



**7th  
Eurasia Conference  
on Biomedical  
Engineering,  
Healthcare and  
Sustainability 2025**

Cheng Shiu University,  
Kaohsiung, Taiwan  
October 23-25, 2025

# **7th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability 2025**

**(ECBIOS 2025)**

**Kaohsiung, Taiwan  
October 23–25, 2025**

**Organized by:**

**Cheng Shiu University, Taiwan  
National University of Kaohsiung, Taiwan  
International Institute of Knowledge Innovation and Invention (IIKII)  
IEEE Tainan Section Sensors Council**

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# Welcome

Welcome to the 7th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability 2025 (ECBIOS 2025). This conference is the collaboration between Cheng Shiu University, National University of Kaohsiung, International Institute of Knowledge Innovation and Invention (IIKII), IEEE Tainan Section Sensors Council to organize an interdisciplinary conference in the field of Biomedical Engineering, Healthcare and Sustainability. Recently, Healthcare Biomedical Engineering, Healthcare and Sustainability. Recently, Healthcare is undergoing a sector-wide transformation thanks to advances in computing, networking technologies, big data, and artificial intelligence. Healthcare is not only changing from reactive and hospital-centered to preventive and personalized but is also changing from disease focused to well-being centered. Healthcare systems, as well as fundamental medicine research, are becoming smarter and enabled in Biomedical Engineering. Furthermore, with cutting edge sensors and computer technologies, healthcare delivery could also yield better efficiency, higher quality, and lower cost. However, these innovations often do not bring in sustainability, health, and happiness for all people. Science and technology are to be complemented by arts, humanities, social sciences, and indigenous know-how and wisdom, in order to increase the accessibility of the benefits for the needy across all regions and classes of people. We need ethically aligned and driven health care system and sustainability. Professional practice in the fields of Biomedical Engineering, Healthcare and Sustainability are welcome to participate in ECBIOS 2025. This conference enables interdisciplinary collaboration of science and engineering technologists in the academic and industrial fields, as well as networking internationally. During the conference, there will be substantial time for presentation and discussion. Attendants will find various activities useful in bringing together a diverse group of engineers and technologists across the disciplines for the generation of new ideas, collaboration potential and business opportunities.

ECBIOS 2025 received a total of 131 submissions, with 91 papers finally selected and registered for this conference. 11 countries and regions of participation includes Bangladesh, China, Italy, Japan, Korea, Malaysia, Taiwan, Thailand, The Philippines, The USA, and Vietnam. These papers on various topics are divided into 24 Regular Sessions and 2 Invited Session. We are happy to say that it is a fine starting point for establishing an international network to facilitate future science and engineering technologists in the academic and industrial fields. I would like to express my sincere gratitude to the participants and committee members for making this event possible. I welcome you all to share in this conference, as an opportunity to make new unforgettable learning experiences and colleagues. Friends, welcome to ECBIOS 2025!

*Cheng-Fu Yang*

Prof. Cheng-Fu Yang, Ph. D.  
Conference Chairman of ECBIOS 2025  
Department of Chemical and Materials Engineering,  
National University of Kaohsiung, Taiwan  
October 23, 2025

# Conference Topics

## *Regular*

- A. Smart Healthcare System Analysis and Design
- B. Computer and Human-Machine Interaction of Healthcare System
- C. Application of Iot (Internet of Things) on Healthcare System
- D. Big Data and Artificial Intelligence Enabled Healthcare Systems
- E. Health-Related Aspects of Sustainability
- F. Environmental Education and Public Health
- G. Environmental Engineering and Biotechnology Rehabilitation Medicine and Physiotherapy
- H. Sports Medicine
- I. Pediatric and Geriatric Emergency Care
- J. Leisure Recreation
- K. Health Promotion
- L. Nourishment and Health Care
- M. Disaster and Health
- N. Health and Environment
- O. Health Services
- P. Occupational Health
- Q. Impact of Safety, Security and Disaster Management on Sustainability
- R. Sustainability Science
- S. Medical Electronics
- T. Biomedical Materials
- U. Biomedical Diagnostic Techniques
- V. Medical Information and Rehabilitation Technology
- W. Electrical Engineering
- X. Other Relate Topics in Healthcare, Sustainability, Biomedical Engineering

## *Invited*

- IV1. Innovations and Challenges in Healthcare and Rescue
- IV2. Bio-Inspired Adhesive Materials and AI-Driven Robotics for Sustainable Intelligent Systems

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## Organizers

Cheng Shiu University, Taiwan

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# Sessions

## *Regular Sessions*

- A. Smart Healthcare System Analysis and Design
- B. Computer and Human-Machine Interaction of Healthcare System
- C. Application of Iot (Internet of Things) on Healthcare System
- D. Big Data and Artificial Intelligence Enabled Healthcare Systems
- E. Health-Related Aspects of Sustainability
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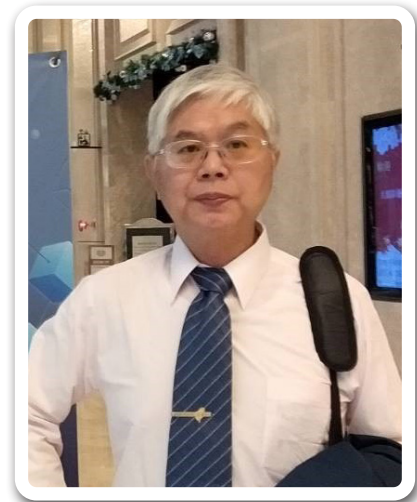
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## Keynote Speaker



### Chi-Cheng Cheng, Ph. D.

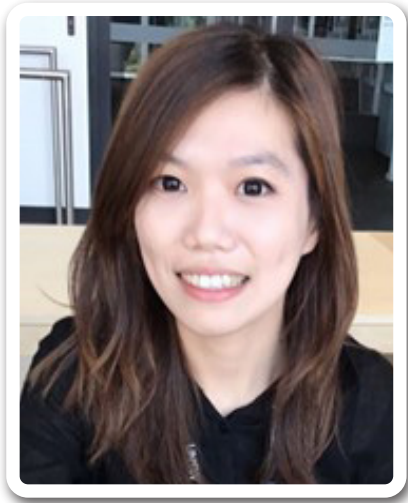
**Professor,**  
Department of Mechanical and Electro-Mechanical  
Engineering,  
National Sun Yat-sen University, Taiwan

#### **A Smart Assistive Guidance System for Visually Impaired Pedestrians Crossing the Road**

Visually impaired people always experience inconvenience to manage many issues in their daily life. Crossing the road without tactile paving becomes a great challenge to the blind. Based on this motivation, this research aims to develop a wearable assistive guiding system using cutting edge techniques of machine vision and artificial intelligence to direct the visually impaired people walking on the central area of the crosswalks while crossing the road. Both safety and autonomy of visually impaired people can therefore be improved. This research incorporates image processing and machine learning approaches to locate the central position of the crosswalks even affected by occlusion of pedestrians and interference of shadow. In addition, statistical approaches are also applied to reduce the influence of fault detection. A wearable device with vibration wristbands is then employed to provide information of guidance for the visually impaired people. Crossing-the-road experiments were conducted to examine performance of the proposed center-line detection algorithm and guidance of vibration strategy. In order to include all possible appearances of crosswalks in real world, different environmental conditions including head-on and oblique directions as well as without and with occlusion were examined. Finally, the presented assistive guiding system demonstrates promising performance to direct healthy human subjects with both eyes fully covered successfully accomplishing the task of passing through the road by walking in the middle along the crosswalk.

**Keywords:** artificial intelligence, image processing, machine learning, machine vision, pedestrian crosswalks, visually impaired people, wearable device.

## Keynote Speaker



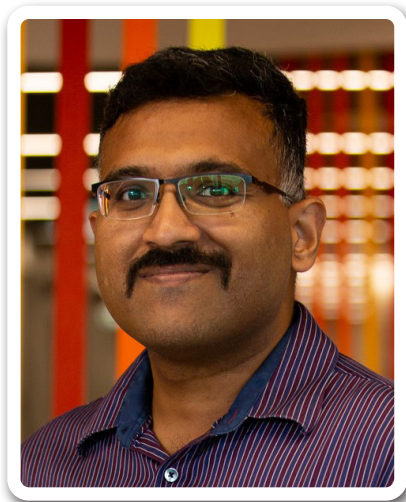
### Wen-Fan Chen, Ph. D.

