Room

Ryuichi Nakayama (University of Yamanashi, Japan); Lu Zhao (Kitagawa Industries Co. Ltd., Japan); Yuki Nakamura, Takanori Hata, Yuji Ueno, Hidetsugu Terada and Koji Makino (University of Yamanashi, Japan)

It is known that various diseases and condition of the patient can be evaluated using the grip strength data. If each finger force can be measured when an object is held, the adaptation range of the medical field becomes wider. Here, there are two kind of finger force; maximum force and minimum force. Many methods and devices to measure the maximum finger force are studied and developed. On the other hand, it is also important to measure the minimum finger force, since the balance of each finger force is also important. However, the number of devices and studies are not many. We developed the measurement system composed of a grip device and a PC, it is found out that there are two problems in usage in the patient room. Therefore, this paper describes the development of a stand-alone device newly. The

feasibility and effectiveness of the improvement are verified by using the real device.

16:06 Towards Adaptive Rehabilitation: Smart 3D-Printed Orthosis with Real-Time Compliance Feedback

Morten Ødegård (ADEPT Research Group, Oslo Metropolitan University, Norway); Anne-Marthe Sanders (Sunnaas Rehabilitation Hospital, Norway); Olga Korostynska (OsloMet - Oslo Metropolitan University & ADEPT Research Group, Norway)

Effective rehabilitation is paramount for individuals recovering from life-changing trauma, as it directly impacts functional recovery, pain management, psychological well-being, and ultimately, their ability to regain independence and quality of life. Rehabilitation compliance to follow physical therapist's instructions and completing prescribed home exercise program is essential for medical and legal purposes. However, the process of monitoring this compliance is in many cases still mainly subjective: it is a patient's word that is the basis of assessment, without objective measurable indicators. There are emerging monitoring technologies that can be used for this purpose, with accelerometers and motion sensors being the more common to implement. This paper reports on design, manufacture and testing of a novel 3D printed smart orthosis with integrated sensors to provide the physicians and welfare authorities with an option for objective assessment of rehabilitation regime compliance. The smart orthosis prototype was developed in collaboration with rehabilitation expert to ensure the device's clinical relevance. It measures the level of motion, which was accurately linked to an activity type and correlated with prescribed rehabilitation plan.

16:24 OrthoPlay: Gamified Smart Orthosis

Vanessa Salazar Balboa, Eeman Fatima, Sivert Ramsrud Kindberg and Elise Andrea Fortun Pleym (Oslo Metropolitan University, Norway); Morten Ødegård (ADEPT Research Group, Oslo Metropolitan University, Norway); Anne-Marthe Sanders (Sunnaas Rehabilitation Hospital, Norway); Olga Korostynska (OsloMet - Oslo Metropolitan University & ADEPT Research Group, Norway)

Orthosis for rehabilitative purposes is a frequently used assistive device for patients experiencing pain and functional impairment after suffering from stroke, nerve injuries, or other neurological conditions affecting motor functions. Orthoses are used as an assistive method for regaining strength and function and reducing pain through given exercises. Existing solutions lack adaptability to each patient and engagement for consistent use. Utilizing 3D-printing technologies it is possible to create a customized cast, enhancing user comfort, adaptability, and flexibility. This study presents OrthoPlay as a solution, incorporating gamification with rehabilitation and a personalized 3D printed design. A game of Pong is designed together with the Nicla Sense ME sensor, monitoring degrees of motion. The combination of real-time feedback with a gamified approach enables the system to be an optimized, user-friendly, and engaging device while conducting exercises to aid in the rehabilitation process.

16:42 Accelerometer-Based Vibration Analysis Under Dynamic Loading for Fault Detection in Ageing ICE Vehicles

Aishvaria Gorityala (BITS-Pilani, Hyderabad Campus, India); Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad Campus, India)

Evaluating the mechanical condition of Internal Combustion Engine (ICE) two-wheelers is a critical step in ensuring the success of Electric Vehicle (EV) retrofitting. This study proposes a diagnostic framework based on vibration analysis under controlled dynamic loading using a chassis dynamometer. Four ICE-powered two-wheelers aged 4, 6, 9, and 10 years were selected for testing. The 4-year and 6-year vehicles were equipped with 4-stroke engines, while the 9-year and 10-year vehicles utilized 2-stroke configurations. A triaxial accelerometer (PCB Model 356B11; 10 mV/g sensitivity, 2-7 kHz frequency range) was mounted directly on the engine block to measure the vibrational response. Data acquisition was performed using an NI 9234 module (four channels, 51.2 kS/s per channel) at a sampling rate of 25.6 kHz. Vibration signals were recorded during five simulated operating conditions, such as idle, ramp-up, steady cruise, deceleration, and transient throttle. Frequency analysis identified distinct fault bands

associated with the crankshaft imbalance (33-49 Hz), piston-related impact (66-98 Hz), and bearing degradation (90-120 Hz). These spectral findings were in close agreement with physical inspections, which confirmed wear-related issues such as oil discoloration, white exhaust smoke, and handlebar misalignment in older vehicles. A Component Health Index (CHI) was developed to quantify the overall degradation, with a 43% decline observed between new and heavily used vehicles. The 9-year and 10-year vehicles showed CHI reductions of 34% and 29%, respectively. The proposed methodology demonstrated a strong match (92%) between the sensor-based analysis and the observed mechanical faults, supporting its potential as a pre-screening tool for selecting retrofit-ready ICE vehicles and minimizing post-conversion risks.

17:00 MEMS Magnetoelastic Sensor Design for Sensitive Exosome Detection: A Conceptual Modeling

Sumedha N. Prabhu (The Chinese University of Hong Kong, Shenzhen, China); Guozhen Liu (The Chinese University of Hong Kong, Shenzhen & N/A, China)

This work introduces a conceptual framework for the design and performance assessment of a micro-electro-mechanical systems (MEMS)-based flexible magnetoelastic sensor tailored for ultrasensitive exosome detection. Exosomes, nanoscale extracellular vesicles implicated in diverse physiological and pathological processes, represent a critical frontier in biomarker-based diagnostics. The proposed sensor calculations utilize properties of a ribbon-shaped METGLAS® 2826MB Alloy and rely on mass-induced changes in magnetization for detection. The model evaluates the sensor's Limit of Detection (LOD) at ±0.65 mT magnetic bias fields, demonstrating an LOD of 149.38 pT/$\sqrt{\mathbf{Hz}}$ at +0.65 mT and 201.11 pT/ $\sqrt{\mathbf{Hz}}$ at -0.65 mT (1 Hz). Additionally, Sensor Detection Mass Sensitivity (SDMS), amplification factor, and the impact of fluid damping are conceptually evaluated to establish the feasibility of discriminating minute exosomal masses from background noise. This study highlights the sensor's potential for highly sensitive, label-free detection of exosomes, paving

the way for advanced Point-of-Care diagnostics in oncology, nephrology, and personalized medicine. Future research directions include sensor optimization, integration of multimodal transduction, and validation in complex biological samples.

15:30PM to 17:18PM S4B: WSN AND IOT

Room: room1

Chair: Takehito Azuma (Utsunomiya University, Japan)

15:30 A Real-Time Regional EEG-Based BCI Framework for IoT-Enabled Smart Light Control

Sayam Chakraborty, Naman Bhat, Aryan Gujral, Ashwani Kumar and Manoj Bs (Indian Institute of Space Science and Technology, India); Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

This paper introduces a real-time Brain-Computer Interface (BCI) system for IoT-based smart light control, aimed at addressing the linguistic inclusivity gap in assistive technologies. Unlike conventional voice or EEG-driven systems that rely on English-language commands, our framework decodes neural activity corresponding to spoken words in a regional Indian language, enhancing accessibility for non-English-speaking and motor-impaired users. The system incorporates wavelet-based denoising and multi-domain statistical feature extraction to preprocess raw EEG signals, which are classified using a Support Vector Machine (SVM) achieving an accuracy of 84.14% in intent recognition. Deployed on a Raspberry Pi for energy-efficient, real-time operation, the solution bridges neuroadaptive control with IoT-based actuation, demonstrating practical viability for smart home environments. Key innovations include: (1) a language localized BCI paradigm utilizing spoken commands familiar to the user's cultural context, and (2) embedded edge deployment optimized for low latency and power consumption. By unifying EEG signal processing with IoT actuation, this work advances culturally adaptive, low-cost BCI systems suitable for deployment in regional and resource-constrained settings.

