ICST2024

Conference »Program

2024 17th International Conference on Sensing Technology (ICST) Program

Sydney time	Monday, December 9	Tuesday, December 10		Wednesday, December 11
8:30 - 9:00		*Late Registrations*		
9:00 - 9:30	S0: *ICST 2024 Opening*			
9:30 - 10:00		S5A: *Gas Sensors* S5B: *Sensors for Home and Activity Monitoring*		S9A: *Sensors for Novel Applications II* S9B: *Special Session IV*
10:00 - 10:30				
10:30 - 11:00	S1: *Keynote 1 & 2*			
11:00 - 11:30				
11:30 - 11:45		S6A: *Thermal and Chemical Sensors*	S6B: *Senors Applications in Challenging Environment*	
11:45 - 11:54				S10: *Special session - Women in Sensing workshop*
11:54 - 12:12	S2A: *Bio-sensors* S2B: *Optical Sensors*			
12:12 - 12:30				
12:30 - 12:39				
12:39 - 13:30				S11: *Closing Ceremony & Awards during LUNCH*
13:30 - 14:00		S7: *Keynote #3 and Tutorial talk*		
14:00 - 15:15	S3A: *Sensors for Environmental Monitoring* S3B: *Magnetic, Inductive and Capacitive Sensors*			
15:15 - 15:30				
15:30 - 15:45				
15:45 - 16:00		S8B: *Sensors for Robots and Autonomous Vehicles*	S8A: *Sensors for Novel Applications I*	
16:00 - 16:57	S4A: *Special session: Bio-med Applications and Medical Devices* S4B: *WSN and IOT*			

16:57 - 17:12

17:12 - 17:15

Monday, December 9

Monday, December 9 9:00 - 9:30

S0: ICST 2024 Opening

Subhas Mukhopadhyay

Monday, December 9 10:00 - 11:30

S1: Keynote 1 & 2

Prof. Judith Dawes, Macquarie University, Australia on Applications of nanoparticles in sensing
Dr. Neil Weste, MORSE Micro, Australia on HaLow WiFi for IoT Sensor Node

Abstract#1: The sensitive and quantitative detection of trace amounts of specific molecules or cells is important for biomedical applications. Nanoparticles can be readily introduced into solutions and tissues, and can be located and observed with light. We have developed and characterised luminescent nanoparticles, and used them for labelling and microscopy. We have also investigated the collective phenomena that arise in random lasers consisting of nanoparticles with various gain materials. The laser action amplifies the optical response, leading to improved detection of trace molecules in solution.

Abstract#2: This talk will outline the use of a new WiFi technology called HaLow (or IEEE 802.11ah). In particular, a single chip solution from Morse Micro in Surry Hills will be described. Then some real world applications will be summarized.

Monday, December 9 11:45 - 12:39

S2A: Bio-sensors

S2A.1 11:45 ***Biofluorometric Sensor and Imaging System for Volatile Chemicals (Acetone and Ethanol)***

Kohji Mitsubayashi, Zhang Geng and Kenta Ichikawa (Tokyo Medical and Dental University, Japan); Kenta Iitani (Tokyo Medical and Dental University & Japan Society for Promotion of Science, Japan)

A biofluorometric sensor for acetone vapor was developed using S-ADH (secondary alcohol dehydrogenase) reverse reaction by detecting NADH fluorometric system. The S-ADH biosensor was possible to continuous measure gaseous acetone from 20 to 5300 ppb with a good selectivity based on the enzyme specificity. The device allows to use the evaluation of the acetone concentration in exhaled air from healthy subjects and diabetes patients (type I & II). Additionally, to develop a novel transcutaneous gas sensor, a biofluorometric sniff-cam (gas imaging system) for ethanol (as model analyte) was also constructed with ADH (alcohol dehydrogenase) immobilized mesh and the NADH visualization unit (UV-LED sheet array & highly sensitive CCD), thus imaging human ethanol vapor not only exhaled air but also skin gas after drinking. Based on these results, novel wearable biosensor would be developed for non-invasive monitoring the transcutaneous volatile biomarkers from blood vessels.

S2A.2 12:03 ***Exploring the Enhancement Effect of Dithiothreitol on CRISPR/Cas12b Biosensing System***

Ruier Xue and Fei Deng (University of New South Wales, Australia)

Biosensors are essential for early diagnoses and effective disease management by enabling rapid and accurate detection of specific biomarkers. However, achieving high sensitivity and accuracy with simplicity and accessibility remains challenging with current CRISPR/Cas technologies, hindering their clinical diagnostic applications. To address this issue, this study investigates the chemical enhancement effect of dithiothreitol (DTT) on the trans-cleavage activity of Cas12b nucleases. Our optimised biosensing system demonstrated elevated fluorescence intensity levels after 30 minutes of thermal incubation, indicating enhanced trans-cleavage efficiency on fluorescent-quench reporters. The DTT-assisted CRISPR/Cas12b system significantly enhances sensor performance by achieving a tenfold improvement in its detection limit, offering a precise, sensitive and rapid tool for detecting nucleic acid targets. This advancement in CRISPR/Cas-based biosensing technology provides a promising approach for more accurate and efficient point-of-care diagnoses.

S2A.3 12:21 ***Biosensor for Automatic Adventitious Respiratory Sound Analysis***

Hakilo Sabit (Auckland University of Technology, New Zealand)

This paper explores the development of a biosensor device coupled with a digital signal processing application to automatically record and analyze adventitious respiratory sounds. These sounds, crucial for diagnosing respiratory conditions such as COPD, asthma, upper respiratory tract infections, and Covid-19, are challenging to interpret using traditional stethoscopes. The project aimed to create a hardware device for capturing high-quality respiratory sounds and a MATLAB application for their analysis, enhancing diagnostic accuracy and efficiency. A functional prototype was developed, capable of capturing respiratory signals. However, it exhibited a significant noise floor, complicating the extraction of relevant sounds, and did not fully meet medical use criteria. The GUI provided visual plots but lacked automated diagnostic features, requiring user discretion for diagnosis. Despite these limitations, the device showed compatibility with the Thinklabs One digital stethoscope, indicating potential with further optimization. The project was completed within budget and demonstrated satisfactory progress given the timeframe and budget constraints.

S2B: Optical Sensors

S2B.1 11:45 ***Rotary Sliding Movement Mechanism using a Hinge with Out-of-plane Deformation for Parallel Mobile Optical Devices***

Satoshi Ikezawa, Taiki Sugihara and Eiji Iwase (Waseda University, Japan)

Rapidly improving demand for small, flat optical sensor systems that require not only the miniaturization of lenses but also the miniaturization and integration of the optical system. Currently, special actuators are needed to drive the lenses, which is an obstacle to miniaturization and simplification of the sensor system implementation. Therefore, a simple and efficient planar drive strategy for thin lenses is required to utilize the variable focus property of the lens fully. This study proposes a new lens-to-drive approach based on kirigami that takes advantage of paper-like flat lenses. This drive structure is designed to form three regions: a beam, a hinge, and a device. The beam is subjected to a stretching force, which causes an out-of-plane deformation of the hinge, thereby rotating the lens support surface connected to the hinge. In doing so, the face slides slightly with the rotational motion, and this sliding mechanism is used to realize the sliding mechanism of the Alvarez lens pair. This kirigami structure has the potential to customize the shape of the device area to achieve more functionality.

S2B.2 12:03 ***Structural Vibration Monitoring Using a Cantilever-Type Hetero-Core Fiber Optic Accelerometer with Aluminum Terminal Coating***

Atsuki Hirose and Miyuki Kadokura (Soka University, Japan); Kazuhiro Watanabe (Soka University Japan, Japan); Michiko Nishiyama (Soka University, Japan)

In this study, we assessed the frequency response and amplitude response characteristics of a cantilever-type hetero-core fiber optic accelerometer with an aluminum coating. Additionally, its performance in dynamic monitoring and applicability to modal analysis were investigated using a cantilever beam. This optical fiber-based accelerometer is resistant to electromagnetic interference and environmental conditions. The proposed accelerometer features a hetero-core fiber optic sensor that remains stable despite temperature fluctuations, making it ideal for outdoor structural health monitoring. Unlike conventional designs, this accelerometer incorporates aluminum deposition. Experiments were carried out using a shaker to validate its characteristics. Furthermore, for dynamic monitoring and modal analysis, the accelerometer was attached to a 600, 800 mm cantilever beam and subjected to impulse hammer excitation. The results indicated that the measurable frequency range is up to 180 Hz, with the sensor's resonance frequency at 380 Hz. Furthermore, it was found that natural vibrations of the structure can be detected within the frequency range up to 100 Hz.