Associate Professor,  
Institute of Medical Science and Technology,  
National Sun Yat-sen University, Taiwan

#### **3D Printed Bionic Ceramic Scaffolds for Bone Repair Applications - From Novel Materials to 3D Printing Technology**

Each year, tens of thousands of patients worldwide undergo bone graft surgeries due to fractures caused by excessive physical activity, traffic accidents, or osteoporosis in the elderly. Although autografts are considered the gold standard for bone grafting, their clinical application is limited by the finite availability of donor tissue and the need for multiple surgical procedures. Allografts, on the other hand, pose risks such as disease transmission and reduced biological activity following sterilization. Currently used medical materials, including metals and polymers, also face several clinical limitations, such as imaging artifacts, excessive stiffness leading to stress shielding and bone overload, allergic reactions, neurotoxicity from metal ions, poor osseointegration, and insufficient mechanical strength of polymer-based materials. To address these challenges, our team aims to develop a next-generation bone substitute that combines high mechanical strength, enhanced bioactivity, and therapeutic functionality. Our research focuses on three main areas: (1) Novel Bioceramic Material Synthesis - Development of a new bioactive ceramic based on diopside ( $\text{CaMgSi}_2\text{O}_6$ ), known for its biocompatibility and osteoconductivity; (2) Advanced 3D Printing Techniques - Fabrication of biomimetic scaffolds with patient-specific architecture by optimizing printing slurry composition, equipment parameters, and sintering conditions to meet diverse anatomical and clinical needs; and (3) Magnetic Nanoparticle Integration - Incorporation of magnetic nanoparticles into the scaffold to enable localized magnetothermal therapy for the elimination of pathological cells near the implantation site. By integrating these innovations, our team aims to create a biodegradable, mechanically robust, and highly bioactive scaffold with therapeutic capabilities, offering a promising solution for the treatment of critical-sized bone defects in clinical settings.

## Keynote Speaker



### **Pramod Koshy, Ph. D.**

**Associate Professor,**  
School of Materials Science & Engineering,  
The University of New South Wales Sydney, Australia

#### **Designing Ce-Based Nanostructures for Diverse Biomedical Applications**

There has been increased research into nanoceria ( $\text{CeO}_2$ ) owing to its unique chemical and defect characteristics which has created interest in its use for several advanced environmental, energy, and biomedical applications. The potential use of nanoceria for biomedical applications is linked to its intrinsic defect characteristics, which arise from the pH-dependent reversible switching between the  $\text{Ce}^{3+}$  and  $\text{Ce}^{4+}$  oxidation states and the resulting alteration of the surface oxygen vacancy characteristics. This can enable nanoceria to be used in cell protective anti-oxidant applications where reactive oxygen species (ROS) are removed or as a cell destructive pro-oxidant where ROS is generated.

This gives nanoceria the ability to be used in cancer treatment, where the cancer cell microenvironment is slightly acidic in comparison to the basic physiological pH in regular cells. Additionally, this capability can be harnessed to develop nanoparticle solutions for theranostics (therapy + diagnostics) and anti-bacterial biomedical applications and also to design nanostructured films/coatings to improve osseointegration.

The present work discusses research into nanoceria, its key characteristics, typical fabrication and design routes, property-morphology characteristics resulting from these processes, functionalisation approaches to improve specificity for different applications, as well as strategies such as doping, morphology tailoring, and vacancy alteration to enhance its surface and chemical characteristics for biomedical applications. The results can help to improve understanding of issues affecting the widespread use of these nanoparticles as well as guide possible design and development strategies to overcome these limitations and enable the successful use of these unique materials.

# Guidelines

## 1. Official Languages

The official language of ECBIOS 2025 is English. All presentations including Q&A should be delivered in English.

## 2. Guideline for Participants

### 2.1. Conference Venue

Cheng Shiu University, Taiwan

(No.840, Chengqing Rd., Niasong Dist., Kaohsiung City, Taiwan)

### 2.2. Registration

Time of Registration:

09:00~ 13:00, October 23, 2025 (UTC/GMT +8 Taipei)

### 2.3. Conference Kit

Conference kit, which contains final program and name badge, will be provided to participants during check-in at the Registration/Information Desk.

## 3. Guidelines for Presenters

3.1. The presenters and session chairs are asked to keep to the paper sequence as shown in the Final Program. By following this predefined schedule, participants can switch between sessions without missing any particular papers of interest.

3.2. The presentation time for each oral presenter is 15 minutes. The session chairs will allow the presenter 12 minutes for presentation and 3 minutes for discussion. Presentation time for each poster presenter is 60 minutes.

3.3. It is required that the presentation language of ECBIOS 2025 papers is in English.

3.4. Notebook PCs and LCD projectors will be available in every session room. Presenters are urged to prepare their files in MS PowerPoint format on a USB and copy the Conference into the PC at the session room before the session begins. Our session aids will assist the presenters to copy any relevant files. If you wish to use your own notebook PC, please be prepared to open the file before your presentation time.

3.5. Please contact the Conference Secretary Desk, the session chairs, or any of the session aids if there are any special requests which might require special and unexpected attention.

# Conference Agenda

**Venue:** Cheng Shiu University, Kaohsiung, Taiwan

**Language:** English

## Main Conference

Thursday, October 23, 2025

08:30 09:00 Conference Registration

09:00 09:10 Opening Ceremony

09:10 10:00 1<sup>st</sup> Keynote Speech

10:00 10:20 Coffee Break

10:20 11:10 2<sup>nd</sup> Keynote Speech

11:10 12:00 3<sup>rd</sup> Keynote Speech

*12:00- 13:00 Lunch Break*

13:00 17:00 Oral Paper Presentation & Poster Paper Presentation

15:30 16:00 Coffee Break

18:00 20:30 Conference Banquet

## Main Conference

Friday, October 24, 2025

08:30 17:30 Technical Visit & Communication

## Main Conference

Saturday, October 25, 2025

08:30 17:30 Technical Visit & Communication & Closing

# Venue

Administration Building, Cheng Shiu University

No.840, Chengqing Rd., Niasong Dist., Kaohsiung City 833, Taiwan



## 正修科技大學 校園地圖

Campus Map | Cheng Shiu University



# Oral Paper Schedule

Thursday, October 23, 2025

Onsite Oral Paper Sessions (Cheng Shiu University, Kaohsiung, Taiwan) UTC/GMT +8 hours		
14:00—15:00	15:00—16:00	16:00—17:00
<b>Session A</b>		
<b>A1</b>	<b>A2</b>	<b>A3</b>
EC250064-D	EC250042-S	EC250119-S
EC250090-D	EC250070-S	EC250045-T
EC250102-D	EC250080-S	EC250050-T
	EC250094-S	
<b>Session B</b>		
<b>B1</b>	<b>B2</b>	<b>B3</b>
EC250067-H	EC250054-W	EC250088-X
EC250062-L	EC250106-W	EC250093-X
EC250068-L	EC250043-X	EC250095-X
	EC250047-X	
<b>Session C</b>		
<b>C1</b>	<b>C2</b>	
EC250048-A	EC250038-IV1	EC250073-IV1
EC250017-B	EC250060-IV1	EC250120-IV1
EC250103-B	EC250061-IV1	
EC250104-B	EC250069-IV1	

Online (Remote) Oral Paper Sessions (ZOOM Meetings) UTC/GMT +8 hours		
13:00—14:00	14:00—15:00	15:00—16:00
<b>Session D</b>		
<b>D1</b>	<b>D2</b>	<b>D3</b>
EC250083-B	EC250075-R	EC250096-U
EC250100-D	EC250082-R	EC250022-V
EC250004-E	EC250077-S	EC250007-X
EC250079-O	EC250081-S	EC250009-X

# Poster Paper Schedule

**Thursday, October 23, 2025**

<b>Onsite Poster Paper Sessions</b> (Cheng Shiu University, Kaohsiung, Taiwan) UTC/GMT +8 hours			
13:00—14:00	14:00—15:00	15:00—16:00	16:00—17:00
EC250046-A	EC250128-IV2	EC250011-Q	EC250030-X
EC250056-A	EC250129-IV2	EC250049-Q	EC250040-X
EC250065-A	EC250130-IV2	EC250122-Q	EC250085-X
EC250076-A	EC250131-IV2	EC250013-S	EC250012-W
EC250039-G	EC250132-IV2	EC250063-S	EC250014-W
EC250109-IV1	EC250133-IV2	EC250026-U	EC250028-W
EC250023-W	EC250092-N	EC250066-U	EC250044-W
EC250037-J	EC250105-P	EC250078-U	EC250059-W
EC250126-C			EC250125-X

<b>Online (Remote) Poster Paper Sessions</b> UTC/GMT +8 hours			
13:00—14:00	14:00—15:00	15:00—16:00	16:00—17:00
EC250116-B	EC250031-A	EC250033-M	EC250015-W
EC250034-C	EC250036-D	EC250101-M	EC250124-W
EC250035-C	EC250099-D	EC250121-R	EC250018-X
EC250074-C	EC250027-D	EC250032-S	EC250053-X
	EC250071-K		

## Paper Abstracts



<https://www.ecbios.asia/abstract>

## Contact us



EC250004

## Assessment of Working Environment Quality and Improvement Solutions in University Medical Center Ho Chi Minh City Branch 2

Ngoc An Dang Nguyen<sup>1,a</sup>, Minh Quan Cao Dinh<sup>2,b</sup>, Hong Thu Nguyen Thi<sup>3,c</sup> and Lam Duc Vu Nguyen<sup>3,d</sup>

<sup>1</sup>University of Medicine and Pharmacy at Ho Chi Minh City

<sup>2</sup>Ho Chi Minh City University of Technology (HCMUT), VNU-HCM

<sup>3</sup>University Medical Center Ho Chi Minh City branch 2

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**Keywords:** Indoor air quality, Occupational environment, HEPA filtration, UVC disinfection, environmental intervention

### Abstract:

This study evaluates the indoor environmental quality of the administrative office at University Medical Center Ho Chi Minh City branch 2 and proposes practical interventions to improve occupational health conditions. A cross-sectional assessment was conducted by monitoring key air quality parameters, including carbon dioxide (CO<sub>2</sub>), fine particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub>), humidity, and illumination. Following baseline measurements, a combined system of HEPA PM<sub>2.5</sub> filtration units, convection fans, and ultraviolet-C germicidal lamps was implemented. Results showed improvements post- intervention: CO<sub>2</sub> concentrations decreased by over 60%, PM<sub>2.5</sub> levels dropped by more than 40%, and the air quality index returned to safe thresholds. These findings confirm that low-cost, scalable environmental engineering controls can effectively mitigate indoor air pollution and enhance workplace conditions in healthcare administrative settings.