15:48 Dual-Band Hybrid Microstrip Patch Antenna Tile Array for Sustainable IoT Sensing

Amir Zahedi, Robert Salama, Karthick Thiyagarajan and Ranjith Liyanapathirana (Western Sydney University, Australia)

This paper presents a dual-band hybrid microstrip patch antenna tile array optimized for sustainable indoor IoT sensing. The design integrates a semicircular patch resonating at 920 MHz (Australian UHF RFID band) and a 1*4 linear array of smaller patches tuned to 2.45 GHz (global ISM band), mounted on a biodegradable cork substrate for eco-friendly deployment in smart floor systems. Full-wave electromagnetic simulations were conducted to evaluate performance in dense IoT environments, analyzing mutual coupling, gain, and radiation efficiency across free-space and concrete-mounted scenarios. The antenna achieved peak gains of 3.1 dBi and 1.74 dBi at 920 MHz, and 12.44 dBi and 11.8 dBi at 2.45 GHz, with corresponding radiation efficiencies of 62%, 57%, 83%, and 81%, respectively. These results demonstrate the antenna's suitability for high-gain, dual-band IoT applications in sustainable built environments.

16:06 A LoRaWAN-Based Landslide Early Warning System Using Unsupervised AI

Ushaloy Chakma, Charmil Alee and Ahmad-aduwa Da-oh (Walailak University, Thailand); Nasrin Afsarimanesh (Curtin University, Australia); Ajalawit Chantaveerod and MD Eshrat E. Alahi (Walailak University, Thailand)

Landslides are devastating natural disasters, making robust early warning systems essential for mitigating their impact. This study details the development of a low-cost, low-power Internet of Things (IoT) system for real-time landslide monitoring. The system utilises prototype nodes, each integrating sensors for rainfall, soil moisture, geophones, temperature, and humidity. Data is transmitted via a Long-Range Wide-Area Network (LoRaWAN) to cloud storage, with a local SD card for

backup. Data quality was rigorously validated using metrics such as Signal-to-Noise Ratio (SNR) and Mean Absolute Error (MAE). An unsupervised machine learning model, Isolation Forest, was deployed to detect anomalies from the sensor data indicative of potential landslide events. The model proved effective in identifying high-risk conditions, achieving an F1-score of 0.73 for detecting ‘Critical' events. While this unsupervised approach is promising for remote areas with limited baseline data, future work will involve developing supervised models using labelled field data to further enhance predictive accuracy.

16:24 Wristwise: IoT-Based Monitoring System with Anomaly Detection and Alerts for Senior Citizens

Sean Derick Habana, Kyle Ethan Lester B. Lizardo, King Ace Naeyjo D. Querubin, Mark Lorenz B. Uy and Mc Joben R. Reyes (National University, Philippines); Alvin E. Camacho (National University Philippines, Philippines)

As the number of older individuals in the world continues to increase, there has been a greater need for methods by which health can be monitored continuously and assistance can be provided during emergencies. Wristwise is presented as a project that makes use of a wearable device along with mobile and web applications, so that measurements related to body temperature and potential falls can be observed and unusual changes can be detected. The device is a wristband containing a microcontroller, which has been equipped with sensors for recording temperature and identifying falls. It does not have a display, and all collected data is sent to cloud platforms, from which it can be accessed by caregivers using applications designed for them. These applications are made in such a way that the information is displayed in a clear manner, allowing caregivers to receive alerts promptly and take necessary action. The project places emphasis on affordability, ease of use, and accessibility for caregivers, and development is still in progress, with improvements being made to hardware and data speed. This work also supports the United Nations Sustainable Development Goal 3, which concerns good health and well-being.

16:42 Sensor-Integrated Control and Monitoring System for a Micro Wind-Solar Hybrid Unit in Emergency Exit Windows of Skyscrapers

Sandeep Vangapalli (BITS PILANI HYDERABAD CAMPUS, India & ARCEDO SYSTEMS PRIVATE LIMITED, India); Aishvaria Gorityala (BITS-Pilani, Hyderabad Campus, India); Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad Campus, India)

This paper introduces a hybrid wind-solar energy system designed for integration into emergency exit window frames in urban high-rises. The setup includes a Savonius vertical axis wind turbine (0.4 m diameter, 0.5 m height) and a 20 W flexible solar panel. At 120 m, the turbine delivers 52 W of power at a wind speed of 12.85 m/s, producing 1.62 Nm torque and 306 RPM. The combined system generates about 1.5 kWh per day, enough to support emergency lighting and communication. Performance is tracked in real-time using an ESP32 microcontroller connected to sensors for wind speed, solar irradiance, RPM, voltage, and current. A comparative study using data from Hyderabad and Tokyo highlights the system's efficiency in both high and moderate resource set-tings, validating its use in varying urban climates. The design supports compact retrofitting and reliable energy delivery in dense vertical infrastructures.

17:00 IoT-Based Multi-Sensor Platform Prototype for Soil, Air, and Light Monitoring in Agriculture

Fahmy Rinanda Saputri, Nabila Husna Shabrina, Vannessa Wong, Novela Chin, Muhammad Rafa Alandra and Lusia Trudy Subik (Universitas Multimedia Nusantara, Indonesia)

This study presents the development of an Internet of Things (IoT)-based plant monitoring system that integrates soil moisture, air temperature-humidity, and light intensity sensors using a NodeMCU ESP8266 connected to the Blynk platform. The system combines a soil moisture sensor and a DHT11 sensor in a single module to monitor soil

and air conditions, while an LDR sensor is used separately to measure light levels at different locations. Experimental results show that soil moisture values increased from 108 at 50 ml to 190 at 250 ml, indicating the sensor's responsiveness to changes in water content. The DHT11 sensor recorded temperature variations from 23.4 °C indoors to 33.3 °C outdoors, with humidity ranging between 51% and 61%, while the LDR sensor detected light intensity differences from 17% in dim indoor conditions to 96% in bright outdoor areas. Although the accuracy of these sensors is lower than that of professional instruments, the system proved effective in providing real-time monitoring and demonstrates potential for supporting automated irrigation, optimizing plant care, and contributing to environmental sustainability. Future improvements include regular sensor calibration and the use of higher-accuracy components to enhance data reliability and system scalability.

9:00AM to 10:30AM S5A: CHEMICAL AND GAS SENSORS

Room: room1

Chair: Krishanthi Jayasundera (University Technology Sydney, Australia)

9:00 The Study of Molecularly Imprinted Polymer-Based Sensor for Sensitive Detection of Glyphosate Pesticide

Juthamas Hongoeb (Macquarie University, Australia & Mahidol University, Thailand); Subhas Chandra Mukhopadhyay (Macquarie University, Australia); Kamonrat Phopin and Tanawut Tantimongcolwat (Center for Research Innovation and Biomedical Informatics, Thailand)

The excessive usage and persistent environmental presence of the hazardous pesticide, glyphosate, lead to significant contamination of the food chain and various ecosystems. Studies indicated the potency of this chemical to exert several severe life-threatening complications, raising health concerns throughout the globe. Unfortunately, conventional methods often suffer from expensive instrumentations, complicated operation, and lengthy analysis time. Therefore, this study proposed a simple, user-friendly, and cost-effective molecularly imprinted polymer (MIP)-modified electrode for sensitive glyphosate detection. Preliminary studies using electrochemical impedance spectroscopy (EIS) demonstrated the possibility of this approach as a promising alternative. The developed sensor revealed a working range of 0.005 to 5 µg/mL, achieving an excellent coefficient of determination (R2) of 0.992 when utilizing the resistance parameter at a particular frequency of 5 kHz for analysis. The calculated limit of detection (LOD) of 0.437 µg/mL was also obtained. As a result, this proposed MIP-modified sensor is able to be further developed into a robust method for glyphosate detection, ultimately facilitating regulatory enforcement and safeguarding human well-being.

9:18 Detection of Gas Emission from the Ground by Drone Using Fountain Flow over Rough Terrain

Kyohei Yamashita, Takeru Kaji, Kasumi Yoshida and Daiki Akaogi (Tokyo University of Agriculture and Technology, Japan); Haruka Matsukura (The University of Electro-Communications, Japan); Hiroshi Ishida (Tokyo University of Agriculture and Technology, Japan)

The high maneuverability of multi-rotor drones makes them an attractive platform for methane emission monitoring in landfill sites. However, the strong downwash generated by the rotors poses a serious problem. When a drone equipped with a gas sensor is hovering over the place of methane emanation, the downwash from the drone blows away the methane released from the ground, and therefore, the gas sensor shows almost no response. In this series of work, we propose to use the fountain flow to solve this problem. When a multi-rotor drone is hovering close to the ground, the downwash from the rotors is deflected at the ground and an upward air current called a fountain flow is generated. In our previous reports, we have presented the results of flow simulations and experiments over a smooth flat floor to demonstrate that the fountain flow can be utilized for ground gas detection: it helps transporting the gas released from the ground surface to height of the gas sensor on the drone. Here we show results of experiments conducted over a rough ground surface. The results show that ground gas detection using the fountain flow is hardly affected by the presence of artificial turf with a height of 50 mm or balls with a diameter of 80 mm.