S2B.3 12:21 ***Evaluation of Refractive Index Characteristic of Fiber Optic SPR Sensor Deposited with Graphene Oxide***

Dowon Kang (SOKA University, Japan); Kazuhiro Watanabe (Soka University Japan, Japan); Michiko Nishiyama (Soka University, Japan)

The fiber optic SPR refractive index sensor is a sensor that generates SPR by depositing a noble metal thin film such as Au, Ag on the outside and can react and detect changes in external refractive index. Meanwhile, graphene oxide (GO) has the effect of strengthening SPR because of its inherent advantageous properties. We experimentally evaluated the sensitivity of the sensor by forming poly-l-lysine and GO using the layer-by-layer method on the hetero-core fiber optic SPR sensor. As a result, the sensitivity increased.

Monday, December 9 14:00 - 15:30

S3A: Sensors for Environmental Monitoring

S3A.1 14:00 ***Application Research of Wireless Sensor Networks in Space Science Experiment Environment Monitoring of Chinese Space Station***

Yuxue Guo (Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, China); Hongen Zhong (Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences); Yanmei Jia (Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, China); Yu Li (Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences)

Space science experiments have a high demand for the measurement of environmental parameters. Real-time, high-precision and in-situ environmental measurement data need to be obtained in the experiment process. At the same time, microgravity, radiation, magnetic field, temperature, humidity and other parameters will affect the results of scientific experiments in the research direction of life science, material science, basic physics and other research directions. At present, the measurement method of environmental parameters used in space science experiments is mainly wired sensor measurement, which has the advantages of sufficient energy supply and simple information transmission. However, there are also problems such as large weight and power consumption demand, inconvenient cable deployment and so on. This paper analyzes the measurement requirements of

space science experiment environment, studies the development of wireless technology and wireless sensor network, and puts forward the concept of deploying wireless sensor network in space. Using wireless sensor networks to measure environmental parameters has the advantages of saving costs, real-time measurement in situ, and reducing cable operation.

S3A.2 14:18 ***A Learning Model for Hyderabad AQI based on Social Behaviour***

Manisha Kumari, RK Sanayaima Singh and Nagender Kumar Suryadevara (University of Hyderabad, India); Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

The interdisciplinary project tasks involve the need for indices that can express the way society perceives their environment in a simplified manner. The social perceptions of air quality, which explains the rising importance of participatory science in our understanding of the atmosphere with the Internet of Things theme, shall be presented. The various techniques for estimating particulates and incorporating those estimations into a solitary air quality file for reducing different toxins shall be revealed. The techniques for estimating particulates and their incorporation into different records, so as to make a move to alleviate the wellbeing effects of air contamination, and the need for considering the social impression of air contamination to get snared inside our logical estimations will be described. To study the AQI, we collected the PM2.5 and PM10 concentrations of five different locations of Hyderabad. The historical data contains the pre, post, and during COVID-19 pandemic years. In this study, we observed a trend and seasonality in the concentration of pollutants during the months of June through October, indicating a low concentration of PM2.5 and PM10 in this period. Also, the annual average of pollutants tends to be lower during the COVID-19 period. Further, we observed that there is correlation between pandemic and post pandemic years in the concentration of pollutants which may signify the change in social behavior post pandemic. The weak negative correlation between pre-pandemic and post-pandemic may indicate the social behaviour changes.

S3A.3 14:36 ***Ionic Hydrogel ECG Electrode for Aquatic Environments***

Cheng Huan Lu, Derek Orbaugh and Xavier Vrijdag (Auckland University, New Zealand); Iain Anderson (University of Auckland, New Zealand)

The risks of diving have been discussed as a critical problem due to the aging diving population. According to the Divers Alert Network (DAN) 2020 estimates, over 40% of underwater illnesses are related to the heart. Monitoring the heart rate of divers underwater and create a warning system would reduce the number of diving accidents. However, it remains a challenge to reliably measure heart rate in the aqueous environment due to the underwater signal detection and transmission. In this study, we report on the development of a mussel-inspired PAA/DA/ChCl hydrogel designed for usage in saltwater environments Our results demonstrate its favorable characteristics, including good swelling ratio and wet adhesion properties in saltwater. Additionally, to assess its practical viability, this ionic-based hydrogel was evaluated in a diver physiological monitoring system as an ECG electrode for real-time underwater heart rate monitoring in both salt and freshwater, under static and dynamic conditions. Consequently, our findings suggest the material's potential for capturing underwater impedance signals and its suitability for integration into future underwater warning systems.

S3A.4 14:54 ***Application of LoRa Technology for assessment of Indoor air quality in work environment***

Abhishek Mitra (Qantec Automation, Australia); Gautam Chattopadhyay (Novel Aquatech, Australia); Deep Bhattacharyya (Microsoft, USA)

The application of Long Range (LoRa) technology in assessing indoor air quality (IAQ) offers a cost-effective and efficient solution for monitoring environmental conditions within work environments. LoRa, a low-power, long-range wireless communication protocol, enables the deployment of extensive sensor networks capable of real-time data collection and transmission over large areas with minimal infrastructure. This technology is particularly suited for assessing IAQ due to its ability to support a

wide array of sensors that measure parameters such as temperature, humidity, carbon dioxide (CO_2) levels, particulate matter (PM), volatile organic compounds (VOCs), and other pollutants. By leveraging LoRa networks, organizations can continuously monitor air quality across multiple locations, facilitating proactive management and ensuring compliance with health and safety standards. In this work the data collected through LoRa-based systems has been integrated in cloud platforms for advanced analytics, providing actionable insights to improve ventilation, optimize HVAC operations, and enhance overall workplace wellbeing. The scalability, energy efficiency, and robustness of LoRa make it an ideal choice for industries seeking to implement sustainable and smart IAQ solutions that contribute to a healthier work environment and increased employee productivity. Occupant productivity can be directly related to the occupants' perception of the IAQ. In this study occupants' perception was captured by asking a set of questions and collecting response for each question in a scale of 1 to 7. Indices were calculated based on the occupant response and the results have been presented.

S3A.5 15:12 ***Development and Performance Evaluation of a Low-Cost Multi-Sensor RF Tag for Real-Time Environmental Monitoring***

Hafsa Anam, Subhas Chandra Mukhopadhyay, Syed Muzahir Abbas and Iain B. Collings (Macquarie University, Australia)

Sensing multi parameters is a significant challenge in wireless and IoT networks. We have proposed a smart low-cost multi sensor chipless RFID tag in this research. The sensor tag operates at a frequency of 11.25 GHz, while the temperature-sensitive tag functions at 5.5 GHz. The tag has been analyzed for stepwise temperature increment from 25°C to 100°C, whereas humidity is monitored from 0%RH to 100%RH levels. Kapton HN substrate is utilized for RH monitoring whereas Rogers RT/Duroid 6010.2LM is used as temperature sensitive substrate. Heat resistant Kapton HN tape is deployed over temperature sensitive tag slot to analyze sensitivity and selectivity of proposed sensor tag. The sensing behavior of tag is reliable and finds suitable applications towards IoT and sensing applications. This research underlines the potential of wireless smart tags to revolutionize IoE connectivity.

S3B: Magnetic, Inductive and Capacitive Sensors

S3B.1 14:00 ***Experimental studies on the magneto-mechanical memory signals of X80 pipeline steel based on orthogonal four-direction magnetic sensor arrays***

He Dang and Jianchun Fan (China University of Petroleum - Beijing, China); Laibin Zhang (China University of Petroleum-Beijing, China); Fumin Gao (China University of Petroleum (Bei Jing), China); Wenlan Chen (China University of Petroleum (Beijing), China); Jie Huang (China University of Petroleum - Beijing, China)

The magneto-mechanical memory (MMM) technique is an effective non-destructive testing method for identifying stress concentrations in ferromagnetic materials. However, the MMM signal is susceptible to both the ambient magnetic field and the initial magnetization of the detected regions, making it difficult to accurately assess the stress concentration levels. In this paper, elastic and plastic tensile experiments were conducted to investigate the magneto-mechanical coupling effect of X80 steel specimens under the local stable alternating magnetization condition provided by a custom magnetic yoke with excitation coils. The use of designed orthogonal four-direction magnetic sensor arrays eliminated the influence of the object edge effect and improved the stress detection results of the MMM technique. The trends of the magneto-mechanical coupling curves along the stress direction showed good consistency under the stable magnetization excitation, and the part of the curves below 75 MPa has a strong linearity. The initial magnetization states significantly affect the curve trends perpendicular to the stress direction. The different magneto-mechanical coupling behaviors in different

directions can support each other and enhance stress detection accuracy. This work can provide new insights and theoretical support for quantitative stress detection based on the MMM technique.

S3B.2 14:18 ***A Stress Detection Method Utilizing Magnetic Memory Effect with Consideration of Initial Remanence***

Wenlan Chen (China University of Petroleum (Beijing), China); Jianchun Fan (China University of Petroleum - Beijing, China); Fumin Gao (China University of Petroleum (Bei Jing), China); He Dang and Jie Huang (China University of Petroleum - Beijing, China)

Magnetic memory sensors utilizing the magneto-mechanical effect have been investigated for their capability to measure stress. To address the limitations encountered in previous studies where certain issues could not be quantified, additional constraints were applied. Experimental results using X80 tubing steel indicate that variations in the initial remanence of the sample significantly influence the magnetic field increment induced by stress. Specifically, as stress increases, samples with low initial remanence exhibit a markedly weaker magnetic field increment compared to those with high initial remanence. Furthermore, a slight increase in the incremental slope was observed in control groups with similar initial remanence. Consequently, it is imperative for magnetic memory sensors to account for the initial remanence of the device when measuring stress. By applying the principles of the magneto-mechanical effect, these sensors are anticipated to provide precise stress measurements.