## The Evaluation of Absolute and Real Signal Values in the Reconstruction of Electrical Impedance Tomography Images

Minh Quan Cao Dinh<sup>1,a</sup>, Hoang Nhut Huynh<sup>1,b</sup>, Tan Loc Huynh<sup>1,c</sup>, Thanh Ven Huynh<sup>1,d</sup>, Dinh Tuyen Nguyen<sup>1,e</sup> and Trung Nghia Tran<sup>1,f</sup>

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**Keywords:** Electrical Impedance Tomography, EIT image reconstruction, Signal reconstruction, Real value signals, Absolute value signals

### Abstract:

This study explores the differences between real and absolute values of signals in Electrical Impedance Tomography (EIT) image reconstruction, with a particular focus on their impact on image quality and accuracy. Simulations were conducted using a finite element mesh model containing three inclusions with varying conductivity values. The inclusions representing regions with moderate, poor, and high conductivity were carefully chosen to create sharp contrasts in conductivity. In the experimental setup, 16 electrodes were placed evenly around the circular domain, a current injection pattern was applied, and the resulting boundary voltages were recorded. The reconstruction based on absolute signal values, depicted in the center image, tended to smooth out sharp conductivity contrasts, leading to significant artifacts and reduced accuracy in localizing the inclusions. In contrast, the reconstruction based on real signal values, shown on the right, provided a more accurate representation of the true conductivity distribution, maintaining sharp contrasts and improving the localization of the inclusions. Quantitative analysis revealed that the mean squared error (MSE) for the absolute signal reconstruction was 0.38, while for the real signal reconstruction it was 0.12. These findings underscore the critical role of considering the real component of the signal in EIT image reconstruction to achieve improved accuracy and higher fidelity in the resulting images.

EC250009

## Evaluation of Current Injection and Voltage Acquisition Patterns for EIT Image Reconstruction: A Simulation Study

Minh Quan Cao Dinh<sup>1,a</sup>, Hai Anh Nguyen Thi<sup>1,b</sup>, Dang Khoa Trinh Vo<sup>1,c</sup>, Lin Dan Lieu<sup>1,d</sup>, Trung  
Thach Nguyen<sup>1,e</sup> and Hong Duyen Trinh Tran<sup>1,f</sup>

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**Keywords:** Electrical Impedance Tomography, image reconstruction, adjacent technique, opposing  
technique, electrode configuration

### Abstract:

This study investigates the influence of different voltage measurement and current injection configurations on the quality of image reconstruction in Electrical Impedance Tomography (EIT) using numerical simulation. Both adjacent and opposing techniques were systematically examined for their effectiveness in voltage acquisition and current delivery. The simulation model employed 16 equally spaced electrodes arranged around a circular domain, with an injected alternating current of 1 mA at a frequency of 50 kHz. A circular object with a conductivity of 0.9 units was sequentially positioned at five distinct locations within the imaging domain, each spaced 0.05 units apart. The reconstructed images were analyzed in terms of positional accuracy and contrast resolution. The findings demonstrate that while each configuration offers specific advantages, they also exhibit inherent limitations depending on the application. The study provides insight into the trade-offs involved in selecting electrode drive and measurement strategies for optimizing image quality in EIT systems.

## An Autonomous AI Agent Swarm for Collaborative and Distributed Malicious Threat Analysis

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**Keywords:** Distributed Threat Analysis, Multi-Agent Systems, Swarm Intelligence, Cybersecurity

### Abstract:

As cyberattacks become increasingly sophisticated and decentralized—particularly with the rise of botnets and advanced persistent threats (APTs)—traditional cybersecurity architectures, which rely on centralized data collection and analysis, have revealed fundamental limitations in terms of detection latency, single points of failure, and data privacy. Attackers are now leveraging distributed coordination strategies to operate outside the "visibility scope" of defenders, rendering single-node defense systems insufficient for perceiving the full scope of an attack.

To address this challenge, we propose HiveMind, a novel distributed threat analysis framework inspired by swarm intelligence in honeybee colonies. HiveMind consists of lightweight, autonomous AI agents deployed across various network endpoints, such as personal computers, servers, and IoT devices. Each agent is specialized in one or more analytical tasks, including static malware analysis, network traffic anomaly detection, or user behavior modeling. When an agent detects a localized suspicious activity, it does not transmit raw data. Instead, it generates a structured Threat Hypothesis, which is then shared with nearby agents through a decentralized network built upon a Gossip protocol.

**Study on the Schottky Energy Barrier Characteristics of Gadolinium Oxide Thin Film Resistive Memory Devices Using Low-temperature Supercritical Fluid Technology**

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**Keywords:** rf magnetron sputtering, gadolinium oxide, resistive random access memory, supercritical carbon dioxide

**Abstract:**

In this study, reactive radio frequency magnetron sputtering was used to deposit thin films. Gadolinium oxide was deposited on titanium nitride substrates at different deposition times and oxygen concentrations. Next, rapid thermal annealing and supercritical fluid were performed. The three-dimensional profiler (alpha - step), X-ray diffractometer (XRD) and X-ray photoelectron spectroscopy (XPS) were used to measure the thickness, surface morphology, crystal structure and elements analysis. Then, indium tin oxide is sputtered and deposited on the gadolinium oxide which covered with the metal mask to form a top electrode, thereby manufacturing a metal/insulator/metal resistive memory (MIM) structure. Finally, a power meter was used to measure the characteristics of the resistive random access memory, including the I-V characteristics, and to explore the leakage current conduction mechanism and component durability.

EC250013

## Integrating AI, Optics, and Electronics: A Pedagogical Framework for Biomedical Sensing Devices

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**Keywords:** Biomedical sensors, Machine Learning (ML), Anti-reflective (AR) films

### Abstract:

The synergy of AI-enhanced anti-reflective (AR) films and semiconductor devices creates a robust platform for high-performance biomedical sensing. These AR films are now being optimized with AI algorithms to boost their effectiveness in bioelectronic applications. By integrating machine learning (ML) techniques, these AR films can be customized for various lighting conditions, significantly improving the precision of embedded sensors in devices.

Simultaneously, we've developed AI-optimized semiconductor devices to enhance the sensitivity and specificity of biomedical sensors. These advanced devices leverage ML models to process complex biomedical signals with greater accuracy, enabling the detection of even subtle changes in biological markers. This research not only showcases technical innovation but also serves as a pedagogical framework, inspiring students and researchers in both information education and applied science education to explore the boundless possibilities of interdisciplinary integration.

EC250014

## Development of a Remote Monitor and Control System using Raspberry Pi, Programmable logic controller and Django Framework

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**Keywords:** Internet of Thing, Django, Programmable logic control, web-based control

### Abstract:

With the advent of Industry 4.0, upgrading traditional control systems to Internet of Things (IoT)-based solutions has become a key trend in future industrial development. This paper presents the design and implementation of a remote monitor and control system, using a power supervisory and control laboratory equipped with a programmable logic controller (PLC) as the experimental environment. The proposed system is built on a Raspberry Pi embedded platform integrated with the Django web framework. Python is employed in the Django background task to implement Modbus TCP communication, enabling seamless bidirectional data exchange with the PLC. Collected data is stored in a database for subsequent processing and analysis. The human-machine interface (HMI) is developed using Django's web-based capabilities, incorporating HTML5 and JavaScript to create a cross-platform remote control interface. By leveraging the flexibility and cost-efficiency of the Raspberry Pi, the existing control system is successfully upgraded to a web-based IoT monitoring solution. This approach supports both local and remote graphical monitoring, real-time data acquisition, control operations, and data analysis.