9:36 Development of SERS Gas Sensor Using a Nonwoven Fabric Substrate for the Detection of Benzaldehyde

Takumi Yokoya, Ren Tomisawa and Yusuke Tahara (Shinshu University, Japan)

In recent years, breath diagnosis has attracted attention as a non-invasive health screening method that imposes little burden on patients both physically and mentally. However, breath analysis is difficult, and the analytical techniques are often complex. Therefore, there is a

demand in medical settings for analytical techniques that are quick and simple, and the use of SERS spectroscopy is being researched. In this study, we developed a SERS substrate using melt-blown nylon nonwoven fabric as the base material, aiming to detect benzaldehyde, a biomarker for lung cancer, with high sensitivity and low cost. The SERS substrate was fabricated by modifying melt-blown nylon nonwoven fabric with silver nanoparticles. Additionally, for capturing benzaldehyde via Schiff base reaction, the substrate was further modified with 6-amino-1-hexanethiol. Raman spectroscopy was performed by supplying benzaldehyde gas, bubbled with nitrogen, to the SERS substrate. From the nonwoven fabric SERS substrate that was exposed to 50 ppm benzaldehyde gas for two minutes, Raman peaks characteristic of benzaldehyde were detected: at 980 cm^-1 and 1580 cm^-1 originate from the benzene ring, and at 1620 cm^-1 originate from the aldehyde group. The developed melt-blown nylon nonwoven fabric SERS substrate successfully detected 50 ppm benzaldehyde gas using the Schiff base reaction.

9:54 Electrohydrodynamic Printing of Optical Waveguides: Advantages, Materials, Integration, and Future Perspectives

Hiyary Villena (Public University of Navarra, Spain); Jesus Corres (Universidad Publica de Navarra, Spain); Ignacio R. Matias (Universidad Pública de Navarra, Spain)

Electrohydrodynamic printing enables highresolution fabrication of optical waveguides on flexible substrates. In this study, PMMA, PET, and PDMS were printed, with PDMS selected for characterization due to its superior optical properties. Optical coupling was found to be critical, and a propagation attenuation constant of $\alpha\alpha$=1.4 dB/mm was measured, indicating efficient transmission for waveguides shorter than 5 mm. These results demonstrate that EHD printing provides a precise and versatile platform for compact photonic devices and sensors, with future opportunities in material development and process optimization for practical applications.

9:00AM to 10:30AM S5B: SENSORS FOR ROBOTS AND VEHICLE MONITORING

Room: room2

Chair: Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

9:00 A Unified Simulation and Hardware Framework for Path Planning in Wheeled Mobile Robots with 2D Augmented Reality-Based Sensing

Meer Shadman Saeed, Pritam Pun, Subhas Chandra Mukhopadhyay and Chris R. Reid (Macquarie University, Australia)

This paper presents an interactive robotic test platform simulator for developing and evaluating path planning algorithms in wheeled mobile robots. The framework operates in three modes-simulation, predefined waypoint testing, and real-time execution-providing flexibility for both research and education. In simulation mode, the platform models differential drive and mecanum robots with modular forward and inverse kinematics, enabling customizable dimensions and velocity inputs. Waypoint testing mode supports repeatable path evaluation for benchmarking algorithms. In real-time mode, an overhead camera with ArUco marker-based pose estimation maps robot motion into a 2D environment, using camera calibration and homography to convert frame waypoints into real-world coordinates. A key feature of the system is its 2D augmented reality capability, which enables the creation of virtual obstacles and sensor fields that interact with the robot as if they existed physically, enhancing experimentation without additional hardware. Waypoints can be generated algorithmically or interactively and transmitted as wheel velocity commands to the robot. By combining simulation, structured testing, augmented reality, and hardware integration, the platform bridges the gap between theoretical algorithm design and practical implementation.

9:18 A Cloud-Integrated Digital Twin Framework for Remote Gearbox Monitoring and Control

Sabareesh Gr (BITS-Pilani, Hyderabad Campus, India); Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad

Campus, India); Toru Yamamoto and Takuya Kinoshita (Hiroshima University, Japan); Anbumani P (Birla Institute of Technology and Science, India); Zhifeng Li (Hiroshima University, Japan); Akashjyoti Barman (Birla Institute of Technology and Science, India)

Digital twin technology has emerged as a transformative approach for monitoring and controlling industrial systems by creating virtual representations of physical systems. However, most existing digital twin implementations are limited to localised or closed-network environments, making them impractical for remote or distributed systems. In rotating machinery such as gearboxes, where timely fault detection and control are critical, there is a growing need for scalable, low-cost, and remotely accessible solutions. The current research proposes a modular, cloud-integrated digital twin framework for real-time monitoring and control of a gearbox system. The framework combines LabVIEW-based data acquisition with Python-driven cloud synchronisation and analytical modelling. Sensor data collected from a physical gearbox setup is automatically uploaded to a cloud platform using an event-driven Python algorithm. A remote digital twin continuously monitors the cloud folder, downloads new data, and processes it to simulate system behaviour and assess control requirements. The twin employs an analytical model to estimate dynamic responses of the gearbox and includes a health-aware PID controller that adapts control inputs based on system indicators. Communication between the physical system and the digital twin is established through file-based synchronisation, ensuring platform independence and minimal infrastructure requirements. The proposed framework offers a lightweight and scalable solution for remote digital twin deployment, particularly in applications where cost, flexibility, and accessibility are critical. The proposed framework lays the foundation for further developing intelligent remote monitoring systems that can be expanded with predictive analytics and multi-system edge integration.

9:36 Beyond Pixels: A Training-Free, Text-to-Text Framework for Remote Sensing Image Retrieval

Jinghao Xiao (University of Tehnology Sydney, Australia); Yiheng Guo

(University of Technology Sydney, Australia); Xing Zi (UTS, Australia); Karthick Thiyagarajan (Western Sydney University, Australia); Catarina Pinto Moreira and Mukesh Prasad (University of Technology Sydney, Australia)

Semantic retrieval of remote sensing (RS) images is a critical task fundamentally challenged by the the Difference Between Model's Low-Level Vision and Human Understanding. While large Vision Language Models (VLMs) offer a promising path to bridge this gap, existing methods often rely on costly, domain specific training, and there is a lack of benchmarks to evaluate the practical utility of VLM generated text in a zeroshot retrieval context. To address this research gap, we introduce the Remote Sensing Rich Text (RSRT) dataset, a new benchmark featuring multiple structured captions per image. Base this Dataset, we propose a fully trainingfree, text only retrieval reference called TRSLLaVA. Our methodology reformulates cross modal retrieval as a text to text (T2T) matching problem, leveraging rich text descriptions as queries against a database of VLM generated captions within a unified textual embedding space. This approach completely bypasses model training or fine tuning on the target dataset. Experiments on the RSITMD and RSICD benchmarks show our training-free method is highly competitive with state of the art supervised models. Notably, it surpasses the standard zero shot CLIP baseline by nearly a factor of two, validating that high quality semantic representation through structured text provides a powerful and cost effective paradigm for remote sensing image retrieval.

11:00AM to 12:30PM S6: KEYNOTE #2 AND #3

Room: room1

Chair: Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

Keynote #2:

11:00 Emergent Functions of Electrically Induced Bubbles in Micro/Nano-Scale Fluid Engineering for Biomedical Applications

Yoko Yamanishi(Kyushu University, Japan)

Cell poration technologies provide powerful tools not only for exploring the behavior of biological molecules but also for advancing genetic manipulation. However, delivering large molecules that carry extensive genomic information remains a significant challenge. In this presentation, I introduce a novel electromechanical poration technique utilizing a core-shell microbubble generator. This device features a fine microelectrode encased in a dielectric material, with a microcavity at its tip that concentrates the electric field upon pulse application. This configuration enables the generation of microbubbles that stimulate cells electromechanically. Remarkably, this method allows for the transfection of extremely large molecules-on the order of thousands of kilodaltons-into cell types traditionally considered difficult to manipulate, such as osteoblasts and Chlamydomonas. Furthermore, we discovered that adjusting the viscosity of the cell suspension significantly improves transfection efficiency, likely due to cytoskeletal remodeling at the membrane level. The versatility of this approach across diverse cell types opens exciting possibilities for emerging applications in gene engineering. I will discuss the underlying mechanism of electrically induced bubble formation and highlight its broad potential in electromechanical poration.