S3B.3 14:36 ***A Novel Kirigami-patterned and stretchable Conductive fabric-based Piezoresistive strain sensor***

Harija H (Technical University Dresden, Germany & Indian Institute of Technology Madras, India); Aniket Chakraborthy (Technische Universität Dresden, Germany); Artem Prokopchuk, Enrico Langer and B. Saran (TU Dresden, Germany); Suresh Nuthalapati (Technische Universität Dresden, Germany); Hans Winger (TU Dresden, Germany); 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 characterization of low-cost, highly sensitive fabric-based sensors. Novel Kirigami patterns were formed on conductive fabrics using a laser patterning process. Conductive fabrics have been essential in forming efficient strain sensors due to their high mechanical flexibility, biocompatible nature, and tolerance to washability. They have been used to create flexible prototypes measuring gross and fine motor skills. Silitex® is one of the conductive fabrics that has been very new in the sensing sector, and not much work has been done yet. The developed sensors are a proof-of-concept with a Kirigami pattern. The design, development, and characterization of these prototypes have been presented here. The results have provided a base for deploying these sensors for fully-functionalized strain sensing systems.

S3B.4 14:54 ***An Inductive Sensor for Independent Estimation of the Level and Inclination of Enclosed Liquids***

Narayanan P P and Srikar Emany (Indian Institute of Technology Palakkad, India); Anil Kumar Appukuttan Nair Syamala Amma (University of Edinburgh, United Kingdom (Great Britain)); Jeshma Thalapil Vaheeda (Lecturer, United Kingdom (Great Britain)); Sreenath Vijayakumar (Indian Institute of Technology Palakkad, India)

This article presents a novel non-contact inductive sensor designed to simultaneously measure both the liquid levels within a container and the inclination of the container. Most existing level sensors fail or are inaccurate when the container is inclined. The proposed sensor shows excellent performance in such conditions. Moreover, the proposed system does not require any movable coils inside the container, utilizing only a floating high-permeability material instead, which simplifies the construction of the system. The sensor includes two pairs of planar inductor coils that are placed exactly opposite around a container and a float consisting of a thin ferromagnetic core. The float is designed to

maintain a minimal radial distance from the coils. Changes in the float's position with respect to the liquid level alter the inductance of the coils, which is proportional to the liquid level. Additionally, the sensor measures liquid inclination through the differential change in inductance experienced by the coils. The proposed sensor exhibits linear output characteristics for both liquid level and inclination measurements. A prototype of the sensor was designed in the laboratory, and its efficacy was tested. The prototype sensor has a worst-case linearity error of 0.81% for level measurement and 1.6% for inclination measurement

S3B.5 15:12 ***Graphene/PEDOT: PSS composite-based sponge for Haptic Sensing Applications***

Aniket Chakraborthy (Technische Universität Dresden, Germany); Artem Prokopchuk (TU Dresden, Germany); Suresh Nuthalapati and Anindya Nag (Technische Universität Dresden, Germany); Andreas Richter (TU Dresden, Germany); M. Ercan Altinsoy (Dresden University of Technology, Germany)

The study focuses on the development and use of graphene/PEDOT: PSS composite sponge-based sensors. Currently, there is a demand for low-cost, printable sensors that may be used in a variety of strain-induced applications. Graphene and PEDOT: PSS have both demonstrated outstanding sensing capabilities, given their improved electrical and mechanical characteristics. The conjugation of two nanomaterials to construct efficient, sensitive, and flexible sensors is demonstrated here. Prototypes were characterized for their electrical performance under mechanical deformation. The findings presented here provide a foundation for the sensors to be employed in real-time strain-sensing applications.

Monday, December 9 16:00 - 17:12

S4A: Special session: Bio-med Applications and Medical Devices

S4A.1 16:00 ***Bactericidal Efficacy of Jute Fiber Reinforced Epoxy Bio-Composite: A Comprehensive Study***

Sakthivel Sankaran (Kalasalingam University, India); Mareeswari Paramasivan (University of Illinois Chicago, USA); Vimal Kumar Dewangan (IIT Madras, India); Kottaimalai Ramaraj (Kalasalingam Academy of Research and Education, India)

This study aims to conduct a comprehensive antibacterial examination of two and three-layer Jute Fibre Reinforced Epoxy Bio-Composites (JFREC). Utilizing cutting-edge composite materials, these composites are aimed for designing and producing biocompatible sockets for patients with transfemoral amputees. Natural fibers are employed to help mitigate allergic skin reactions that may occur due to prolonged contact with the socket. Natural fibers have a lot of potential as a substitute material for socket preparation because of their favorable characteristics, including affordability, low density, biodegradability, and environmental friendliness. Through a variety of procedures, including agar plate zone inhibition tests and bacteria-kill assay tests, the antibacterial abilities of the fiber samples were evaluated. Numerous bacterial strains, including Gram-positive Staphylococcus aureus and Gram-negative Escherichia coli, were used in these trials. The results show a substantial reduction in bacterial growth, showing the jute fiber composites' potent antibacterial efficiency.

S4A.2 16:18 ***3D printing allows for agile sensor development and new trade-offs in hygiene vs. waste***

Constanze Kiese (HFU Furtwangen University, Germany); Jaqueline Altmann and Hans-Peter Landgraf (OTH Regensburg (OTHR), Germany)

Research on surface-electromyography (EMG) for anal function testing started 20 years ago. However as of now, no medical device is commercially available for anal neuromonitoring or clinical studies. Pathological alteration of neuronal structures in the event of fecal incontinence (FI) are not understood because the morphology and geometry of anal innervation cannot be investigated. FI is multifactorial and the people affected range from newborns with malformations to geriatric patients including young women postpartum, middle aged men and women who underwent colorectal surgery or radiation therapy. A diagnostic medical device that serves all members of this heterogeneous group equally might be variable in shape and size. This paper analyzes the need for variable sensor shapes and possibilities of 3D-printed bio-compatible and biodegradable sensors. Additively manufactured sensors can enable cost-efficient, eco-friendly single-use products to improve patient safety and hygiene without driving waste and carbon footprint.

S4A.3 16:36 *Unlocking the Potential of Molecularly Imprinted Polymer-based Early Detection of Creatinine Rise - A Prognostic Leap Towards Enhanced Kidney Healthcare*

Sumedha N. Prabhu (University of Cincinnati, USA); Guozhen Liu (The Chinese University of Hong Kong, Shenzhen & N/A, China); Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

This study introduces a novel approach for detecting creatinine levels in heat-inactivated serum samples using Electrochemical Impedance Spectroscopy (EIS) and Molecularly Imprinted Polymer (MIP) technology. The structural and functional properties of MIP and Non-Molecularly Imprinted Polymer (NIP) materials were thoroughly investigated using Ultra-High Performance Liquid Chromatography (UHPLC) technique. Specifically, the MIP polymers demonstrated exceptional selectivity towards creatinine and structurally related compounds, as validated by UHPLC. Ethical considerations were addressed by utilizing heat-inactivated human serum samples in the testing phase. The developed biosensor exhibits robust specificity, high selectivity, and efficient rebinding capability for the target creatinine molecule. Detection limits were determined to be as low as 0.1 parts per million (ppm). At the same time, the biosensor demonstrated the ability to detect concentrations as high as 50 ppm, which is three times the typical level found in human serum. This research contributes to advancing biosensor technology for precise and sensitive detection of creatinine, promising significant applications in clinical diagnostics and biomedical research. The findings underscore the potential of MIP-based biosensors in enhancing analytical methodologies for biomarker detection and monitoring in medical settings.

S4A.4 16:54 *In Situ Detection of Fungicide Residue on Green Leafy Vegetable Using 10-gene Symbolic Genetic Model Embedded in Electronic Nose*

Ronnie Concepcion II, Giolo Rei Mababangloob, Marian Lubag, Kevin Napisa, Jasper Matthew Tan and Marla Maniquiz-Redillas (De La Salle University, Philippines); Jesson Del-Amen (Benguet State University, Philippines)

Lettuce is one of the most susceptible green leafy vegetables to soil-borne pathogenic fungi especially when the soil is untreated before the cultivation stage. In the hinterlands, fungicide is applied through foliar to avoid fungal disease in lettuce but overapplication contributes to greenhouse gas emissions and pose human health problems when consumed excessively. To avoid these negative impacts of fungicide, in situ detection technologies should be developed. This study developed an electronic nose equipped with seven MQ gas sensors with computational intelligence (CI) predictive model embedded in the Arduino module for in situ detection of fungicide residue presence in fresh harvested iceberg lettuce heads. The electronic nose chassis was customized to hold the electronic sensing subsystem capable of transmitting sensor data to free ThingSpeak platform, and 3D printed with polylactic acid material. Four biological inspired CI algorithms were modeled, namely, Autoencoder, Spiking Neural Network, Deep Recurrent Neural Network, and Multigene Genetic Programming (MGGP) to indirectly detect the fungicide residue presence through volatile compounds data stream measured by MQ

sensors. Based on the findings, the developed 10-gene MGGP resulted in highest accuracy (98.571%), specificity (97.297%) and sensitivity (100%) and fastest inference time (1.1x10-17 s) among the other three models, making it the fittest model for real time detection as these metrics reflect reliability, network complexity and efficiency in resource constraints. The lettuce smellprint revealed that ozone and sulfide compounds are significant in lettuce sprayed with fungicide. This implied that employing MGGP-embedded electronic nose could improve the process of in situ fungicide residue detection on a larger scale.