## Design Study of a Compact Dual-Outlet Blower Motor for Air Conditioning Applications

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**Keywords:** Dual-Outlet Blower Motor, Air conditioning system, Taguchi method, Sensitivity analysis

### Abstract:

This paper presents the design of a compact dual-outlet blower motor tailored for commercial vehicle air conditioning systems, capable of meeting performance requirements under both low-speed and high-speed operating conditions. The motor geometry is first developed and analyzed using the finite element software FluxMotor (Altair). Subsequently, the model is imported into Flux2D (Altair) for mesh generation, circuit configuration, and detailed evaluation of torque ripple, back electromotive force (EMF), efficiency, and line voltage. Through a comparative analysis of various slot/pole combinations, the 12-slot/8-pole configuration is identified as the optimal design. Sensitivity analysis further reveals that key parameters influencing motor performance include slot opening, air gap, magnet thickness, magnet arc angle, number of turns, and wire diameter. The Taguchi method is then employed to optimize these design parameters. Simulation results indicate that, under an input current of 1.35 A and a speed of 2678.5 rpm, the motor's efficiency improves from 67% to 82%. At a constant line-to-line voltage of 21 V, the speed increases from 2678 rpm to 3178 rpm, efficiency rises from 67% to 74.1%, and torque ripple is significantly reduced from 114% to 22.2%. These results validate the effectiveness of the proposed design approach for a compact dual-outlet blower motor in air conditioning applications.

EC250017

## An AI-assisted robotic arm for automated surgical instrument passing

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**Keywords:** Robotic Arm, Surgical Instrument, Voice Recognition, Image Recognition, Automated Passing

### Abstract:

In modern operating rooms, the precise and timely delivery of surgical instruments plays a crucial role in enhancing surgical efficiency and ensuring patient safety. This study presents an AI-assisted robotic arm system designed for the automated passing of surgical instruments. The system integrates voice and image recognition technologies to identify the surgeon's verbal commands and the required instrument types in real time. It also incorporates dimensional and coordinate measurement modules to accurately determine the spatial location of instruments. Based on this integrated information, the robotic arm performs stable and precise grasping and handover of the instruments. This system effectively reduces human error, improves surgical team coordination, optimizes sterile workflow, and alleviates the workload of surgical assistants, thereby contributing to the advancement of smart operating rooms and surgical automation.

EC250018

## Human-Machine Collaboration Performance Evaluation Model Based on Multiple Regression and Monte Carlo Simulation: An Empirical Analysis of Smart Irrigation in the Jianan Plain

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**Keywords:** Human-machine collaboration, smart irrigation, multiple regression analysis, Monte Carlo simulation

### Abstract:

Quantifying collaborative efficacy in human-machine systems remains a critical challenge for sustainable smart agriculture. This study introduces the Human-Machine Collaboration Rate (HMC Rate) and develops an integrated evaluation framework combining multiple regression and 10,000-iteration Monte Carlo simulation. Empirical validation based on 217 IoT-enabled irrigation units in Taiwan's Jianan Plain identifies key technological drivers:

Automation level ( $\beta = 0.68$ ,  $p < 0.001$ ), Augmentation adoption ( $\beta = 0.54$ ,  $p < 0.01$ ), Collaborative integration ( $\beta = 0.49$ ,  $p < 0.01$ ).

Socioeconomic and demographic variables were found to be statistically insignificant ( $p > 0.05$ ). The model demonstrates exceptional explanatory performance (adjusted  $R^2 = 0.974$ , RMSE = 0.032) and robustness validated via structural equation modeling (CFI = 0.981, SRMR = 0.023). These results suggest that strategic deployment of technology, rather than socioeconomic context, is the dominant factor in enhancing HMC effectiveness. This work contributes:

1. A validated quantitative framework applicable to agricultural human-machine systems.
2. Policy guidelines emphasizing automation-augmentation synergy.
3. Simulation-based planning tools for precision irrigation infrastructure.

**On a novel driving simulator for bilateral robotic rehabilitation of the upper limb in poststroke patients**

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**Keywords:** poststroke rehabilitation, driving simulator, upper limb, bilateral robot

**Abstract:**

Neurophysiological robotic rehabilitation is significant for the recovery of motor capabilities in poststroke patients. The active involvement of the affected subjects in the rehabilitative path is crucial for increasing their motivation and the expected benefits. It is demanding, however, to provide a variety of exercises able to adapt to their needs, since not all the devices offer multiple training modalities. Moreover, it is difficult to evaluate the abilities achieved by the subjects during therapy and hence to understand whether they will be able to get back to doing daily activities. A driving simulator could be interesting from this perspective, both for the physical and psychological recovery of the patient, presenting an involving daily activity and processing a large amount of data. With these premises, a novel bilateral driving simulator for robotic rehabilitation of the upper limb in poststroke patients is presented in this work. The proposed driving simulator presents an innovative structure that enables bilateral rehabilitation, which is proved to improve neuroplasticity and motor functions. The device is designed to have multiple modalities implemented to maintain the patients motivated, adapting to their state and enhancing the effectiveness of the therapy, making the robot suitable for different poststroke stages. The simulator aims to be economic and commercial, so that rehabilitation is made available to everyone in need. With the aim of supporting therapists in the administration of therapy and reducing their physical effort, the device will be tested in clinical settings, with the expectation of improving poststroke prospects for the treated patients.

## Development of A Real-Time Monitoring System for Cooperative Vehicles in Car Lanes

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**Keywords:** driving safety, monitoring system, raspberry pi, convolutional neural network, change of curvature, real time

### Abstract:

The content of automobile monitoring technology in the 21st century is to improve driving safety and the reliability of autonomous driving, which including two main aspects: driving monitoring and vehicle monitoring. The significant point of monitoring system is focused on monitoring the surrounding environment of the vehicle, and provides monitoring of the current environment to assist driving functions through the sensing system and imaging that to ensure driving safety. Therefore, the main point of the research is on the monitoring of abnormal road damage. Currently, in the monitoring system of abnormal road damage, cameras and laser radars are generally directly installed on the car, and then the visual algorithms in the well-known mathematical model are integrated to directly monitor the road surface defects. Hence, each car needs to be equipped with a complete set of equipment to obtain complete information, so the warning information for the manual driving of traditional cars cannot be fully provided. Therefore, the paper proposes to combine the research of lane coordination, integrate the camera with the roadside detection system, complete an integrated system, also to develop the overall real product. The research proposed mainly used the Raspberry Pi control circuit and convolutional neural network to identify the image area obtained by the camera on the car window, propose the defects of the road surface by the change of curvature, and transmit the road damage information in real time. Through actual theoretical analysis and testing, the traditional method of installing cameras and laser radars on cars and integrating visual algorithms has been improved, so that road defects can be directly monitored. In addition to obtaining more complete information, the cost of the overall system can reduce at least 70 percentage. At the same time, it also apply for patents to generate huge business opportunities.

## Integrative Machine Learning Framework for Epigenetic Biomarker Discovery and Disease Severity Prediction in Childhood Atopic Dermatitis

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**Keywords:** Atopic dermatitis, DNA methylation, CpG sites, machine learning, biomarker

### Abstract:

This study presents a machine learning framework for the identification and validation of CpG methylation biomarkers in atopic dermatitis (AD). Through integration of multiple feature selection algorithms including CALF, Elastic Net, mRMR, and RFECV, key methylation sites were prioritized for their predictive value in disease classification and severity estimation.

A central overlap panel of 8 CpG sites consistently selected across methods yielded perfect AD classification (AUC = 1.00), with 100% sensitivity and specificity. This panel demonstrated high disease specificity, showing poor classification performance for systemic lupus erythematosus (AUC = 0.46), Crohn's disease (AUC = 0.50), and oral squamous cell carcinoma (AUC = 0.58). Severity prediction using RFECV-selected 63 CpG sites (RFE63) achieved high accuracy across classifiers, with Random Forest (accuracy = 0.92) and SVC (accuracy = 0.88) outperforming others. Functional enrichment of CpG-associated genes revealed key immune-related transcriptional regulators. These genes are linked to chromatin remodeling, T helper cell differentiation, and interleukin-2 regulation, which are critical in AD pathogenesis and severity.

This work provides a foundation for epigenetic biomarker development and precision diagnostics in AD.

# RP-DoRA: Directionally Decoupled Low-Rank Adaptation with Riemannian Preconditioning for Efficient Language Model Fine-Tuning

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**Keywords:** Parameter-Efficient Fine-Tuning (PEFT), Low-Rank Adaptation (LoRA), Riemannian Optimization, Weight Decomposition, Geometric Deep Learning, Large Language Models (LLMs).