Keynote #3:

11:45 Intelligent Sensors for Measuring Mechanisms and Effects of Art Therapy

Olga Korostynska,(Oslo Metropolitan University, Norway)

Art therapy is a psychosocial health intervention that promotes emotional and physical well-being. It is used to manage various disorders, including somatic or psychosomatic pain and could offer cost-effective pain management without the side effects that medications often have. Integrating art therapy into public healthcare services can decrease the financial burden on the system and make it more sustainable. But how does it work? Is it for everyone? How can mechanisms and effects of art therapy be objectively measured? This

talk will focus on intelligent sensors that can be used to answer these questions. This will help to understand the extent to which non-pharmacological interventions, such as art therapy, can alleviate pain. Ultimately, the findings may provide valuable justification for the long-term use of such interventions in pain regulation and their correlation with physiological and neural responses.

13:30PM to 15:00PM S7A: ACOUSTIC SENSORS

Room: room1

Chairs: Ikuo Ihara (Nagaoka University of Technology, Japan),
Daisuke Mizushima (Aichi Institute of Technology, Japan)

13:30 Feasibility Study on the Application of Multispectral Photoacoustic Microscopy in Plant Science

Masato Sato, Kainat Zahra, Taisuke Nishimura, Ikuo Ihara and Takeshi Hirasawa (Nagaoka University of Technology, Japan)

The effectiveness of multispectral photoacoustic microscopy in plant science research was evaluated by performing experiments on Arabidopsis thaliana leaves. As a result, PA signals with spectral characteristics associated with chlorophyll and yellow pigments were detected in both cotyledons and true leaves. In true leaves, distinct signal patterns were observed between the green and dark green regions. These results demonstrate the advantage of multispectral photoacoustic microscopy in the sensitive detection and spectral differentiation of pigments.

13:48 Improving Signal-to-Distortion Ratio of Self-Coupling Type Laser Microphone Aided by Deep Sound Separation Models

Daisuke Mizushima, Rin Furuya and Norio Tsuda (Aichi Institute of Technology, Japan)

A laser microphone utilizing the self-coupling effect of a semiconductor

laser operates on a novel principle that obviates the need for a diaphragm. Nevertheless, the output is affected by unidentified noise, which must be eliminated for practical application. To characterize this noise, this paper employs a source separation deep neural network to extract the speech signal from the noise. It has been reported that the signal-to-distortion ratio can be enhanced through various types of real-time processing of the noise features identified by the separation results.

14:06 A Simulation Study on Phase-Based Ranging for Dual-Antenna Channel Sounding

Masaaki Fujii, Takuya Kitajima and Yoshihiro Nakamura (MinebeaMitsumi Inc., Japan)

An enhanced phase-based ranging (PBR) algorithm is described for multiple-antenna Bluetooth Low Energy (BLE) channel sounding to cope with non-line-of-sight (NLOS) channels. The multi-channel signals acquired sequentially through a one-on-one connection are combined in the form of exponential moving average of correlation matrices. MUSIC algorithm with a limited search range is then utilized to perform highly accurate distance estimation with reduced complexity. With our enhanced PBR scheme applied to dual antennas, the misdetection probability of the first arrival path timing was reduced to 2.0% when the channel correlation between dual antennas was 0.4 in NLOS multi-path environments.

14:24 Integrated Approach to Target Following Using Reinforcement Learning and Echo Localization with Mid-Air Ultrasonic Actuators

Mifuka Nakamura, Rin Furuya and Daisuke Mizushima (Aichi Institute of Technology, Japan)

In mid-air ultrasonic haptics, a depth camera detects the finger position in real time. However, these methods struggle to control focus by moving freely in the air. We propose tracking finger positions by forming

a high-pressure focus using reinforcement learning (DQN or PPO). switching the speakers of the actuator for reception and measuring the time-of-flight (ToF) of the reflected waves. From experimental results, the PPO generates higher sound pressure than the DQN. In ToF measurement results, the maximum error was 7 mm at Z = 70 mm, which is within the sensible range of the human index finger length.

14:42 Enhancing Accuracy in Three-Electrode OCV Measurements for Flow Batteries by Mitigating Elusive Noise Effects

Giacomo Marini (University of Padova, Italy); Massimo Guarnieri (Università di Padova, Italy)

Accurate open-circuit voltage (OCV) measurements are essential for reliable state-of-charge (SOC) monitoring in vanadium redox flow batteries (VFBs). Measurement accuracy can be severely degraded by elusive parasitic effects when using a three-electrode setup with a reference solution. This work analyzed two main sources of measurement error: parasitic currents drawn by the acquisition system and shunt currents flowing through the hydraulic connection between the OCV cell and the main power cell. Possible strategies to mitigate these effects were implemented and tested. Experimental validation demonstrated a significant reduction of measurement errors. The OCV-SOC curves obtained from this improved setup showed good agreement with analytical models derived from simplified Nernst equations. These findings offer practical guidance for designing accurate SOC monitoring systems in VFBs.

13:30PM to 15:00PM S7B: SENORS APPLICATIONS IN CHALLENGING ENVIRONMENT

Room: room2

Chair: Olga Korostynska (OsloMet - Oslo Metropolitan University & ADEPT Research Group, Norway)

13:30 GPU-Accelerated Chirplet Transform: Scalable Runtime Profiling

and Analysis

Nishant Kumar (University of Toronto, Canada); Steve Mann (MannLab Canada, Canada & MannLab, USA)

The chirplet transform provides a powerful and flexible approach to analyzing non-stationary signals in all types of sensing modalities. Its broad application has been hindered, however, by the computational expense of its dictionary-based search procedure, especially in cases where high-resolution parameter sweeps are needed. This paper presents a hardware-accelerated framework for chirplet decomposition based on GPU parallelism with unified memory that achieves scalable performance across a variety of signal types.

The system was tested on seven simulated sensing signals with different temporal and spectral dynamics, including EEG (awake and sleep), EMG, radar, and vibration signals. Results demonstrate up to 18x acceleration in the chirplet search process, with considerable reduction of CPU usage and system memory load. Remarkably, the GPU version is increasingly faster for longer signals, e.g., sleep EEG, even with overhead from unified memory. The results prove the potential of GPU-accelerated chirplet transforms for large-scale or near real-time sensing applications, while also highlighting dictionary generation as an important area for further optimization.

13:48 Stepwise Optimization Calibration Method for Stereo Deflectometry

Xiuyuan Wu, Xiang Wei and Bing Li (Xi'an Jiaotong University, China)

Calibration of stereo deflectometry systems is fundamental for accurate reconstruction of mirror surfaces. In this study, we present a stepwise optimization algorithm for system parameter calibration that requires only a single spherical mirror pose. The proposed method addresses the issue of matrix ill-conditioning typically caused by an excessive number of variables in the optimization process. By exploiting the characteristics of stereo deflectometry, the parameter space is decomposed and optimized in stages, enabling effective and stable calibration. Experimental results confirm that the method accurately

calibrates all relevant parameters and significantly improves reconstruction precision, providing an efficient and practical calibration approach.

14:06 Sparse Signal Blind Deconvolution Using Bayesian MAP Estimation

Jack Bourdin White (IMT Atlantique, France & Safran Data Systems, France); Abdeldjalil Aïssa-El-Bey and Matthieu Arzel (IMT Atlantique, France); Jean-Marc Leveau (Safran Data Systems, France)

Blind deconvolution tackles the issue of recovering a signal from a convolution between an initial signal and a filter with an unknown kernel. To address the ill-posed nature of blind deconvolution, we leverage the sparse characteristics of the signals in a pre-existent dictionary. Rather than imposing sparsity directly on the signal using L0 or L1 penalties, we express it as a prior on the signal's covariance matrix. The hierarchical prior acts like a decoupling between the signal and its sparsity, making estimation a classical a posteriori problem. The proposition revolves around a maximum a posteriori estimation in an Expectation - Maximization framework for alternate optimization of the signal and the filter. We give simulation results in comparison with MAP oracle values for any sparse basis.