S4B: WSN and IOT

S4B.1 16:00 ***Early Detection of Wildfire Using IoT Sensors without Labelled Fire Data***

Qingyang Zhuang, Chiu Chun Chan, Xiangyun Zhou and Salman Durrani (The Australian National University, Australia)

Wildfires, commonly referred to as bushfires in Australia and forest fires in Europe, pose significant threats to life, property, and the environment. Prompt identification of wildfires is crucial to prevent them from escalating into catastrophic events. This paper considers the use of wireless sensors to measure environmental conditions, in particular carbon dioxide, to detect wildfire at its early stages. We propose a detection algorithm that leverages exclusively non-fire measurement data, without relying on labelled fire data. This differs significantly from earlier research in this field, which generally presumes the existence of labelled fire data. In addition, our algorithm takes into account the temporal and spatial correlations in the sensor measurements to determine the existence of fire. Experimental burns are conducted in a campsite by igniting a small fire from a 0.7 square metres fire pit. The result shows that our algorithm applied to the experimental data can be tuned to minimise false alarms, at the same time detecting small fires within 50 metres and within 4 to 14 minutes after ignition.

S4B.2 16:18 ***ADCS-IoT: Anomaly Detection with Cryptographic Security Framework for the Internet of Things***

Sonam Lata (IILM University, India); Fadwa Alrowais and Shabana Urooj (Princess Nourah Bint Abdulrahman University, Saudi Arabia)

Security of data and anomaly detection are real concerns across many Internets of Things (IoT) applications. For IoT networks several safety mechanisms have been developed based on classical cryptography and symmetric-key encryption algorithms. But these algorithms have their own security problems, such as susceptibility to its chosen plaintext attacks, brute force attack and difficulty of computation. An efficient and realistic way to increase the security in IoT is cryptography combined with Machine Learning and Deep learning algorithms. The key goal of this paper is to create a framework that will provide reliable and secure data transmission even while extending the lifespan of WSNs and efficient anomaly detection. We proposed Anomaly Detection with Cryptographic Security Framework for the Internet of Things integrating these advanced technologies to enhance the security and reliability of IoT networks. We have used Advanced Encryption Standard (AES for secure data transmission and utilized Machine learning and Deep learning algorithms, Support Vector Machine (SVM), RF (Random Forest), Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN) for anomaly detection. Experimental results demonstrate significant improvements in both security and system robustness, highlighting the potential of the proposed framework. Additionally, it defeated numerous safety breaches, which includes brute-force attacks, HELLO flood attacks, selective transmitting attacks, and impaired clustered head attacks.

S4B.3 16:36 ***Machine Learning Technique for Route Discovery in Dynamic Internet of Things Environments: A Theoretical Perspective***

Mohammad M. Kadhum (Algonquin College & Queen's University, Canada)

The rapid expansion of the Internet of Things (IoT) has necessitated the development of efficient and adaptive routing protocols capable of handling the dynamic and resource-constrained nature of IoT environments. Traditional routing protocols, such as AODV and DSR, struggle to maintain performance in the face of frequent topology changes and energy limitations inherent to IoT networks. This paper presents a theoretical analysis of a novel Q-Learning-based efficient route discovery mechanism tailored for Internet of Things (IoT) networks. The proposed protocol aims to enhance route discovery in dynamic and resource-constrained environments by leveraging reinforcement learning techniques to optimize path selection. We provide a comprehensive mathematical formulation, along with proofs demonstrating the effectiveness and scalability of the proposed method. The analysis shows significant potential for improving routing efficiency and reducing communication overhead, particularly in large-scale IoT deployments.

S4B.4 16:54 ***Aged Care Act Compliance, Roughness Index, Edge Intelligence, and an Optimised Process***

Ollencio Rosario Jude D'Souza (Macquarie University, Australia & Technologycare, Australia)

Introducing aged care and healthcare is the focus of our research. We addressed the current need for an optimised process to meet legislative and quality requirements of the Aged Care Act 2024. We developed inference model-based microcontroller sensor clusters to deliver operational data and confirm the delivery and quality of scheduled care. Our research observations have devised the right mix of parameter and activity-based sensing to meet the heightened situational awareness required by the Act. We enhance workflow effectiveness by improving actionable intelligence. We use ML-trained microcontroller devices with onboard sensors to deliver real-time operational guidance and optimised healthcare processes.

Tuesday, December 10

Tuesday, December 10 8:30 - 9:00

Late Registrations

Tuesday, December 10 9:00 - 10:30

S5A: Gas Sensors

S5A.1 9:00 ***Laser-based sensing of trace-level methane in agricultural and environmental air***

Brian J Orr and Yabai He (Macquarie University, Australia); Julian Hill (Ternes Agricultural Consulting Pty Lyd, Australia)

Narrowband tunable diode lasers, operating at molecule-specific near-infrared wavelengths, are useful for spectroscopic sensing of molecules in the atmosphere, e.g., of greenhouse gas (GHG) or other agricultural and environmental species. Application of highly sensitive techniques, such as cavity-enhanced spectroscopy, is often limited by the need to maintain alignment, cleanliness and fine control of a high-finesse optical cavity. We therefore need a compromise between state-of-the-art performance (optimizing high sensitivity and specificity) against the requirements for practical instruments to be rugged, user-friendly and relatively inexpensive. Our research focuses on the less sensitive but more robust technique of wavelength modulation spectroscopy (WMS), used to monitor methane (a significant GHG) from the breath of ruminant livestock at trace levels in air. Our prototype WMS sensor is the forerunner of compact, rugged instruments that can ultimately be deployed at

modest cost for automated monitoring of methane emissions from individually identified livestock. We need such instruments to validate innovative methane-reducing feed supplements fed to cattle, sheep, etc. This approach is supported by Australia's ZNE-Ag CRC and MERiL schemes and aims to yield reduced methane emissions while benefiting animal productivity in agricultural industry.

S5A.2 9:18 ***Design Optimisation of Electronic Nose with Multichannel Gas Sensor***

Yugal Pachori and Richa Thakur (IIT Mandi, India); Avinash Kushwaha and Prashant D Kulkarni (Indian Institute of Technology, Mandi, India); Dinesh Singh and Aditya Nigam (IIT Mandi, India); Shubhajit Roy Chowdhury (School of Computing and Electrical Engineering, IIT Mandi, India)

Human nose detects every kind of odors and our brain responds to every kind of smell that we are inhaling, so in the same way artificial nose or the electronic nose is a device that detects the smell and can enable the scope of digital smell technology. So, this paper proposes to optimize the design of an electronic nose that will eventually bring modification to the various digital platforms like internet, computers, mobile, television and tablets. We focused on design optimization of electronic nose which is built on a multichannel gas sensor array. The proposed electronic nose will enable the transmission or reception of smell over the internet and other digital platforms. The device can detect the smells of vapors coming out of volatile organic compounds. The sensing system is 3D printed in the model of a human nose. The sensing system works with an accuracy of detection of 90.45%. The response time of the electronic nose is 60 to 90 seconds, sometimes it is lesser than 60 seconds and it varies from substance to substance.

S5A.3 9:36 ***Design and comparative analysis of different structures of Surface Acoustic Wave sensor for Hydrogen gas detection***

Vishal Kumar (Indian Institute of Technology (ISM) Dhanbad, India); Rupesh Kumar (Indian Institute of Technology (ISM), India); Debjani Mitra and Nirupama Mandal (Indian Institute of Technology (ISM) Dhanbad, India)

The paper presents a comprehensive study on the design and comparative analysis of Surface Acoustic Wave (SAW) sensors for hydrogen gas detection. Three distinct 2D models of sensing layers are investigated: layered structure, nano-rod configuration, and trench configuration between input and output Interdigitated Transducers (IDT). The substrate chosen for these models is lithium niobate(LiNbO3), with platinum(Pt) as IDTs and zinc oxide(ZnO) as the intermediate and sensing layers, respectively. The primary objective is to analyze the variations in displacement graphs of these structures by varying the sensing layer and IDT gap dimensions to find the optimum dimension. Additionally, the frequency shift is studied concerning changes in the concentration of hydrogen gas in parts per million (ppm). The sensitivity and performance characteristics of each model are evaluated and compared through finite element simulations on COMSOL software.