## Abstract:

Parameter-Efficient Fine-Tuning (PEFT) aims to overcome the prohibitive costs of full fine-tuning for large-language models (LLMs). This paper introduces RP-DoRA, a novel PEFT framework designed to simultaneously address two core challenges: enhancing model expressiveness and ensuring the geometric stability of the optimization process. Our central idea is to situate the LoRA update process for the directional component, within the weight decomposition framework of DoRA, into a low-rank manifold gradient framework defined by a Riemannian preconditioner. Specifically, we introduce a symmetric bilateral preconditioner,  $(B^T B + \delta I)^{-1}$  and  $(A A^T + \delta I)^{-1}$ , for the directional updates of DoRA and interpret it as a metrically induced scaling with clear geometric significance. Experiments on five standard commonsense reasoning benchmarks show that RP-DoRA, in its optimal configuration, achieves a 3.45 percentage point absolute improvement in macro-average accuracy (a 5.2% relative improvement) compared to the strongest DoRA baseline. Notably, this significant performance gain is realized without a decrease in validation loss, indicating that our method guides the model to converge to a solution with better generalization capabilities. Particularly on the challenging WinoGrande task, the performance improvement reaches as high as 5.28%, demonstrating the effectiveness and robustness of our proposed method.

**Developing Instructional Frameworks for Practice-Based Courses: A Teaching Practice Study  
Using Interpretive Structural Modeling**

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**Keywords:** Interpretive Structural Modeling (ISM), Laboratory Instruction, Control Engineering,  
Vocational Training, Educational Framework

**Abstract:**

his study employs Interpretive Structural Modeling (ISM) to develop a structured instructional framework for the Control Systems Practice course. The methodology systematically analyzes the logical dependencies among instructional elements, enabling a transition from fundamental concepts to advanced applications in vocational education. Semi-structured interviews with instructors and industry experts were conducted to extract and validate key learning components. An ISM-based questionnaire was then applied to establish pairwise relationships, construct an adjacency matrix, and derive the reachable, antecedent, and intersection sets for hierarchical classification.

The analysis identified 15 core instructional elements, which were organized into a coherent and layered framework. This structure provides instructors with a clear basis for designing logically sequenced curricula, while supporting students in progressively strengthening their analytical and practical competencies. The ISM-based design was verified to enhance both the internal coherence of teaching materials and students' deep learning outcomes in control system applications. Furthermore, this approach is highly transferable, offering a rigorous model for curriculum innovation in practice-based courses and a solid foundation for future research on industry-academia integration.

**Verification of the effect of visual information manipulation on motor control indicators in the Waiters bow test**

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**Keywords:** motor control, Waiters bow, muscle activity

**Abstract:**

**Introduction :**Recent evaluations of motor control have examined the effects of adjusting visual load settings on the sensorimotor system, but the impact of such adjustments on trunk motor control indicators remains unclear. The purpose of this study was to examine the effects of changes in the sensorimotor system caused by manipulating visual information on motor control indicators in the Waiters bow test.

**Method:** The subjects of this study were 25 healthy young men with no history of musculoskeletal disorders. The motor task was the Waiters' Bow Test, which is a trunk flexion movement limited to the hip joint. The angle during the motor task was calculated using an accelerometer. Muscle activity indicators were calculated as the maximum muscle activity of the rectus abdominis and erector spinae muscles.

**Results:** The results suggest that visual information deprivation during the Waiters' Bow Test may have reduced the maximum flexion angle of the lumbar and upper lumbar spine. Additionally, some participants who were negative under open-eye conditions became positive under closed-eye conditions.

**Discussion** The results suggest that muscle activity in the rectus abdominis and erector spinae muscles was not affected by visual information. This study suggests that visual sensory feedback is one of the factors influencing lumbar motor control, and that restricting visual information could be utilized in evaluating motor control focused on sensory reallocation in the Waiters' Bow Test.

EC250031

## Circular Economy Approaches to Medical Device Manufacturing via Green Additive Manufacturing

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**Keywords:** Additive Manufacturing, Medical Device Manufacturing, Process Innovation

### Abstract:

The healthcare industry is a significant contributor to global material waste and carbon emissions, with medical device manufacturing being a critical driver of environmental impact. Traditional subtractive manufacturing processes for medical devices often rely on non-renewable raw materials, energy-intensive fabrication, and generate considerable waste, challenging global sustainability objectives. This research proposes a comprehensive framework for integrating circular economy principles into medical device manufacturing through green additive manufacturing (GAM) technologies. The study focuses on designing and fabricating medical devices—such as prosthetics, orthotics, surgical tools, and implantable components—using recyclable, biodegradable, and bio-derived materials, including plant-based polymers, polyhydroxyalkanoates (PHA), and recycled medical-grade thermoplastics. Energy-efficient 3D printing techniques, such as selective laser sintering (SLS) with renewable-powered systems, will be combined with closed-loop material recovery processes to enable full lifecycle traceability. Life Cycle Assessment (LCA) methodologies will be employed to quantify environmental impacts across raw material extraction, production, use, and end-of-life stages, benchmarking against conventional manufacturing. Furthermore, digital twin models will be utilized to optimize design parameters for material efficiency and structural performance, while blockchain-enabled traceability systems will ensure compliance with regulatory and sustainability standards. By merging green additive manufacturing with circular economy strategies, this research aims to reduce medical device manufacturing waste by over 60%, lower energy consumption by at least 40%, and set a blueprint for net-zero, sustainable medical device production. The findings will have far-reaching implications for policymakers, manufacturers, and healthcare providers seeking to transition towards environmentally responsible, resource-efficient biomedical engineering practices.

EC250032

## Sustainable Wearable Health Monitoring Using Energy Harvesting and Biodegradable Electronics

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**Keywords:** Health Monitoring, Energy Harvesting, Biodegradable Electronics

### Abstract:

The rapid expansion of wearable health monitoring technologies has led to unprecedented advancements in continuous patient care, yet their increasing production and disposal contribute significantly to electronic waste (e-waste) and resource depletion. Conventional wearable devices rely heavily on non-biodegradable materials, toxic components, and disposable batteries, creating environmental and sustainability concerns. This research investigates a next-generation sustainable wearable health monitoring platform that integrates energy harvesting mechanisms with biodegradable electronic systems to enable environmentally responsible, long-term health tracking. The proposed design incorporates multi-modal energy harvesting techniques—including piezoelectric nanogenerators, thermoelectric converters, and flexible photovoltaic layers—to eliminate the need for frequent battery replacement. Biodegradable substrates such as polylactic acid (PLA), silk fibroin, and cellulose nanofibers will be combined with transient electronics made from magnesium, zinc, and conductive polymers, ensuring safe degradation at the end of the device lifecycle without toxic residue. Embedded AI-driven signal processing will enable real-time monitoring of vital signs, including heart rate, ECG, respiration rate, and blood oxygen saturation, with low-power edge computing to optimize energy consumption. Life Cycle Assessment (LCA) and cradle-to-cradle sustainability metrics will be applied to quantify environmental impact reductions compared to traditional wearables, targeting a 50–70% decrease in material waste and a 40% improvement in device energy autonomy. The research will also address regulatory compliance, biocompatibility, and user safety, ensuring scalability for clinical and consumer applications. The outcomes aim to establish a blueprint for sustainable, self-powered wearable health systems, aligning biomedical engineering innovation with global sustainability and circular economy objectives.

EC250033

## Flood-Adaptive Primary Care Clinics with Smart Microgrids and Rapid-Deploy MedTech

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**Keywords:** Smart Microgrids, MedTech, Artificial Intelligence

### **Abstract:**

Malaysia's recurrent monsoon-driven floods, particularly in Kelantan, Terengganu, and Pahang, cause prolonged disruptions to primary healthcare delivery, isolating vulnerable populations and impeding timely access to medical services. Conventional clinic infrastructures are often immobile, grid-dependent, and ill-equipped to maintain critical care during extreme weather events, leading to elevated morbidity and mortality rates. This research proposes a flood-adaptive primary care clinic model integrating elevated modular architecture, smart DC microgrids, and rapid-deploy medical technologies to ensure uninterrupted healthcare during disaster scenarios. The proposed design employs prefabricated, buoyant, and elevated clinic modules engineered to withstand Category 4 flood loads, incorporating amphibious access systems and water-resistant med-tech enclosures. The embedded microgrid integrates solar PV, small-scale wind, and battery-supercapacitor hybrids, with adaptive load management prioritizing life-saving equipment such as oxygen concentrators, vaccine refrigeration, diagnostic imaging, and satellite-linked telemedicine. Rapid-deploy medical units—including portable ultrasound, point-of-care diagnostic kits, and drone-accessible medical supply lockers—are integrated with an IoT-based patient tracking system to enable continuity of care even in isolated flood-affected areas. The control architecture leverages edge AI algorithms for dynamic energy allocation, predictive flood impact mapping using hydrological data, and real-time medical resource optimization. A digital twin of the clinic and microgrid system will be developed for simulation, resilience testing, and predictive maintenance. Environmental performance will be assessed through Life Cycle Assessment (LCA) and resilience metrics, targeting a 70% reduction in diesel generator dependency and >95% uptime for essential medical services during flood events. This blueprint aims to redefine disaster-resilient healthcare delivery in Malaysia, supporting national climate adaptation strategies while aligning with UN SDGs 3, 7, 9, 11, and 13.