14:24 Physics-Based Modeling of a Soft Sensor for Flow Rate Prediction in Control Valves

Johannes Göhring, Alessandro Esposito, Dominic Häuslein, Christian Hölzer and Ronald Schmidt-Vollus (Technische Hochschule Nürnberg, Germany)

Soft sensors are gaining increasing importance in the process industry as they replace invasive and costly measurement systems. The aim is to achieve a single, centralized soft sensor that simplifies system architecture and minimizes hardware dependencies. Approaches for soft sensors differ between data-driven and physics-based models, with the former being subject to certain limitations, such as data availability

or generalizability. Thus, this work presents a physics-based electrohydraulic analogy model combined with an Unscented Kalman Filter to predict flow rates in control valves. For model validation, data is collected from a valve test rig and two valve types with distinct operational profiles. The proposed model shows a deviation of less than 2 % for the examined valves across a wide range of valve lifts. The defined methodology establishes a foundation for developing transferable soft sensors that maintain comparable accuracy while reducing reliance on costly measurement instrumentation.

15:30PM to 17:00PM S8A: IMAGE SENSORS

Room: room1

Chair: Kentaro Iwami (Tokyo University of Agriculture and Technology, Japan)

15:30 High-Speed Volumetric Macro Capture System for Small Moving Objects

Hao Duan, Shaopeng Hu, Feiyue Wang, Kohei Shimasaki and Idaku Ishii (Hiroshima University, Japan)

Volumetric video technology enables the reconstruction of 3D shape and motion from synchronized multi-view image sequences and is widely used in applications such as motion analysis, robotics, and immersive media. However, most existing systems are designed for human-scale targets and are not suitable for capturing fast, unconstrained motion of millimeter-scale objects. To address this limitation, we propose a compact, high-speed macro imaging system based on a two-layer circular camera array. The system comprises 32 high-frame-rate RGB cameras with macro lenses, arranged in upper and lower concentric rings around a 1 cm-scale measurement volume. Operating at 200 fps, the system provides omni-directional coverage, including top and bottom views, with fixed camera calibration. Using conventional multi-view stereo algorithms, it reconstructs time-resolved 3D shape and estimates 6-DOF trajectories of freely moving targets. Experimental validation with a rotating 1 cm-sized, color-textured soybean confirms accurate 3D reconstruction and motion tracking,

demonstrating the system's capability for non-contact, high-precision volumetric capture in dynamic small-object scenarios.

15:48 Model-Based Multi-Modal Volumetric Sensing via Fusion of Stereo HFR, ToF, and Thermal Cameras

Tegar Palyus Fiqar and Feiyue Wang (Hiroshima University, Japan); Kohei Shimasaki (Designated Assistant, Japan); Idaku Ishii (Hiroshima University, Japan)

Multi-modal, non-contact sensing systems have become in-creasingly critical in diverse fields such as biomedical diagnos-tics, structural health monitoring, and manufacturing. These applications often require synchronized measurement of tem-perature, vibration, displacement, and surface appearance. Conventional methods that rely on separate sensors for each modality face challenges in spatial alignment, temporal syn-chronization, and physical integration, particularly when ap-plied to non-rigid or moving targets. In this paper, we present a model-based volumetric capture system capable of simulta-neous three-dimensional (3D) visualization of thermal and vi-brational characteristics. The system integrates stereo high-frame-rate cameras at hundreds of frames per second (fps), a time-of-flight depth camera, and a thermal infrared camera operating at several dozens of fps. The system employs a uni-fied 3D model as a spatial reference to which Multi-modal data are registered. A model-based 3D digital image correlation (3D-DIC) algorithm enables the estimation of small displacements and vibrations in the range of several tens to hundreds of hertz. To demonstrate the effectiveness of our system, thermal mapping is performed on the same 3D model, enabling visuali-zation of the spatial distribution and temporal evolution of both vibration and temperature during the heating and boiling process of an electric kettle.

16:06 Evaluation Using Motion Curved Surface and Skeleton Animation in Sports Movements

Kaoru Mitsuhashi (Teikyo University, Japan)

Quantitatively instructing sports movements often faces challenges, with assessments typically limited to qualitative evaluations or localized kinematic data. We evaluate movement differences between sports experts and beginners using novel motion curved surfaces in this research. Our method uniquely connects human joint positions and time series data to create these surfaces, which visualize velocity, acceleration, and curvature through color gradients. We can represent movement rhythm and timing by analyzing the patterns of velocity and acceleration generation on these motion curved surfaces. Simultaneously, the shape and curvature of the surfaces illustrate movement trajectories. We track full-body joint positions using Microsoft Kinect and convert these trajectories into motion curved surfaces to assess upper-body sports movements like the table tennis forehand stroke. This approach allows for a quantitative clarification of movement distinctions between beginners and experts based on the motion curved surface shape and the observed velocity and acceleration changes.

16:24 Temperature Distribution Estimation for Electrical Connections from an Angle Using a Thermal Camera

Shota Masayasu (Tottori University, Japan); Kazuyuki Hidaka (Kinden Corporation, Japan); Katsuya Kondo (Tottori University, Japan)

A technique is presented for estimating the temperature distribution in thermal images obtained by a thermal camera. This technique considers both the material of the object and shooting angle. Thermal images are used to detect abnormalities in electrical facilities. Although high-resolution thermal images can detect minute temperature changes and abnormalities, they are costly. Furthermore, given that objects are frequently composed of multiple materials, each with a distinct appropriate emissivity, accurate measurement of the temperature with a thermal camera is difficult. The conventional method involves dividing each material into regions using an area segmentation technique and applying the appropriate emissivity to each region. However, in practical applications, taking a picture from the front is not always possible; therefore, the emissivity should be applied considering the shooting angle. To address these issues, this study proposes a high-accuracy temperature distribution estimation method that takes an estimate of the

shooting angle into consideration. Subsequently, it applies the appropriate emissivity and leverages the Swin Transformer for image restoration (SwinIR), to enhance resolution. In an image captured from an oblique viewpoint, the temperature is measured to be higher than the actual temperature due to reflection, to address this issue, a weight map was created and applied to the temperature information.

16:42 Advanced Terahertz Imaging for Non-Destructive Evaluation: Addressing Subjectivity Using PCA and ICA

Hiroto Enjoji, Koichi Ichige and Kaori Fukunaga (Yokohama National University, Japan)

This paper presents an advanced approach to Terahertz Time-Domain Imaging (THz-TDI), specifically designed for non-destructive evaluation and aimed at enhancing objective internal analysis. High-precision sensing is increasingly needed for various industrial and scientific applications, particularly non-destructive THz-TDI for internal object analysis. The current challenge is the subjective signal extraction in THz-TDI imaging. This research proposes using Principal Component Analysis (PCA) and Independent Component Analysis (ICA) to objectively extract features and separate pulses, aiming to create a versatile and objective internal imaging method, validated through clustering of the results.

15:30PM to 17:00PM S8B: SENSORS FOR ROBOTS AND AUTONOMOUS VEHICLES

Room: room2

Chair: Daisuke Mizushima (Aichi Institute of Technology, Japan)

15:30 Sensing-Aware Emotion Recognition: Optimizing Robot Viewpoints for Human-Robot Interaction

Katie Powell and Lei Shi (University of Technology Sydney, Australia); Sarath Kodagoda (University of Technology, Sydney, Australia);

Teresa Vidal Calleja (University of Technology Sydney, Australia)

Social robots are expected to interact meaningfully with humans, yet emotion recognition (ER) continues to pose challenges in human-robot interaction (HRI). To improve recognition and interaction quality, a robot's preparatory behaviors such as positioning and sensing is important. Its ability to interpret emotional cues and adjust its viewpoint can significantly influence the success of the interaction. Most ER models applied in HRI are trained on generic computer vision datasets, which do not reflect the robot's visual perspective during interaction. While some HRI-specific datasets exist, they are often narrow in scope or tailored to a single task or environment. Furthermore, there has been limited investigation into how a robot's viewing angle affects ER, leaving a gap in understanding optimal positioning strategies for HRI. To address these limitations, we present a novel HRI-specific dataset captured via a multi-camera setup simulating robot viewpoints. Using this dataset, we fine-tune an extended ER model (HRI-Emotic), perform model explainability analyses, and investigate optimal sensor angles to inform sensing-aware robot positioning strategies. Our results show that face and body channels become primary sources of emotional information in HRI, while context contributes less. Fine-tuning with HRIspecific data improves average precision across six emotions, and our angle analysis identifies the 0°-60° range as optimal for reliable ER. These findings offer actionable strategies for sensing-aware robot design and adaptive positioning in HRI, contributing to more emotionally intelligent and responsive social robots.