S5A.4 9:54 ***Evaluating Hysteresis and Time-Response in Palladium Nanoparticle-Based Hetero-Core Fiber Optic Hydrogen Sensors***

Yuna Nakamura (Soka University, Japan); Kazuhiro Watanabe (Soka University Japan, Japan); Michiko Nishiyama (Soka University, Japan)

In this study, we proposed a hetero-core optical fiber hydrogen sensor composed of alternating layers of PLL and PdNPs and conducted a detailed investigation of hysteresis and real-time response to changes in hydrogen concentration. It was suggested that reducing the particle size of PdNPs can mitigate hysteresis. The proposed sensor demonstrated a hydrogen gas detection range of 0.25% to 4%, showing superior sensitivity and response times compared to other optical fiber sensors.

S5A.5 10:12 ***Design and Analysis of SAW sensor using different substrates for DCM gas detection***

Nirupama Mandal (Indian Institute of Technology (ISM) Dhanbad, India); Rupesh Kumar (Indian Institute of Technology (ISM), India); Debjani Mitra (Indian Institute of Technology (ISM) Dhanbad, India); Rajan Sarkar (Asansol Engineering College, India)

This work makes the comparative analysis of SAW gas sensor made up of three different piezoelectric substrates individually for the detection of Dichloromethane (DCM) gas which is basically volatile organic carbon (VOCs) gas. Lithium Niobate (LiNbO3), Lithium Tantalate (LiTaO3) and Zinc Oxide (ZnO) are the three-substrate material used for making this SAW gas sensor. The sensor model is simulated using Comsol Multiphysics software, which is a finite element method-based simulation platform. Sensor performance is affected by the substrate and hence we have found the best one i.e., LiNbO3 over the other two upon simulation as we have got maximum shift in frequency in case of Lithium Niobate. The sensing layer and its thickness are other important parameters that decide the performance of the SAW gas sensor. So, optimization of the thickness of the sensing layer is done to get the maximum sensitivity. Thickness is varied from 0.2 μm to 1.2 μm, and Lithium Niobate provides maximum sensitivity at the thickness of 0.7 μm. This SAW sensor is designed at the resonance frequency of 872 MHz. LiNbO3 shows the maximum eigenfrequency of 837.76 MHz, while ZnO shows the least eigenfrequency of 666.45 MHz. The gas concentration is also varied from 50 ppm to 200 ppm, and linear response is observed for all the substrates, whereas Lithium Niobate shows a maximum shift in frequency. Better sensitivity and higher eigenfrequency corresponding to the LiNbO3 are due to its high electromechanical coupling coefficient (K2) and SAW velocity.

S5B: Sensors for Home and Activity Monitoring

S5B.1 9:00 ***Enhancing Elderly Care: Indoor Detection of ADL and Gait Disorders with IoT and LiDAR***

Anuroop Gaddam, Shreyas Nair, Muhammad Zeeshan and Dhananjay Thiruvady (Deakin University, Australia)

The elderly population has been rapidly increasing in recent years, placing extra demand on healthcare facilities such as hospitals and aged care centres. This growing demographic has also exerted significant pressure on healthcare professionals, including doctors, nurses, and carers, due to a critical shortage of staff. Consequently, round-the-clock monitoring of vulnerable elderly patients susceptible to falls and gait disorders proves to be immensely difficult. Often, random falls of elderly patients go unnoticed for many minutes or even hours. By the time the patient is discovered, irreversible damage to their body and health may have already occurred. This paper aims to address this problem by proposing a novel solution that leverages technologies such as the Internet of Things (IoT), 3D LiDAR (Light Detection and Ranging) sensors, Artificial Intelligence, and Deep Learning. The system is designed to detect abnormalities in the ADL (Activities of Daily Living) of elderly patients, along with features for fall detection and gait disorder detection. Importantly, the use of 3D LiDAR sensors in this context ensures that the privacy of individuals is not compromised, addressing a common concern associated with traditional camera-based systems. Furthermore, there is a significant research gap in this area. Currently, no systems or research combine these technologies in the proposed manner, highlighting the need for innovative solutions. This paper contributes to filling this gap by presenting a unique approach to elderly care monitoring. The research employs a quantitative methodology, utilising various metrics to evaluate the performance, efficiency, and accuracy of the IoT-LiDAR system.

S5B.2 9:18 ***YogaFi: WiFi sensing based Yoga Pose Recognition using Machine Learning Model***

Gayathri Gorrepati, Sruthi Penmetsa and Udgata Siba Kumar (University of Hyderabad, India)

Wi-Fi sensing is an emerging technology that leverages wireless signals to detect and interpret various environmental changes and human activities. By analyzing the variations in Channel State Information (CSI), Wi-Fi sensing can provide fine-grained insights into movement, presence, and even gestures. Yoga is being used worldwide for maintaining physical and mental health. This paper explores the

innovative application of Wi-Fi sensing technology for recognizing different yoga poses. Leveraging the variations in Wi-Fi signals caused by human movement, we develop a low-cost, non-invasive, privacy-preserved system that recognizes different yoga postures. We conducted experiments in the Lab environment to collect the CSI values corresponding to seven different yoga poses. Two low-cost ESP32 modules, one as a transmitter and the other as a receiver, are placed at a distance of 10 feet in line-of-sight condition, and the yoga exercise is done in between. We propose a two-stage machine-learning approach for yoga pose classification. The combined accuracy of both machine learning stages provides an accuracy of the proposed model of around 83% for classifying all seven yoga poses.

This method offers a non-intrusive, privacy-preserved, cost-effective alternative to traditional vision-based systems. This provides new opportunities for remote fitness monitoring and personalized training.

S5B.3 9:36 ***Gait Phase Identification using Wearable Sensors for Physiotherapy Assistance***

Rufyid u Nissa (IITB-Monash Research Academy, India; Dept. of ECSE, Monash University; Dept. of Electrical Eng., IIT Bombay); Mohin Shaikh (Indian Institute of Technology Bombay, India); Nemai Karmakar (MONASH University, Australia); Maryam Shojaei Baghini (IITB, India)

Real-time, unobtrusive identification of gait phases is essential for effective gait-related therapy and early identification of neurological conditions. Long-term, real-world gait phase identification requires on-device sensing and computation, achievable through wearable technologies that integrate sensors with microcontrollers. This study proposes a multi-modal sensing approach to identify gait phases using a one-dimensional convolutional neural network (1D-CNN). We gathered data from both plantar pressure sensors and an inertial sensor to accurately capture the complexities of human movement. The gathered multi-sensor gait data were processed offline and prepared as input for the 1D-CNN. Gait phases were labeled by analyzing the periodic signal waveforms. The 1D-CNN model was trained on sequential gait data and demonstrated high performance, achieving accuracy, precision, specificity, and F1 scores of 97.07%, 96.70%, 98.90%, and 96.80%, respectively. The method was validated in real-time, showing rapid response in gait phase identification. To enhance sequence learning and address the misclassifications observed with the 1D-CNN, subsequent investigations will focus on models that capture long-term dependencies, including recurrent neural networks such as long short-term memory.

S5B.4 9:54 ***Comparative Analysis of Computer Vision and IMU Sensing Systems for Accurate Determination of Gait Parameters***

Mohd Irfan, Nagender Kumar Suryadevara and RK Sanayaima Singh (University of Hyderabad, India)

Gait analysis is a crucial technique in the fields of sports science, biomechanics, and rehabilitation. The two primary technologies used in gait analysis are vision systems and inertial measurement units (IMUs). While vision systems are excellent at giving precise and comprehensive gait data, IMUs are well-suited for portable and affordable applications. There are other marker-based systems for gait analysis, but they are very expensive, and one cannot access them easily. To fully grasp the potential of marker-less technology in joint angle analysis and biomechanics, this work uses the BlazePose machine learning model. IMU devices attach to four separate locations on the patient's body using the MPU6050 to obtain joint angles while the subject is walking. This paper examines the reliability, precision, and applicability of these two technologies in various scenarios. Our findings indicate that while IMUs are more affordable and portable, Vision Systems are also affordable and offer more accuracy and a greater amount of data to enable comprehensive gait analysis.

S5B.5 10:12 ***Pressure Sensor Array-Camera Based Activity Level Monitoring at Home: A Feasibility Study***

Anil Kumar Appukuttan Nair Syamala Amma, Longfei Chen, Robert B. Fisher and Srinjoy Mitra (University of Edinburgh, United Kingdom (Great Britain))

Detecting 'lack of movement' is an important capability for supporting ageing adults who are trying to live independently. This paper introduces a novel system for monitoring inactivity at home by combining a pressure sensor array embedded in a cushion with an RGBD camera. This approach aims to improve the reliability of the detection of human activity, addressing limitations that arise when solely relying on camera-based monitoring. The practicality of the system was evaluated through a series of experiments where participants engaged in various activities, including movements and prolonged stillness. The feasibility study results indicate that the pressure sensor array can accurately detect small movements that may go unnoticed by the camera alone. This integrated setup offers a reliable solution for comprehensive activity monitoring in home environments.