EC250034

## Sustainable Telemedicine: Low-Energy Edge AI and Green Data Center Routing for National Rollout

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**Keywords:** Sustainable Telemedicine, Artificial Intelligence, Green Data Center

### Abstract:

The rapid adoption of telemedicine in Malaysia, accelerated by the COVID-19 pandemic, has transformed healthcare accessibility but has also introduced significant energy consumption, data processing, and carbon footprint challenges. Conventional cloud-centric telemedicine platforms rely on high-bandwidth, energy-intensive data centers, which undermine sustainability objectives and strain rural connectivity infrastructure. This research proposes a sustainable telemedicine framework integrating low-energy edge AI and green data center routing to support a scalable, energy-efficient national rollout. The proposed system employs on-device AI inference for medical image pre-processing, noise reduction, and real-time diagnostic support, reducing upstream bandwidth by over 60% while maintaining diagnostic accuracy. Edge hardware will leverage ultra-low-power processors and AI accelerators optimized for medical workloads, enabling seamless performance even in low-connectivity zones such as Sabah's interior and remote Orang Asli villages. Workload distribution is orchestrated through renewable-powered green data centers using dynamic routing algorithms that minimize CO<sub>2</sub> emissions per transaction by considering data center energy mix, geographic proximity, and network latency. The platform incorporates privacy-preserving federated learning to continuously improve AI diagnostic models without centralizing sensitive patient data, ensuring compliance with Malaysia's Personal Data Protection Act (PDPA). A digital twin of the telemedicine network will be developed for energy modeling, latency optimization, and resilience testing under peak loads and disaster scenarios. Sustainability performance will be measured using ISO 50001 energy management metrics, Life Cycle Assessment (LCA), and CO<sub>2</sub>e per consultation benchmarks, targeting a 40% reduction in energy use per patient interaction and 30% lower carbon emissions compared to conventional cloud-only models. This framework positions telemedicine as a climate-resilient, low-carbon healthcare delivery model for Malaysia, aligning with UN SDGs 3, 7, 9, 11, and 13 while enhancing equitable access to quality care.

## AI-Enabled Medical Equipment Predictive Maintenance for Energy and Waste Reduction

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**Keywords:** Artificial Intelligence, Predictive Maintenance, Energy and Waste Reduction

### **Abstract:**

Medical equipment in Malaysian hospitals and clinics—including diagnostic imaging systems, ventilators, infusion pumps, and dialysis machines—represents a significant capital investment and a critical component of healthcare delivery. However, unplanned equipment failures not only disrupt patient care but also lead to increased energy consumption, excessive maintenance costs, and premature disposal of functional components, contributing to medical waste generation. This research proposes an AI-enabled predictive maintenance framework designed to optimize the operational lifespan, energy efficiency, and environmental sustainability of medical equipment in Malaysia's healthcare system. The system integrates IoT-enabled sensor networks for real-time monitoring of key performance parameters such as vibration profiles, thermal signatures, electrical load fluctuations, and operational duty cycles. Collected data will be processed locally through edge AI algorithms—including convolutional neural networks (CNNs) for anomaly detection and long short-term memory (LSTM) models for remaining useful life (RUL) prediction—reducing the need for constant high-bandwidth cloud connectivity. Predictive insights will be used to schedule proactive servicing, calibrations, and part replacements, minimizing energy-inefficient operation modes and avoiding catastrophic breakdowns. The architecture incorporates energy consumption profiling to identify operational optimization opportunities, while blockchain-based maintenance logs ensure transparent compliance with ISO 13485 and ISO 50001 standards. A digital twin of each equipment type will be developed for simulation-based fault prediction and energy impact analysis, enabling scenario testing before deployment. Field trials will be conducted in selected Malaysian hospitals across Peninsular and East Malaysia, targeting a 20–30% reduction in unplanned downtime, a 15–25% reduction in total energy use, and a significant decrease in equipment waste through life extension of 2–5 years. This project will establish a scalable, sustainable maintenance paradigm for the Malaysian healthcare sector.

EC250036

## Sustainable Cold Chain Logistics for Vaccine and Blood Supply in East Malaysia

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**Keywords:** Artificial Intelligence, Sustainability, Cold Chain Logistics

### **Abstract:**

Ensuring the integrity of vaccines and blood products in East Malaysia—particularly in Sabah, Sarawak, and remote island communities—presents persistent logistical and sustainability challenges due to long supply routes, limited grid access, tropical humidity, and frequent transportation delays. Conventional cold chain systems depend on diesel-powered refrigeration units and single-use packaging, resulting in high operational costs, elevated carbon emissions, and significant medical waste. This research proposes a sustainable cold chain logistics framework integrating renewable energy-powered refrigeration, advanced thermal storage, and IoT-enabled monitoring to ensure temperature stability from origin to point-of-care while minimizing environmental impact. The system will employ solar photovoltaic (PV) arrays with lithium-titanate (LTO) battery storage, complemented by phase change materials (PCMs) tuned for vaccine (2–8 °C) and blood (1–6 °C) thermal envelopes, enabling 72+ hours of passive cooling during transport interruptions. Cold storage units will be equipped with AI-driven predictive thermal control that dynamically adjusts compressor cycles based on route conditions, ambient temperature forecasts, and load profiles, reducing energy demand by up to 30%. IoT telemetry modules with LoRaWAN connectivity will provide real-time temperature, vibration, and door-opening event data, even in areas with limited cellular coverage, enabling proactive intervention before thermal breaches occur. A blockchain-enabled traceability system will ensure regulatory compliance with WHO PQS and Malaysia's Ministry of Health cold chain standards, while providing end-to-end verification of product quality. Life Cycle Assessment (LCA) will be conducted to compare carbon footprint, energy use, and material waste reduction against conventional diesel-refrigerated transport. Field deployment will be piloted on vaccine and blood supply routes from Kota Kinabalu to rural clinics in Kudat and from Kuching to longhouse communities along the Rajang River.

EC250037

## Color Design in Graphic Notation Based on Listener Perception: Music, Emotion, and Color Correspondence

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**Keywords:** graphic notation, color design, crossmodal correspondences, music–emotion–color mapping, emotion

### Abstract:

This study investigates the crossmodal correspondences among music, emotion, and color from the perspective of listener perception, with a focus on verifying the mediating role of emotion. The aim is to establish color design guidelines for application in graphic notation. The research integrates full-length music listening, subjective segmentation, emotion annotation, and color selection to analyze the correspondence patterns and consistency across musical segments. Unlike most previous studies that employ pre-segmented short excerpts, this study allows participants to segment music according to their own perceptions, thereby reflecting a more authentic listening experience. The main outcomes include: (1) verification of the mediating effect of emotion in music–color correspondences; (2) examination of individual differences in segmentation behavior; (3) evaluation of inter-listener consistency in emotion and color annotations for the same musical segments; and (4) summarizing the correspondence among music, emotion, and color, and exploring its potential value in the color design of graphic scores. The research outcomes are expected to offer design guidelines with both theoretical depth and practical value, serving as references for multisensory art creation, music education, and visual performance.

Examples of graphic notation for Ligeti's Artikulation and Malinowski (reference links for reviewers):

[https://www.youtube.com/watch?v=71hNI\\_skTZQ](https://www.youtube.com/watch?v=71hNI_skTZQ)

<https://www.youtube.com/watch?v=2PVX7Umth1A>

## IoT-Based Anomaly Detection for Long-Term Care Using Principal Component Analysis and Isolation Forest

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**Keywords:** Isolation Forest, Principal Component Analysis, Anomaly Detection, IoT, Long-Term Care

### Abstract:

Taiwan's rapid demographic shift toward a super-aged society has intensified the demand for long-term care, yet staffing levels remain insufficient, posing safety risks from environmental incidents such as fires, HVAC failures, or sudden health events. To address this, we propose an IoT-based intelligent environmental monitoring and early-warning system tailored for long-term care facilities, aiming to enhance safety, reduce manpower burden, and enable smart services. The system adopts a three-layer IoT architecture: (1) Perception layer integrates temperature/humidity, illuminance, air quality, and noise sensors for comprehensive monitoring; (2) Network layer employs ESP-NOW for low-power point-to-point communication and Wi-Fi Mesh topology for robust, scalable, and self-healing networking; (3) Application layer provides user interfaces, data analysis, remote monitoring, historical queries, and real-time anomaly alerts.

To address the high dimensionality and computational complexity of multivariate IoT data, Principal Component Analysis (PCA) is applied to transform correlated variables into uncorrelated principal components, retaining the most representative variance structure. When the cumulative explained variance of selected components reaches a threshold, these are input into the Isolation Forest algorithm, an unsupervised method that isolates anomalies more quickly due to their sparse distribution in feature space.

The system features a modular, node-based design: sensor nodes handle data collection and validation; security nodes transmit and verify data; control nodes adjust environmental devices. Edge computing enables local real-time analysis, minimizing cloud latency and security risks. A closed communication network with pairing, error retransmission, and anomaly counting enhance reliability and end-to-end protection.