15:48 Guide-LLM: an Embodied LLM Agent and Text-Based Topological Map for Robotic Guidance of People with Visual Impairments

Sangmim Song (University of Technology Sydney, Australia); Sarath Kodagoda (University of Technology, Sydney, Australia); Amal Gunatilake (University of Technology Sydney, Australia); Marc Carmichael (University of Technology, Sydney, Germany); Karthick Thiyagarajan (Western Sydney University, Australia); Jodi Martin (Guide Dogs NSW ACT, Australia)

Navigation presents a significant challenge for persons with visual

impairments (PVI). While traditional aids such as white canes and guide dogs are invaluable, they fall short in delivering detailed spatial information and precise guidance to desired locations. Recent developments in large language models (LLMs) and vision-language models (VLMs) offer new avenues for enhancing assistive navigation. In this paper, using vision sensing, we introduce Guide-LLM, an embodied LLM-based agent designed to assist PVI in navigating large indoor environments. Our approach features a novel text-based topological map that enables the LLM to plan global paths using a simplified environmental representation, focusing on straight paths and right-angle turns to facilitate navigation. Additionally, we utilize the LLM's commonsense reasoning for hazard detection and personalized path planning based on user preferences. Simulated experiments demonstrate the system's efficacy in navigating indoor environments based on user queries, underscoring its potential as a significant advancement in assistive technology. The results highlight Guide-LLM's ability to offer efficient, adaptive, and personalized navigation assistance, pointing to promising advancements in this field.

16:06 Hardware-in-the-Loop (HIL) Based Interoperability Implementation Using Sensors for an Hybrid Electric Vehicles

Gondu Vykunta Vykunta Rao (Birla Institute of Technology and Science, Pilani, Hyderabad Campus, India & Birla Institute of Technology and Science, Deemed University, India); Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad Campus, India)

A safe & secure HIL based hybrid electric vehicle HEV testing is prerequisite for an increasing share of electric mobility development sector. The monitoring, protection and control (MPC) of HEV can be done by sensors, which can improve the reliability & safety. With respective their standards, there were two major challenges in the sensor data interoperability of the HEV such are optional functions and implementation. The assurance and achievement of the measurement and assessment methodologies can be done by interoperability modelling and testing certification. This work proposes a HIL simulation-based interoperability testing method for HEV in the closed-loop MPC

use cases of testing. In this testing method, a sensor connected cord as hardware or device user test (DUT) is connected into the closed-loop MPC application simulation of HEV to test its interoperability with the test of simulation system. The working illustration of IEC 61850-9-2 test case interoperability done by HIL-simulation of 4-pin terminal merging unit (TMU) with Ti-F28379D controller. The test method focuses on major aspects rather than just exchanging the data among 4-pin TMU & protective relay (PR), its tests how the information can be used by PR from the sensors for MPC application. The The time factor considered for both test cases executed at same interval of time in operating the closing and opening of CB at 1.1 is synchronized in both the cases. The testing data further under use for the research application and for BITS WILP students learning from various manufacturing companies and OEM's to develop testing system which helps to achieve interoperability and ultimately, plug- and play of HEV with various sub-systems and sensors integrated for various resources for a hybrid vehicle HEV.

16:24 Visual Marker Search for Autonomous Drone Landing in Diverse Urban Environments

Jiaohong Yao, Linfeng Liang and Yao Deng (Macquarie University, Australia); Xi Zheng (Macquarie University & School of Computing, Australia); Richard Han and Yuankai Qi (Macquarie University, Australia)

Marker-based landing is widely used in drone delivery and return-to-base systems for its simplicity and reliability. However, most approaches assume idealized landing site visibility and sensor performance, limiting robustness in complex urban settings. We present a simulation-based evaluation suite on the AirSim platform with systematically varied urban layouts, lighting, and weather to replicate realistic operational diversity. Using onboard camera sensors-RGB for marker detection and depth for obstacle avoidance-we benchmark two heuristic coverage patterns and a reinforcement learning-based agent, analyzing how exploration strategy and scene complexity affect success rate, path efficiency, and robustness. Results underscore the need to evaluate marker-based autonomous landing under diverse, sensor-relevant conditions to guide the development of reliable aerial

navigation systems.

16:42 Developing a Low-Cost, Real-Time Obstacle Avoidance System to Enhance Powered Wheelchairs with Semi-Autonomous Functionality

Luke Triston and Nasrin Afsarimanesh (Curtin University, Australia); MD Eshrat E. Alahi (Walailak University, Thailand)

Motorized wheelchairs are vital for the mobility of many individuals with disabilities yet navigating complex and obstacle-rich environments remains a significant challenge. This paper presents the development and evaluation of a low-cost, real-time obstacle avoidance system designed for retrofitting existing powered wheelchairs, thereby enhancing user safety and autonomy. The system architecture integrates an Intel RealSense D435i depth camera for 3D environmental mapping and passive infrared (PIR) sensors for detecting obstacles in the camera's blind spots. A Raspberry Pi 5 serves as the central processing unit, leveraging its improved performance to execute a Convolutional Neural Network (CNN) for real-time object detection and classification. The system's modular design ensures broad compatibility with various wheelchair models. A comprehensive experimental evaluation was conducted to compare the performance of six different CNN-based models (including YOLOv11, YOLOv8, and MobileNet) on the resource-constrained Raspberry Pi 5 platform. Performance was assessed based on positional accuracy, obstacle sizing accuracy, and computational refresh rate. Results indicate that lightweight models, such as MobileNet and YOLO11n, offer a superior balance of speed and accuracy for this application, validating the feasibility of using advanced computer vision on low-cost hardware to create practical and accessible mobility solutions.

9:00AM to 10:30AM S9A: SENSORS FOR NOVEL APPLICATIONS

Room: room2

Chair: Anindya Nag (Technische Universität Dresden, Germany)

9:00 Validation of Conductive Resin as Electrode Material in Neuromonitoring with 3D Printed Probes

Marvin Schmid (Institute for Microsystems Technology (iMST), Germany); Sumith Thayambath (Hochschule Furtwangen University, Germany); Hans-Peter Landgraf (HFU Furtwangen University Germany); Volker Bucher (Hochschule Furtwangen & Institute for Microsystems Technology (iMST), Germany); Constanze Kiese (HFU Furtwangen University, Germany)

We conducted a proof-of-concept study for an additively manufactured complex 3D electrode structure for anal neuromonitoring using silver resin. Recent developments in additive manufacturing promise significant advantages for prototyping medical sensors. These prototypes are scalable and customizable, with a variety of biocompatible 3D-printable materials available at reasonable manufacturing costs, and an increasing range of printable conductive materials. However, difficulties arise in reaching stable conductivity in complex electrode configurations. Since reliable conductive properties are key characteristics of biomedical sensors, we aimed to find an experimental set-up that mimics the signal propagation of connective tissue and allows for spatial resolution of signals for rapid self-testing of multi-electrode sensors.

9:18 Non-Intrusive Bio-Derived LIG-Based Level Sensing Systems

Harija H (Technical University Dresden, Germany); Payel Majumdar and Anindya Nag (Technische Universität Dresden, Germany); Andreas Richter (TU Dresden, Germany); M. Ercan Altinsoy (Dresden University of Technology, Germany)

The paper presents the fabrication and implementation of non-contact laser-induced graphene (LIG)-based level sensing systems. The LIG has been formed from cork substrates to induce sustainability and biocompatibility of the sensing systems. LIG-based sensors have been highly effective for multimodal applications due to their ease of customisation, rapid fabrication, quick response, and high sensitivity. These LIG-based sensors have been used as non-contact sensors to detect the changes in fluid level. The sensors were embedded in signal-conditioning circuitry for real-time applications. The results presented in this paper provide proof of concept for utilising these prototypes for precise liquid level measurements in industrial applications.

9:36 Method for Extending Measurement Range of Self- Coupling Modulated Laser Sensor Using Signal Offset Pattern Analysis

Daiki Sato and Norio Tsuda (Aichi Institute of Technology, Japan)

In this paper, we explain a relation between the variation in offset direction of the detected signal and signal frequency based on the self-coupling effect of semiconductor laser and propose a method to extend the effective measurement range as instrumentation. self-coupling laser sensor is an interferometer that perform measurement using optical beat signal generated by interference between the return light from the target and the light within the active layer of the laser diode during laser irradiation. Self-coupling laser sensor having modulation drive can be used to measure various parameters such as distance to the target, velocity, and direction of movement. However, when the Doppler shift of the return light due to target movement is large relative to the signal frequency, the signal frequency may invert, potentially causing critical measurement errors. As a countermeasure, we devised a signal processing method that detects signal frequency inversion based on the relationship between fluctuations in the signal offset direction and the signal frequency, resulting in accurate measurement outputs. We observed signal waveforms under strong Doppler shift conditions where signal frequency inversion is possible and confirmed that signal frequency inversion can be detected from the resulting offset patterns.