Tuesday, December 10 11:00 - 11:54

S6A: Thermal and Chemical Sensors

S6A.1 11:00 ***Noble Metal Nanoparticles Functionalized 2D Transition Metal Dichalcogenides by Atomic Layer Deposition for Enhanced Sensing Properties Toward Amino Acids***

Jisang Yoo, Sangyoon Lee, Jaehyeok Kim, Inkyu Sohn, Seung-min Chung and Hyungjun Kim (Yonsei University, Korea (South))

Here, we report surface functionalization of 2D WS2 with Pt nanoparticles (NPs) by atomic layer deposition (ALD) to enhance sensing properties towards amino acids (AAs). The ALD window of the ALD Pt film was confirmed to be 200 °C to 250 °C, and the growth per cycle (GPC) was ~1.2 Å/cycle at 200 °C. After surface functionalization, the increased n-type doping effect by lysine (LYS) molecules was measured through peak shifts in photoluminescence (PL) and X-ray photoelectron spectroscopy (XPS). Furthermore, the concentration-dependent linearity also increased in Pt-WS2 system, and limit of detection (LOD) was also improved. Selectivity to other interfering biomolecules also enhanced. Our results demonstrate that surface functionalized 2D TMDC with noble metal (NM) could enhance the sensing properties towards AAs.

S6A.2 11:18 ***Additively Manufactured Miniaturized RF Sensor for Temperature Sensing***

Md Ashif Islam Oni and Shuvashis Dey (North Dakota State University, USA)

This paper presents the development and characterization of a miniaturized RF sensor designed for temperature sensing applications, leveraging advanced additive manufacturing techniques. The sensor utilizes NiTiNOL, a superelastic alloy, as the temperature-sensing material, integrated into a split-box resonator structure. The resonator operates at a frequency of 38.125 GHz, and the design benefits from the flexibility and precision offered by 3D printing technology. This approach allows for a compact form factor and robust performance in harsh environments. The sensor's performance was evaluated through a series of simulations, demonstrating high sensitivity and reliability in temperature measurement. The results highlight the potential of additively manufactured RF sensors in various industrial, medical, and environmental monitoring applications, offering advantages such as reduced size, weight, and power consumption, along with enhanced mechanical robustness and thermal stability. This work underscores the significance of additive manufacturing in advancing next-generation sensor technologies.

S6A.3 11:36 ***Estimation of Slag Temperature in Direct-to-Blister Flash Smelting using VIS-NIR Optical Probes***

Jonathan L Torres-Sanhueza (Marquette University & Radiometric Sensing Solutions for Mining, USA); Franco Rivas P. (Universidad de Concepcion, Chile); Andres De la Fuente (Radiometric Sensing Solutions for Mining, Chile); Francisco Perez, Roberto Parra and Sergio Torres (Universidad de Concepcion, Chile); Mark O'Sullivan (BHP Olympic Dam, Australia)

Real-time monitoring of the temperature of the reactions in copper smelters and specifically in the flash smelting conversion process is crucial to evaluate the operating process. To achieve this, a radiometric optical system based on a visible to near infrared spectrometer (VIS-NIR), configured with a specialized method is proposed as a sensor for BHP's Olympic Dam Direct-to-Blister flash smelting furnace, thus providing real time information to assist in the control of the process. The proposed sensor captures the irradiance from the surface of the molten slag over the flash furnace settler by means of an opto-mechanical probe to estimate the temperature using a multi-wavelength calculation method based on the Planck radiation model. Using thermocouples as a reference point measurement errors have been found in average to be below 15 °C.

Tuesday, December 10 11:00 - 12:12

S6B: Senors Applications in Challenging Environment

S6B.1 11:00 ***Two-layer smart system to predict HIV risk***

Thi Phuoc Van Nguyen (Thanh Do University, Vietnam); Trinh Duc Minh Nguyen (Hanoi Amsterdam school, Vietnam); Viet Tien Le (Hanoi University of Industry, Vietnam); Mai Hoang Long Nguyen (FPT, Australia); Phuc Hau Nguyen (Thanh Do University, Vietnam)

In this work, a two-layer privacy protection system was proposed for HIV risk prediction. The system involves various clinic centres, each using its data to build a model to predict HIV risk. The models from each clinic are gathered at a central server/cloud to create a global model. To protect the individual clinic models, they are encrypted before being sent to the server. At the server, the encrypted models are aggregated to create the global model without decryption. The encrypted global model is then distributed to each clinic for use. This method ensures that patient information from each clinic is protected by two layers: modelling and encryption. We used data from Vietnam 2005 to validate the proposed framework. The performance of the proposed method is superior the local model in terms of accuracy and AUC (Area Under The Curve). The enhancement is larger than 10%

S6B.2 11:18 ***Optimizing Transistor Selection Using AH-TOR for Low Noise Amplifier Design in Sensing Applications***

Dayarnab Baidya (Indian Institute of Science Education and Research Bhopal, India); Karthick Thiyagarajan (Western Sydney University, Australia); Mitradip Bhattacharjee (Indian Institute of Science Education and Research Bhopal, India); Yang An (Western Sydney University, Australia)

The design of a wireless sensor network receiver requires an efficient Low Noise Amplifier (LNA), with the transistor being a critical component that influences its performance. Selecting an optimal transistor for LNA design is a complex and time-consuming process due to the conflicting criteria involved. This study utilizes the Analytic Hierarchy Tradeoff Ranking Method (AH-TOR), an integrated Multi-Criteria Decision-Making (MCDM) approach, to facilitate the selection of a suitable transistor for LNA design. Four types of transistors were evaluated as alternatives based on four criteria, with the Pseudomorphic High Electron Mobility Transistor (PHEMT) emerging as the optimal choice. The weight of PHEMT was calculated to be 1.0787, and its performance was benchmarked against other existing methods. Further analysis demonstrated the robustness of the AH-TOR method across various

scenarios, consistently identifying PHEMT as the most suitable option. These findings highlight the reliability of the AH-TOR method for transistor selection in diverse applications.

S6B.3 11:36 ***Investigation of evaluation methods for tactile stimuli in mid-air haptics***

Daisuke Mizushima, Mifuka Nakamura and Nobuya Sato (Aichi Institute of Technology, Japan)

In actuators that present a vibration sensation, it is clear that the amount of skin displacement is related to the intensity of the vibration sensation. Haptic actuators using mid-air ultrasonic waves are suitable for such measurements. The authors have proposed a system that simultaneously performs tactile sensation presentation and displacement measurement using a small mid-air ultrasonic actuator and a laser displacement meter for skin displacement measurement. In this presentation, we developed an actuator that employs lateral modulation and has 25 % higher acoustic radiation pressure than conventional actuators. Using this actuator, we measured the displacement of dummy skin and human skin, and succeeded in measuring a maximum displacement of 150 μm in dummy skin, which is more significant than in previous studies. The displacement of human skin was consistent with the model proposed in the previous study. We also measured the threshold displacement of tactile sensation and confirmed that the threshold displacement is consistent with existing studies. The heat generated by focused ultrasound irradiation of the skin was also measured. The results showed that a small actuator and a pocket thermal camera could be used to confirm the heat generated by the dummy skin, indicating the possibility of measuring the magnitude of the tactile stimulus without invasive measurements such as viscoelasticity.

S6B.4 11:54 ***Measurement of Blink Duration Using a Continuous-Wave Radar Sensor and Continuous Wavelet Transform***

Jae-Hyun Park, Jun-Ho Jeong and Kyung-Tae Kim (Pohang University of Science and Technology (POSTECH), Korea (South))

Blink duration measurement has important applications such as driver status monitoring, sleep analysis, human-computer interaction, and clinical diagnostics. Conventional sensors of measuring blink duration, such as electrooculography sensor and vision-based sensors, are often limited by high computational requirements, intrusiveness, and sensitivity to lighting conditions. This study proposes a novel approach using a 120 GHz continuous wave (CW) radar sensor combined with continuous wavelet transform (CWT) to non-invasively measure blink duration. The CW radar sensor captures the Doppler shift caused by eyelid movements, and the Morlet wavelet-based CWT processes these signals to accurately detect the opening and closing phases of blinks. The duration of an eye blink was measured by applying signal processing techniques for rising and falling edge detection to the detected eye movements. Experimental validation using a commercial CW radar sensor showed that the proposed technique achieves high accuracy in blink duration measurement using camera-based measurement as a reference. The results show the potential of this radar-based approach for various applications requiring precise blink duration monitoring.

Tuesday, December 10 13:30 - 15:15

S7: Keynote #3 and Tutorial talk

Dr. Tomonori Hu, NSSN, Sydney, Australia on Smart Sensing needs for wildlife conservation
Prof. Shiva Udgata, UoH, India on Wi-Fi Sensing: Principle, Implementation and Applications

Abstract: Smart Sensing has transformed several industries - from wearable technologies to smart buildings, and even space-based remote sensing. However, what role does smart sensing have in preserving our biodiversity? This

becomes more important as climate change puts for pressure on our environment. In this talk, I will cover projects that the NSW Smart Sensing Network has engaged in such as wildlife acoustic monitoring for endangered species, to upcoming challenges around localised tracking of animals. Traditionally, the area of conservation has been difficult to find funding, but great innovations have emerged from this field. I would like to call upon sensing experts to become involved and help tackle these emerging challenges.