Through continuous monitoring and intelligent alerts, the system mitigates manpower shortages and reduces health risks from environmental hazards, while its scalability allows deployment in other indoor environments such as community centers requiring long-term environmental quality assurance.

**Muscle activity of the hip adductor during CKC movement.**

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**Keywords:** EMG, Hip adductor, CKC

**Abstract:**

**【Introduction】**The closed kinetic chain is an essential method of movement for humans in daily life, and is also important as a training method. However, there are only a few studies that focus on the hip adductor muscles. We therefore focused on the muscle activity of the hip adductor muscles during bicycle ergometer exercise and squats, in comparison with walking and standing as activities of daily living, and compared these muscle activity levels as an indicator of training intensity in rehabilitation. **【Method】**This study involved 13 subjects, and was conducted after obtaining their consent. The study was approved by the Yamato University Ethics Committee. Electromyograms were measured during bicycle ergometer exercise in the hip adductor muscles, rectus femoris, vastus medialis, adductor muscles, semitendinosus, medial gastrocnemius, and tibialis anterior. Joint angles of the hip, knee, and ankle were calculated using a motion analysis device. The bicycle ergometer exercise was performed at a power of 50W or 100W and a rotation speed of 50 rpm. Treadmill walking was performed at speeds of 4km/h and 5km/h. Squats were performed at 60 rpm with knee flexion between 90° and 0°. For chair stand-up, subjects started with their feet on the floor and their knees at 110°, crossing their arms in front of their chest and standing at their own speed. Five stable cycles of each movement were measured, and data from three cycles was used. Maximum isometric contraction of each muscle was normalized to 100%. Statistical analysis was performed using a repeated measures one-way analysis of variance with Tukey-Kramer multiple comparisons. **【Result】**Muscle activity of the hip adductor muscles ranged from 9.6 to 14.4% during bicycle ergometer exercise. During treadmill walking, it ranged from 17.0 to 19.1%. During squats, it ranged from 11.3 to 19.15%. When standing up from a chair, the figure was 8.7%. **【Discussion】**With regard to the role of the adductor muscles, they are thought to stabilize the pelvis during the unilateral support phase when walking, and to act as hip extension and hip alignment adjustment during cycle ergometer exercise.

## Exploratory Correlation Analysis of Respiratory Waveform, Instantaneous Respiratory Depth and Rate in Relation to Parasympathetic Indices During Spontaneous Breathing

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**Keywords:** Respiratory Depth, Respiratory Rate, Parasympathetic, Spontaneous Breathing, Hilbert transform

### Abstract:

Respiration is closely related to heart rate variability (HRV), and respiratory sinus arrhythmia (RSA)—characterized by heart rate acceleration during inspiration and deceleration during expiration—is well known. This fluctuation occurs within a single respiratory cycle, with parasympathetic nervous system (PNS) activity reduced during inspiration and increased during expiration, suggesting an inverse relationship between respiratory phase and PNS activity. Over a longer timescale, deep and slow breathing has been reported to enhance PNS activity, indicating that not only the timing (phase) but also the respiratory depth and rate may influence autonomic nervous system activity. However, under spontaneous breathing, it remains unclear which of the following best reflects PNS activity: (i) the raw respiratory waveform, (ii) respiratory depth, or (iii) respiratory rate.

This study compared the relationships of these three respiratory measures with PNS activity during spontaneous breathing. Respiratory depth was defined as instantaneous amplitude and respiratory rate as instantaneous frequency, both derived from the Hilbert transform. Respiratory waveforms and electrocardiograms were recorded at rest for 5 minutes in 37 healthy young adults. Instantaneous amplitude and frequency were computed from the respiratory waveform, while PNS indices—high-frequency (HF) power, root mean square of successive differences (RMSSD), and cardiac vagal index (CVI)—were calculated from the ECG as time series using a sliding-window approach. Within-participant correlations between each respiratory measure and PNS index were obtained, and repeated-measures ANOVA with respiratory measure as a factor was used to compare correlation strengths. Results showed a significant main effect, with instantaneous amplitude consistently exhibiting significantly stronger correlations than the respiratory waveform across all PNS indices. These findings suggest that Hilbert-derived amplitude serves as a useful indicator of respiratory depth during spontaneous breathing and that depth may play an important role in the modulation of PNS activity.

**Design of diaper real-time monitoring system based on MQTT and API**

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**Keywords:** Diaper dermatitis, RF433, Microprocessor, MQTT

**Abstract:**

This paper aims to address the problem of diaper dermatitis (DD) in newborns caused by delayed diaper changes. A real-time diaper wetness monitoring system based on IoT technology is designed. The perception layer utilizes an RF433 wireless transmission module and a moisture sensor to achieve low-power, real-time, and low-interference detection. When a diaper wetness threshold is reached, the system immediately notifies the caregiver via an alarm and simultaneously transmits the data to a backend server via the MQTT protocol by a microprocessor at the transport layer. The data processing layer utilizes an API and database for storage and statistical analysis. The application layer developed Web and APP interfaces to simultaneously monitor the status of multiple patients across multiple platforms and includes real-time push notifications for alerts. Clinical trials have demonstrated that this system effectively reduces the incidence of DD, hospital stays, and caregiver stress, thereby improving overall care quality. This research has also shown that while MQTT offers real-time performance but exhibits significant latency, APIs offer greater stability and minimal latency, making them suitable for real-time display and management. Overall, this system demonstrates high scalability and practicality, and is poised for future expansion into long-term care and elderly care settings.

## Near-Field Electrospinning Optimization of Piezoelectric Nanofibers for Sensor Applications

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**Keywords:** Near-field electrospinning, Composite, Piezoelectric sensor, Process optimization

### Abstract:

This study aims to develop a near-field electrospinning (NFES) process for fabricating piezoelectric sensors, investigating the formulation and selection of piezoelectric solution concentrations to determine optimal concentration and processing parameters. The NFES technique was employed to produce stably aligned fibers with uniform diameter, which were subsequently spun into thin films. A piezoelectric sensor was constructed by integrating a high-pass filter circuit. The processing parameters examined in this study included solution concentration, applied voltage, needle-to-collector distance, and flow rate. The piezoelectric solutions comprised pure polyvinylidene difluoride (PVDF) and PVDF-graphene composite solutions, which were tested and compared systematically. This research provides a detailed analysis of the piezoelectric solution concentrations and electrospinning process parameters for both pure PVDF and PVDF-graphene composites, correlating Taylor cone formation with fiber morphology outcomes. The experimental results demonstrate that an 11% pure PVDF solution with processing parameters of 3 kV applied voltage, 1 mm needle-to-collector distance, and 1 mL/h flow rate yielded the finest fibers with a diameter of 3.066  $\mu\text{m}$ . The most stable processing conditions with optimal fiber alignment and uniform diameter consistency were achieved using 11% pure PVDF solution with 2 kV applied voltage, 1 mm needle-to-collector distance, and 1 mL/h flow rate. The resulting sensor, integrated with a 7 kHz high-pass filter circuit, demonstrated a maximum output voltage of 472 mV when subjected to finger tapping stimulation.

**Automated Aerospace Component Recognition System Using Artificial Intelligence for Sustainable Manufacturing**

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**Keywords:** Artificial intelligence, Aerospace, Recognition, Manufacturing

**Abstract:**

As global industries transition toward sustainability, traditional manufacturing processes that rely heavily on manual material identification have increasingly exposed limitations including low efficiency, energy waste, and excessive carbon emissions, thereby hindering enterprises from fulfilling their Environmental, Social, and Governance (ESG) responsibilities. This study develops an automated aerospace component recognition technology that integrates image processing with artificial intelligence to enhance identification efficiency, reduce human dependency and misclassification rates, ultimately minimizing resource consumption and achieving carbon footprint reduction and circular economy objectives. The proposed system incorporates multiple image recognition algorithms coupled with advanced image preprocessing techniques to establish an accurate and stable identification workflow. To address the susceptibility of static image recognition to on-site lighting variations and background interference, this research introduces a dynamic recognition mechanism that consolidates classification results through multi-frame information integration, significantly improving recognition stability and accuracy while preventing material waste and manufacturing rework caused by misidentification. Regarding experimental design, the study conducts comparative performance evaluations of various algorithms, assessing the optimal balance among processing speed, accuracy rate, and practical applicability to select the most suitable algorithm. The research validates system stability and scalability through simulation of smart factory application scenarios. This research enhances production line operational efficiency and demonstrates concrete achievements in production line intelligentization, sustainable manufacturing, and circular economy implementation, thereby accomplishing effective smart manufacturing transformation.