9:54 Stress Sensing in Pedicle Screw: A Simulation Approach

Ankita Kar (Indian Institute of Technology, Madras, India); Boby George and Chinthaka Pasan Gooneratne (Indian Institute of Technology Madras, India); K. Karthik Kailash (Sri Ramachandra Institute of Higher Education and Research, India); Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

Pedicle screw fixation is a widely adopted technique for spinal stabilization, yet mechanical failure due to excessive stress concentration remains a significant concern in long-term clinical outcomes. This study investigates the stress distribution within a functional pedicle screw under physiologically relevant loads and explores the feasibility of integrating real-time sensing mechanisms for in vivo monitoring. A novel experimental approach was used to identify potential locations for sensor placement, with the objective of capturing representative stress patterns without compromising the structural integrity of the screw. Finite element analysis was performed under a range of physiological boundary conditions; however, a reference axial load of 500 N (51kg) was selected for a detailed evaluation. The findings highlight critical stress concentration zones and propose optimal sensor placement regions, thereby offering insights into the design of smart pedicle screws capable of continuous load monitoring. This work contributes to the advancement of smart spinal implants that can improve postoperative assessment and improve patient outcomes through early detection of implant overload.

9:00AM to 10:30AM S9B: SENSORS DATA PROCESSING WITH ML/AI

Room: room1

Chair: Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

9:00 Cost-Optimized Multi-Sensor Fault Diagnosis of Induction Motors Using CNN and Wavelet Feature

Kommanaboina Mahender (Birla Institute of Technology and Science Pilani Hyderabad Campus, India); Divyajot Singh (BITS Pilani Hyderbad Campus, India); Radhika Sudha (Birla Institute of

Technological Sciences, Pilani, Hyderabad Campus, India); Sabareesh Gr (BITS-Pilani, Hyderabad Campus, India); Takehito Azuma (Utsunomiya University, Japan)

Ensuring the operational reliability of induction motors is essential for industrial systems, where unexpected faults can lead to significant downtime and economic loss. This paper presents a multi-sensor fault diagnosis framework that leverages wavelet-based feature extraction and machine learning models, Support Vector Machine (SVM), Convolutional Neural Network (CNN), and XGBoost for accurate classification of rotor and stator faults under varying severity levels (0%, 25%, 50%, 75%). Sensor data from three-phase voltage, three-phase current, and triaxial vibration signals were collected under controlled loading conditions. Discrete Wavelet Transform (DWT) was used to extract robust time-frequency features. A comparative study of different sensor configurations and models revealed that CNN achieved the highest fault classification accuracy (up to 99.1%) with fused sensor data, while XGBoost offered strong generalization with efficient training. Additionally, a cost-performance analysis demonstrated that a dual-sensor setup (current + vibration) maintained high diagnostic accuracy about 98.6%, while reducing deployment costs by over 25%. The proposed system supports real-time condition monitoring and aligns with Industry 4.0 goals by balancing sensing accuracy and economic feasibility, making it ideal for scalable industrial applications.

9:18 Short-Term Forecasting of Electrical Power Demand Using Nonlinear μ-Marcov Models

Yusaku Matsumoto (Utsunomiya University, Japan); Takehito Azuma (Utsunomiya University, Japan)

In this paper, a method to forecast electrical power demand is proposed based on the μ-Marcov model, which are one of the nonlinear models. The system identification problems of the proposed μ-Marcov models are solved based on the least-squares estimation problem. The effectiveness of the proposed method is shown based on the short-term power demand forecast.

9:36 Nonlinear Temperature Forecasting Using Polynomial AR Models Based on Least Squares Methods

Sodai Yokota (Utsunomiya University, Japan); Takehito Azuma (Utsunomiya University, Japan)

The article considers temperature forecasting based on nonlinear AR models. Polynomial AR models are introduced as a kind of nonlinear AR models. System identification problems of the polynomial AR models are reduced to least squares problems using multiple output data if the nonlinear functions are assumed to be polynomial. A numerical example is shown to demonstrate the effectiveness of the proposed method about temperature forecasting in Tokyo.

9:54 A Formal Framework for Ethics-by-Design in AI Entertainment Systems

Sonika Arora, Prashanth Josyula and Ankit Rajput (Salesforce, USA)

In this work, we outline a layered architecture aimed at building AI-powered entertainment systems that have ethics woven in from the ground up. The framework is split into five distinct layers, each addressing specific concerns, ranging from bias in algorithms to privacy safeguards and the need for transparency. Rather than just listing these layers, we connect them through a mathematical foundation and back them up with formal proofs that show the design can scale, remain composable, and uphold ethical integrity across the system.

We also looked closely at the cost of adding these ethical checks. The analysis shows they introduce only a polynomial-time overhead, expressed as $O(|E| \cdot |U| \cdot \log |C|)$, which means the approach holds up even for large-scale deployments. To make this practical, we developed new algorithms that can integrate constraints on the fly and trigger interventions in a structured hierarchy, both with guaranteed convergence.

Theory is one thing, but we also wanted to see this work in practice. A complete implementation was built and tested on 3,440 decision

requests. The results showed very low latency, with an average of 0.19 ms and minimal variance, high throughput of up to 6,320 requests per second, and a perfect record in applying interventions whenever an ethical breach was detected.

Because the framework is compositional, developers can work on different parts without breaking system-wide ethical properties. To make this concrete, we present three entertainment-related scenarios in detail and outline patterns for implementation. We believe that this approach provides a solid foundation, both theoretical and practical, for creating AI entertainment systems that are ethical by design and not as an afterthought.

10:12 AI/ML Based Video Sensing Technologies for Tornado Speed Determination and Prediction from the Windborne Debris Captured in the Tornado

Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad Campus, India); Masahiro Matsui (Tokyo Polytechnic University, Japan); Yukio Tamura (Chongqing University, China); Sabareesh Gr (BITS-Pilani, Hyderabad Campus, India); Anbumani P (Birla Institute of Technology and Science, India)

For past few decades here have been tremendous increase in unpredictable meteorological events, like tornadoes, cyclones etc. Although short lived, the most disastrous tornadoes among them caters maximum losses. The level of damage is determined based on the speed of the tornado, which is conventionally determined using doppler radar, photogrammetry, and analyzing debris trajectories, has their own risks. The current work aims to estimate and predict the speed of a tornado by using object tracking techniques in Machine Learning aided by video sensing. The tracking object will be any wind-borne debris captured inside the moving tornado. The relative speed of this object with respect to the tornado speed is considered for estimating the speed of the tornado. To increase the database to fine tune the speed estimation and prediction of Tornado speed using AI/ML algorithms, Tokyo Polytechnic University, Tokyo, Japan, Tornado Simulator facility has been utilized. Hence a risk less tornado speed determination and

prediction are done from the captured video of the tornado in the Tornado simulator. Fine-tuning object detection and tracking is done using CNN (Convolutional Neural Network) based LSTM (Long Short-Term Memory) and on validation with the actual speed generated by the Tornado simulator, a correlation of 0.98 is observed.

11:00AM to 12:30PM S10A: MECHANICAL, MEMS AND VIBRATION SENSORS

Room: room2

Chair: Robert N Dean (Auburn University, USA & University of Waikato, New Zealand)

11:00 Dynamic Scaling Immersion and Invariance Adaptive Control of MEMS Gyroscope with Disturbance Observer

Wesley Fei (University of Science and Technology of China, China); Jiapeng Xie and Juntao Fei (Hohai University, China)

In order to ensure that the proof mass of the MEMS gyroscope maintains the desired vibration modes, this paper proposes a dynamic scaling immersion and invariance adaptive control with a disturbance observer. To address the problem of the integrability obstacle, the parameter regression matrix is reconstructed by introducing auxiliary variables to substitute the relevant parameters to achieve the integrability of the parameter regression matrix. In addition, a new type of scaling factor is used to eliminate the effect of the construction error of the parametric regression matrix. A disturbance observer is designed to compensate the disturbances, which effectively improves the robust ability of the system. A robustness modification term is added to the original parameter adaptive laws, which ensures that the system errors and the parameter estimation errors are uniformly ultimately bounded when the system is disturbed. Simulation results confirm the effectiveness of the control method designed, showing the system exhibits good tracking performance and maintains a small tracking error.