Abstract of the tutorial talk: Device free Wi-Fi sensing has gained much attention due to its simplicity, low cost, and no requirement for additional hardware sensors. The main advantages of Wi-Fi sensing are that it is unobtrusive, can operate through walls, work without lighting, is ubiquitous, and does not require users to carry any additional wearable devices. CISCO estimated that there will be 543 million Wi-Fi hot spots in the whole world by end of 2022 and it is growing exponentially, which makes the Wi-Fi signal availability almost omnipresent. The traditional methods of video and sensor based system suffer from many short comings like acceptability, availability, affordability and moreover privacy concerns. The received Wi-Fi signal characteristics changes with change in the dielectric constant of the medium and other reflections and scattering. These change in the Wi-Fi signal patterns can be exploited to detect various events, environmental conditions in the wireless zone, identify the materials in the wall and also detect faults. Recently Wi-Fi sensing techniques are also being used for measuring the physiological parameters like heartbeat, breathing rate monitoring among a few other things. This tutorial talk is an attempt to demonstrate the potential of device free general purpose Wi- Fi sensing system to track events and recognize activities even through the wall and other materials using the Channel State Information (CSI) values extracted from the received Wi-Fi signals at the receiver end using channel estimation. The received signal characteristics changes with the presence of the human beings, and their activities affect the signal propagation, resulting from reflection and scattering. The activities can be recognized by analyzing the CSI values corresponding to different sub-carriers of the received signal. CSI values contain fine grain information such as amplitude and phase to achieve better sensing accuracy with a unique pattern that can be observed corresponding to each activity and material. We will present our experience of developing the transmitter and receiver hardware modules together with the necessary software for capturing the CSI from Wi-Fi signals and multiple experiments conducted using the low power, low cost ESP-32 Wi-Fi module and Intel 5300 NIC module, for human presence, activity detection, material detection, ambient condition in indoor environments.

Tuesday, December 10 15:45 - 17:15

S8A: Sensors for Novel Applications I

15:45 ***Calibration of Polyvinylidene Fluoride Nasal Sensor to Measure Breathing Pressure***

Roopa Manjunatha (Energy Institute Bengaluru, India); Konandur Rajanna (Indian Institute of Science, India); Alisha Das (Rajiv Gandhi Institute of Petroleum Technology, India)

This paper presents an experimental setup for measuring human respiration/breathing pressure using a U-tube manometer. The human nasal breathing pressure was in the range of 2-40 mmH2O, corresponding to slow, regular, and fast breathing. A simple calibration procedure was developed for the polyvinylidene fluoride (PVDF) nasal sensor using a MEMS low-pressure sensor. The sensitivity of the PVDF nasal sensor for measuring human breathing pressure was 46 mVp-p/mmH2O. The discrepancy of 1.42% was calculated for the PVDF nasal sensor, which shows good agreement between experimental and theoretical pressure values. The PVDF nasal sensor can be utilised for routine monitoring of human respiration patterns non-invasively.

16:03 ***MEMS-based Magnetoelastic Sensor for the Detection of Creatinine Molecules - A Conceptual Evaluation***

Sumedha N. Prabhu (University of Cincinnati, USA); Guozhen Liu (The Chinese University of Hong Kong, Shenzhen & N/A, China); Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

This study presents the development and performance evaluation of a micro-electromechanical systems (MEMS)-based flexible magnetoelastic sensor for biomolecular detection, focusing on its

application in sensing the mass of creatinine molecules as a potent biomarker. The sensor's Limit of Detection (LOD) was measured at a standard frequency of 1 Hz under varying magnetic bias fields ($\boldsymbol{Bbias}$). At +0.65 mT, the sensor achieved an LOD of 149.38 pT/√$\boldsymbol{Hz}$, while at -0.65 mT, the LOD increased to 201.11 pT/√$\boldsymbol{Hz}$. These results highlight the sensor's high sensitivity to changes in magnetization. Additionally, the Sensor Detection Mass Sensitivity (SDMS) was evaluated using a conceptual approach, and the sensor's mass sensitivity and amplification factor were calculated. The findings demonstrate the sensor's potential for precisely detecting biomolecular masses, making it a promising candidate for biomedical kidney healthcare sensing diagnostics applications.

16:21 ***Classification of Underwater Crown-of-Thorns Starfish Using Vision Transformer Networks***

R-jay S Relano and Ronnie Concepcion II (De La Salle University, Philippines); Bernardo Duarte (University of Lisbon, Portugal); Vanessa Fonseca (Universidade de Lisboa, Portugal); Mark Anthony Redo (Tokyo University of Marine Science and Technology, Japan)

The population count of crown-of-thorns starfish (CoTS) raises concern due to its regional and seasonal outbreaks resulting in unwanted damage to coral reefs, thus monitoring its spread is a vital responsibility to maintain balance in biodiversity. Conventional CoTS detection and monitoring techniques usually require specialized skills, expensive devices and time-consuming. Deep Learning-based image classifier, particularly the ViT-B16, has been developed for CoTS detection but it is confirmed limited to inductive biases, lacks multi-scale feature extraction, and has difficulty in handling fine-grained details. With these emerging challenges, this study developed a comparative analysis of different variants of Vision Transformer (ViT) networks for classifying CoTS and non-CoTS species based on custom underwater images extracted from Kaggle. Nine ViT variants were configured, modelled and tested, namely, SimpleViT, NesT, LeViT, Convolutional ViT (CvT), T2TViT, CrossFormer, XCiT, RegionViT, and NaVit. The developed CVT model outperformed other ViT variants, achieving an accuracy of 82.84% and F1-Score of 83.92%, making it the most recommendable and suitable choice for environmental monitoring tasks such as CoTS classification. Additionally, CVT requires moderate computational resources as compared to other variants of ViTs which are known for significant hardware requirements. Thus, the findings of this study contribute to the ongoing efforts to monitor and mitigate the spread of CoTS by correctly classifying CoTS species, providing valuable insights for the actual deployment of ViT classifiers in marine pest management.

16:39 ***Audio signal compression in a surround environment using wavelet transform***

Miyuki Shirai (Niihama College, National Institute of Technology, Japan); Shotaro Yamamoto and Tomoyuki Matsumoto (National Institute of Technology KOSEN, Niihama College, Japan); Mikiko Sode Tanaka (National Institute of Technology, Niihama College, Japan)

When a machine emits an abnormal sound, it is often necessary to take measures such as stopping the factory line. Therefore, we have developed a system that detects machine failures using sound. The feature of the proposed system is that it converts voice data into images using wavelet transform, and uses the images as input to determine abnormalities using machine learning. The important thing in this system is the size of the voice data. We would like to compress the voice data to make it easier to send. In this paper, we discuss the compression of voice signals using wavelet transform. We consider reducing the size of voice data without removing abnormal sounds contained in the voice data. We apply several different transformation methods and compare the features of abnormal sounds on the time-frequency plane.

16:57 ***Joint Space-Time waveform design Based on DFRC MIMO-OFDM System***

Wenshuai Ji (Sun Yat-Sen University, China)

This paper designs encrypted sparse transmitting waveforms and receiver beamforming to suppress clutter and encrypt signals in the spatial domain and leverage the Maximize-Signal-to-Interference-Noise Ratio (MSINR) as a criterion on sparse arrays. In the time domain, the DFRC signal's Peak Side

Level (PSL) is minimized to enhance radar detectability while constraining the communication Bit Error Ratio (BER) and the constant envelope value of the signal to maintain communication quality. To address the non-convex optimization problem, we develop a Block Successive Upper-bound Minimization (BSUM) framework, which alternately updates each communication phase location. This framework aims to lower the dual-function crossand autocorrelation peak sidelobe levels, referred to as the Block Successive Upper bound Minimization for DFRC PSL (BSUM-DPSL) algorithm. The proposed algorithm's effectiveness is theoretically validated, and simulation results demonstrate the designed waveform's effectiveness compared to the Linear Frequency Modulation (LFM) waveform.

Tuesday, December 10 15:45 - 16:57

S8B: Sensors for Robots and Autonomous Vehicles

15:45 ***A Laser-Guided Docking Method for Differential Drive Mobile Robot fusing Camera and Sensors***

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

A novel laser-guided docking method for differential drive mobile robots is proposed, aimed at small robots with limited computational power. Traditional docking methods, such as those employing ArUco marker pose estimation, often require significant processing capabilities, making them unsuitable for low-cost, resource-constrained robots. In the proposed method, a laser beam is emitted from the docking station to guide the robot, which uses a simple camera to detect the beam. Upon detection, the robot approaches the beam location and then rotates to identify the docking station's marker. Final alignment and docking are achieved using line sensors, ensuring precision and reliability. Computational demands are reduced while maintaining high docking accuracy. The effectiveness of the proposed method is demonstrated through experimental results, indicating its viability for small mobile robots in various applications. Finally experimental analysis identified parameters upon which success of the docking using the proposed algorithm depends.

16:03 ***Vibration measurement using accelerometer and load cell sensors for a BLDC motor***

Mohammadreza Hojati, Subhas Chandra Mukhopadhyay and Richard Han (Macquarie University, Australia); Foad Taghizadeh (Macquarie University Sydney, Australia)

Torque ripple is a significant and influential parameter in brushless direct current (BLDC) motors, as it can cause vibrations that affect system performance and reduce the lifespan of components. Therefore, it is crucial to measure these vibrations accurately. In this article, motor vibrations are measured using both an accelerometer and a load cell. The results from these two sensors are compared to facilitate the selection of the most suitable sensor for future tests.

16:21 ***Short-Term Time Series State of Charge Prediction in Electric Vehicle LGM50 Batteries: A Rolling Forecasting Approach***

Zeyang Zhou (University Technology Sydney, Australia); Angelo Greco (Clarios Varta Hannover GmbH CLARIOS Germany, Australia); Fenix Huang (KERF Technology Ltd., Australia); Karthick Thiyagarajan (Western Sydney University, Australia); Jun Li (UTS, Australia); Mukesh Prasad (University of Technology Sydney, Australia)

The prediction of the state of charge (SOC) for battery management systems has become increasingly important with the rapid growth of the electric vehicle industry. Traditional methods for SOC prediction often depend on extensive historical data from vehicles, which can be unreliable due to various uncontrollable factors such as driving behavior, weather, and road conditions. To overcome these

limitations, we propose a rolling forecasting model that leverages month-by-month data from electric vehicles to predict the SOC for the subsequent month. This approach to short-term SOC prediction aims to enhance intelligent mechatronic monitoring systems, enabling the delivery of personalized driving and charging strategies to customers.

16:39 ***Residual-CBAM CNN-based Railway Environment Classification Using Distributed Acoustic Sensing Data from Train Operations***

Hye-yeun Chun (Korea University of Science and Technology, Korea (South)); Dongkue Kim, Jungtai Kim and Sungjin Kim (Korea Railroad Research Institute, Korea (South))

While Distributed Acoustic Sensing (DAS) is well-suited for temporal and spatial continuous measurements and remote monitoring over long distances, large datasets are generated that require precise and reliable analysis algorithms. In this study, a deep learning model incorporating Convolutional Neural Networks (CNN) with residual blocks, and the Convolutional Block Attention Module (CBAM) was developed and its classification performance was validated to accurately classify railway environments (open field, tunnel, bridge, tongue rail, and crossing) using vibration data obtained from a DAS system during train operations. A method was devised to detect the time intervals when the train occupies each spatially sampled position, and vibration data within the time intervals were converted into spectrograms. These spectrograms were then fed into the developed model to classify the railway environment based on the vibration data near the tracks as the train passed by. The Residual-CBAM CNN model classified five railway environments with an accuracy of 0.9688, precision of 0.9778, recall of 0.9245, and an F1 score of 0.9490. The high classification performance demonstrates that the developed model can be effectively applied in railway research using DAS data.

Wednesday, December 11

Wednesday, December 11 9:00 - 10:30

S9A: Sensors for Novel Applications II

9:00 ***A nonlinear programming approach to demand responses using polynomial performance indexes***

Takehito Azuma (Utsuminiya University, Japan); Radhika Sudha (Birla Institute of Technological Sciences, Pilani, Hyderabad Campus, India)

In this paper, demand response problems are discussed based on nonlinear programming. The considered demand response problems are defined as nonlinear optimization problems with some constraints and polynomial performance indices. The optimization problems are described as a class of mixed integer nonlinear programming with polynomial performance indices. By considering the polynomial performance indices, the optimization problems with integer variables are reduced to nonlinear programming with no integer variables.

9:18 ***Temperature compensation in linear-approximated refraction boundary for near-infrared measurement of aqueous solution***

Takahiro Yamada (Tottori University, Japan); Naoto Kakuta (Tokyo Metropolitan University, Japan); Katsuya Kondo (Tottori University, Japan)

This paper presents a temperature measurement technique that can be used to analyze the production and transfer of heat stemming from aqueous solution reactions in microfluidic chips. Temperature imaging is performed on a target reaction that occurred when two different aqueous solutions are injected from the left and right sides of a Y-shaped channel and mixed at the center where the channel intersects. When near-infrared light is irradiated into the solution, the solution absorbs some of the light energy, and the intensity of light transmitted through the solution decreases. The intensity image of transmitted light can be captured and converted to a temperature image using the temperature dependence of the near-infrared light absorption of water. Conventionally, a temperature distribution is approximated based on the assumption that light travels straight through a solution. However, the refractive indices of aqueous solutions are not uniform, which affects temperature sensing. The present study is unique in that it considers the effect of refraction on the temperature imaging of aqueous solution reactions in a Y-shaped channel, with a ray tracing method used to analyze the effect of refraction. Original images were complemented by estimating the effect of refraction to obtain temperature images with a suppressed refraction effect, and experiments were conducted to evaluate the refractive effect by linearly approximating the refractive boundary. Furthermore, temperature imaging experiments with refractive compensation were performed to evaluate the method's performance.

9:36 ***Microlens Array-Based Wavefront and Intensity Profile Sensing with Physical Constraint Learning***

Shean-Jen Chen, Feng-Chun Hsu and Chun-Yu Lin (National Yang Ming Chiao Tung University, Taiwan); Chia-Yuan Chang (National Cheng Kung University, Taiwan)

The wavefront and intensity profiles of laser beams are crucial in many applications, including micromachining. This letter proposes a microlens array (MLA)-based methodology, similar to a Shack-Hartmann wavefront sensor (SHWS), to simultaneously measure the wavefront and intensity profiles of an incoming laser beam using a physical constraint learning approach. First, a pretrained network based on MLA simulation datasets is developed and then refined through transfer learning. To create a practical MLA-based measurement system, this pretrained network is further trained with datasets modulated by a spatial light modulator. Experimental results show that the proposed network can reconstruct both the wavefront and intensity profiles in real time. Compared to conventional SHWS methods, this approach improves computation speed by over 100 times and increases wavefront sensing accuracy by about 5 times.

9:54 ***Noise estimation of self-coupled laser microphone using Transformer-based source separation models***

Takemasa Okita (Aichi Institute of Technology, Afghanistan)

Transformer-based models excel in a wide range of deep learning areas, such as natural language processing and image recognition, and have recorded the highest accuracy in source separation, which separates the speech of each source from a mixture of multiple speech sounds. The laser microphone used in this study has more noise superimposed on it than general microphones and has not yet been used in practical applications. Therefore, in this study, we performed source separation using Transformer-based models to reduce noise in laser microphones and compared the improvement in scale-independent signal-to-distortion ratio (SI-SDRi) with a conventional model (convolution-based model). Transformer-based models are structurally capable of capturing temporal dependencies with high accuracy. Therefore, the separated speech is very close to the target signal, and sufficient noise reduction is achieved. The audio after separation was also analyzed for noise specific to the laser microphone. It was found that the noise specific to the laser microphone was present in the low frequency band below 100 Hz and that a constant noise such as white noise was superimposed in the other frequency bands.

10:12 ***Fabrication of a 940 nm RuS2 Photodetector via Post-Sulfurization of Ru Thin Film Grown by Atomic Layer Deposition***

Jaehyeok Kim (Yonsei University, Korea (South)); Tatsuya Nakazawa (TANAKA Kikinzoku Kogyo K.K, Japan); Donghyun Kim (Yonsei University, Korea (South)); Yohei Kotsugi (TANAKA Kikinzoku Kogyo K.K, Japan); Seung-min Chung (Yonsei University, Korea (South)); Soo-Hyun Kim (Ulsan National Institute of Science and Technology, Korea (South)); Hyungjun Kim (Yonsei University, Korea (South))

In this study, we report RuS2 thin films fabricated by atomic layer deposition (ALD) of Ru thin film followed by a post-sulfurization process. The chemical states, surface morphologies, and electrical properties of RuS2 films were investigated with respect to Ru film thickness through several analyses such as SEM, TEM, and XRD. Furthermore, to compare the surface morphologies of ALD, RuS2 was also synthesized using physical vapor deposition (PVD) Ru films, and the influence of metallic Ru surface morphology before sulfurization and its reaction with H2S were discussed. We fabricated RuS2 940 nm photodetector with metal-semiconductor-metal structured electrodes and evaluated optical properties. Our results suggest that RuS2 films could be a potential candidate material for 940 nm photodetectors

S9B: Special Session IV

Wednesday, December 11 11:00 - 12:30

S10: Special session - Women in Sensing workshop

Wednesday, December 11 12:30 - 14:00

S11: Closing Ceremony & Awards during LUNCH

Subhas Mukhopadhyay