11:18 Graphene-Integrated Paper-Based Sensors for Pressure Sensing Applicationsr

Aniket Chakraborthy, Ananya Mukherjee, Swarup Bose, Suresh Nuthalapati and Anindya Nag (Technische Universität Dresden, Germany); M. Ercan Altinsoy (Dresden University of Technology, Germany)

The paper presents the fabrication and implementation of low-cost paper-based sensors. Facile technology has been utilised to develop graphene-integrated paper-based sensors for pressure-sensing applications. Graphene has been a pivotal element in flexible electronics due to its exceptional electromechanical characteristics. The conjugation of graphene with paper allows the formation of simple, non-invasive sensors for low-vibration pressure sensing. The results presented in this paper highlight the efficiency of the sensors in terms of reproducibility and stability of the responses. These results can serve as a foundation for developing paper-based commercial sensors for low-vibration sensing applications.

11:36 A Cylindrical Electrical and Ultrasonic Multi-Imaging System Based on Piezoelectric Composites

Akira Kimoto and Yui Adachi (Saga University, Japan)

In this paper, an ultrasonic and electrical multi-imaging system which consists of sixteen piezoelectric composites is developed. This system makes it possible to reconstruct both ultrasonic and electrical images of the living body since the piezoelectric composite has low acoustic impedance as one of the characteristics. Ultrasonic waves are measured by piezoelectric composites which are directly contacted to the living body, and the electrical conductance are measured by using the surface electrodes of piezoelectric composites. From their measured values, ultrasonic and electrical images are respectively reconstructed. In addition, the information of the living body is clearly detected since the electrical imaging is improved by using the ultrasonic image. In the experiment, the ultrasonic and electrical images at the

living body model which plaster was inserted in 0.1 % NaCl solution tank were demonstrated by the developed multi-imaging system. The system was evaluated.

11:00AM to 12:30PM S10B: SENSORS SIGNAL PROCESSING

Room: room1

Chairs: Takehito Azuma (Utsunomiya University, Japan)
Jesus Corres (Universidad Publica de Navarra, Spain)

11:00 Connector Fitting Judgment Using Intersections Magnitude and Autoencoders

Ryusho Itoh, Kotone Sato, Mako Sasaki and Koichi Ichige (Yokohama National University, Japan); Hirotatsu Matsuo, Atsushi Ugaji, Matsutaro Hata and Kazuhiro Motomura (Nissan Motor Co., Ltd., Japan)

This paper proposes a connector fitting judgment method using vibration data collected during the automobile assembly process. It employs Intersections Magnitude (IM) with moving average and Attenuation Rate (AR) as features, reconstructs data using an Autoencoder, and judges fitting based on the Reconstruction Error (RE). This achieves high-accuracy judgment for various connectors and contributes to reduced processing time.

11:18 FUSleepNet: A Dual-Branch Time-Frequency Fusion Network for Sleep Stage Classification

Zhaonian Guo, Xiang Li and Zhiheng Zhang (The Chinese University of Hong Kong, Shenzhen, China); Xin Wang (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China); Ke Zhang and Shixiong Chen (The Chinese University of Hong Kong, Shenzhen, China)

Automatic sleep staging plays a crucial role in diagnosing sleep disorders and understanding brain dynamics during sleep. Traditional

manual scoring is time-consuming and prone to inter-rater variability, motivating the development of data-driven solutions. In this paper, we propose a dual-path deep learning model for sleep stage classification based on single-channel EEG. The FUSleepNet (Fusion U-Sleepnet) model extracts temporal features using Bi-LSTM and spectral features via spectrograms, which are then fused using a U-Net architecture to leverage both local and global information. Experimental results on the Sleep-EDF-78 and Sleep-EDF-20 dataset using 20-fold cross-validation demonstrate that our model achieves improved performance across multiple metrics, with an Accuracy of 90.2%, Macro F1-score of 77.7%, and Cohen's Kappa of 76.2% on Sleep-EDF-78, Accuracy of 92.1%, Macro F1-score of 80.4%, and Cohen's Kappa of 79.7% on Sleep-EDF-20.

11:36 A Hyper-Local Two-Stage Machine Learning Framework for Soil Classification and Nutrient-Aware Crop Recommendation

Sahil Rajadhyaksha, Preksha Koli, Sanskruti Sankhe, Durgesh Dere, Shrut Patil and Sheetal Vilas Mapare (Vidyalankar Institute of Technology Mumbai, India)

Precision farming is a necessity for achieving sustainable agriculture, especially in contexts where smallholder producers contend with soil heterogeneity, nutrient deficiency, and declining productivity. Typical practices based on generalized recommendations or farmer intuition cannot keep pace with this level of diversity. Conventional methods fail to capture micro-level variety. This paper outlines an ML-based integrated soil image classification and nutrient-related prediction system for cropping systems. In contrast to unimodal CS frameworks, where Convolutional Neural Networks (CNNs) solely recognize soil texture and ensemble models characterize nutrient profiles, we leverage a combination of both the visual and the chemical modalities for a precise and scientific solution for the local farmers of Palghar. In this paper, we introduce a unique ML framework that integrates soil imagery with nutrient profiling, based on a fully curated dataset from different areas of Palghar. Our soil classification system consistently performed better than standard baseline algorithms and was robust

through real agriculture applications. With intended usage in real environments with low-cost NPK sensors and a smartphone, the system provides a scalable, farmer-centric, and resource-efficient path toward sustainable crop planning.

11:54 DSTSFN: A Dual-Path Dynamic-Static Feature Fusion Network for Robust Epileptic Seizure Detection

Zixin Yang III (The Chinese University of HongKong (Shenzhen), China); Xiang Li, Zhaonian Guo, Chuqi Yang and Ke Zhang (The Chinese University of Hong Kong, Shenzhen, China); Changmiao Wang (Shenzhen Research Institute of Big Data, China); Shixiong Chen (The Chinese University of Hong Kong, Shenzhen, China)

Epilepsy, a critical neurological disorder with sudden, recurrent seizures, severely impacts patients' daily lives, cognitive abilities, and emotional well-being, necessitating advanced detection methods for timely interventions. We propose the Dynamic and Static Temporal-Spatial Feature Network (DSTSFNet), a dual-path network that integrates dynamic temporal variations and static spatial patterns from EEG signals, using spatio-temporal attention mechanisms to accurately capture complex seizure dynamics. The model employs Temporal Convolutional Networks (TCN) to model short-term changes and Spatial-Attention with Pearson Correlation Coefficients to highlight inter-channel relationships, ensuring a thorough EEG analysis. Evaluated on the CHB-MIT dataset, comprising EEG recordings from 22 pediatric subjects at 256 Hz, DSTSFNet achieves an accuracy of 99.19%, a sensitivity of 99.30%, and a specificity of 98.97%, showing its potential for clinical diagnostics and improved patient care.

12:12 Hybrid Meta-Ensemble Learning for High-Frequency Price Forecasting in the Australian National Electricity Market

Michael Panagopoulos (University of Technology Sydney, Australia & Transperfect, Australia); Zeyang Zhou (University Technology Sydney, Australia); Thomas Storey (University of Technology, Sydney,

Australia); Karthick Thiyagarajan (Western Sydney University, Australia); Catarina Pinto Moreira and Mukesh Prasad (University of Technology Sydney, Australia)

Australia's National Electricity Market presents complex forecasting challenges driven by five-minute settlement intervals, extreme price volatility, and increasing renewable integration. This study develops the TriModal MetaBoost framework as an intelligent sensing approach for short-term market prediction. The framework combines Long Short-Term Memory networks, XGBoost, and Random Forest models through a meta-regressor to detect and interpret nonlinear dynamics in high-frequency market signals. Using nine years of data across five regions, it achieved superior accuracy in three markets compared to eleven baselines and four hybrid methods. The results highlight the role of advanced sensing-driven ensembles in supporting reliable forecasting, risk management, and decisionmaking during Australia's renewable energy transition.

13:30PM to 15:00PM S11: CLOSING CEREMONY & AWARDS, FAREWELL RECEPTION

Room: room1

Chairs: Takehito Azuma (Utsunomiya University, Japan),

Subhas Chandra Mukhopadhyay (Macquarie University, Australia)