EC250045

## Non-enzymatic Glucose Biosensor based on NiWO<sub>4</sub> Nanoparticles Modified Screen Printed Carbon Electrode

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**Keywords:** Glucose Biosensor, NiWO<sub>4</sub>, Nanoparticles, Screen Printed Carbon Electrode, Health care devices

### Abstract:

Non-enzymatic electrochemical glucose sensors have emerged as promising alternatives to enzymatic counterparts due to their superior stability, cost-effectiveness, and tolerance to harsh operating conditions. In this study, nickel tungstate (NiWO<sub>4</sub>) nanoparticles were synthesized via a controlled hydrothermal method and employed to modify screen-printed carbon electrodes (SPCEs) for the sensitive and selective detection of glucose. The physicochemical properties of the NiWO<sub>4</sub> nanoparticles were systematically characterized using X-ray diffraction (XRD), field-emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDS), and Fourier-transform infrared spectroscopy (FTIR), confirming their phase purity, nanostructured morphology, and chemical composition. Electrochemical performance was evaluated through cyclic voltammetry (CV), chronoamperometry, and electrochemical impedance spectroscopy (EIS) in alkaline medium. The NiWO<sub>4</sub>-modified SPCE exhibited enhanced electrocatalytic activity toward glucose oxidation, attributed to the synergistic redox behavior of Ni<sup>2+</sup>/Ni<sup>3+</sup> couples and the high surface area of the nanoparticles. Under optimized conditions, the sensor demonstrated a wide linear detection range, low detection limit, and rapid response time, along with excellent repeatability, stability, and selectivity against common interfering species such as ascorbic acid, uric acid, and dopamine. Real-sample analysis in spiked human serum further validated the practical applicability of the proposed non-enzymatic glucose sensor, highlighting its potential for point-of-care diagnostics and continuous glucose monitoring.

EC250046

## Dynamic Cone of Economy Analysis with Joint Torque Estimation Using Identified Body Segment Inertial Parameters

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**Keywords:** cone of economy, efficiency cone, body segment inertial parameters, dynamic model, joint torque estimation

### Abstract:

To investigate the relationship between balance efficiency and fall risk, the concept of the Cone of Economy (CoE) has been introduced to quantify the range of motion of the head and center of mass during upright standing. However, static CoE contours alone fail to capture the underlying dynamic factors, such as inertial forces induced by the body segment velocity and acceleration during measurement. In this study, we propose a dynamic model of the human body based on a simplified Cone of Economy framework and a procedure for identifying the body segment inertial parameters using a custom-designed measurement device and a force plate. These identified parameters allow for the estimation of torque trajectories at the hip and ankle joints during external CoE measurements, offering more intuitive and comprehensive insights into early signs of balance impairments from a dynamic perspective. To validate the feasibility of the proposed model and evaluate the effectiveness of the identified inertial parameters for torque estimation, the estimated torques are compared with the torques measured with a force plate. The RMSE of ankle joint torques in the sagittal and coronal directions are 5.83 Nm and 7.74 Nm, respectively. Preliminary results also underscore the importance of incorporating joint torque estimation into CoE assessments, particularly when evaluating different dynamic conditions.

EC250047

## A Trainable Multi-Cellular Phase Field Model for Targeted Pattern Formation via Local Interactions

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**Keywords:** pattern formation, Multi-Cellular Phase-field Model, regenerative medicine

### **Abstract:**

Multicellular systems form complex dynamic patterns through chemical and physical interactions between cells. To understand the principles of such pattern formation, we propose a trainable Multi-Cellular Phase-field Model in which the morphology and position of each cell are represented as a continuous field, and state updates are performed using only local information from the neighborhood. The results of simulation experiments based on this model demonstrated that multiple cells can learn to form a given target shape through local interactions. The ability to infer the required cell arrangements and interactions from a target shape could contribute not only to understanding biological phenomena but also to establishing design principles in tissue engineering and regenerative medicine.

EC250048

## Intelligent and Automated Scheduling Framework for Resident Physicians in Smart Healthcare Systems

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**Keywords:** Intelligent scheduling, Resident physician scheduling, Constraint-based optimization, Mixed-Integer Linear Programming (MILP), Fairness and Compliance

### Abstract:

In recent years, the complexity of hospital operations and the need for rapid cross-department collaboration have heightened the challenges of scheduling resident physicians. Manual methods often fail to adapt to dynamic staffing requirements, leading to inefficiencies, regulatory breaches, and unequal workload distribution. This study proposes an intelligent, automated scheduling framework using mixed-integer linear programming and constraint-based optimization to generate fair, regulation-compliant rosters in real time. These capabilities are implemented through a modular architecture with API integration, enabling seamless data exchange with hospital systems and supporting scalability.

Evaluation results indicate: (1) A two-stage scheduling engine enhances fairness and reduces scheduling time from hours to minutes compared to manual methods. (2) Dynamic inputs, such as last-minute leave requests and cross-department support, are processed automatically, reducing administrative workload and improving responsiveness. (3) In modern healthcare resource management, adopting an intelligent, automated scheduling platform is critical to improving workforce efficiency, ensuring compliance, and enabling scalable deployment across multiple hospitals.

## Information Security and Data Privacy Research: A Systematic and Bibliometric Review

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**Keywords:** Information security, Personal data protection, General Data Protection Regulation (GDPR), Systematic literature review, Bibliometric analysis

### Abstract:

This study presents a comprehensive systematic literature review and bibliometric analysis of research on information security and personal data protection published between 2014 and 2024. Drawing from 353 publications indexed in the Web of Science Core Collection, the analysis reveals that academic research has surged dramatically since 2020, peaking in 2022, driven by technological advances in cloud computing, IoT, and AI, regulations like GDPR, and the COVID-19 pandemic.

The bibliometric analysis demonstrates strong interdisciplinary characteristics extending beyond computer science to encompass healthcare and telecommunications, indicating the evolution of security and privacy into complex socio-technical challenges. Geographically, China, the US, and UK lead research contributions, while Asian and Middle Eastern countries show rapidly growing capabilities. Open Access journals, particularly MDPI, play crucial roles in facilitating rapid knowledge dissemination.

Research has shifted toward emerging technologies including blockchain, IoT security, and differential privacy, with healthcare data protection receiving particular attention among highly-cited publications. This study contributes a structured knowledge map outlining key research domains, influential countries and institutions, and evolving thematic trends over the past decade. The findings offer valuable insights for academics, policymakers, and industry professionals navigating digital security and privacy governance, providing a foundation for future research directions and strategic decision-making in information security and data protection.

EC250050

## Electrical Property Enhancement of a Breast Fat-Equivalent Phantom for Microwave Mammography

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**Keywords:** phantom, breast fat equivalent phantom, relative permittivity, conductivity, microwave mammography

### Abstract:

This study describes the development of a breast fat-equivalent phantom for evaluating the performance of microwave mammography systems operating within a frequency range of 1 to 15 GHz. Breast cancer is one of the most common cancers. Conventional breast cancer screening methods have several drawbacks, including pain during examinations, potential radiation exposure and reduced diagnostic accuracy in dense breast tissue, which is more common among Asian women. Microwave mammography has consequently emerged as a promising diagnostic modality. Performance evaluation is essential in the development of microwave mammography; however, ethical concerns have increasingly restricted the use of animals and human subjects in such research. Therefore, the use of an electromagnetic phantom, which mimics the relative permittivity and conductivity of the human tissue is essential.

This study presents the development of a new phantom equivalent to breast fat by further refining the composition established in previous studies. The complex dielectric constant was measured using a coaxial probe combined with a dielectric probe and a network analyzer. The parameters obtained include relative permittivity and conductivity.

The phantom proposed in previous studies exhibited two primary issues. Firstly, it was difficult to maintain its shape, and secondly, it had a soft texture. Consequently, in order to resolve these two problems, the type of the detergent, one of the additives, was modified. However, this alteration led to a substantial average error in conductivity. To enhance conductivity, sodium chloride (NaCl) was incorporated into the solution. Furthermore, the amounts of salad oil, TX-151, and detergent were adjusted to improve the correlation between the phantom and the target values. These adjustments resulted in a significant reduction in the average error rate, decreasing from 20.0% for relative permittivity and 81.1% for conductivity in the previous composition to 8.26% for relative permittivity and 16.9% for conductivity in the proposed composition. This outcome aligns well with the target values and represents a substantial improvement over previous research.

EC250053

## How ESG Perceptions Drive Trust and Loyalty: Evidence from the Insurance Sector

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**Keywords:** ESG perception, corporate trust, brand loyalty, repurchase intention, insurance industry

### **Abstract:**

As global attention to sustainable development intensifies, consumers are increasingly valuing corporate performance in Environmental, Social, and Governance (ESG) dimensions. This trend is especially significant in the insurance industry, where trust plays a critical role in consumer decision-making. This study examines the impact of consumers' perceptions of ESG initiatives by insurance companies on corporate trust, brand loyalty, and repurchase intention.

Using a questionnaire survey, the study collected empirical data and applied descriptive statistics, cross-tabulation, and regression analysis to test the proposed relationships. The findings indicate that consumers' ESG perceptions—including cognition, identification, and transparency—have a significant positive impact on trust in insurance companies. Trust, in turn, has a positive influence on brand loyalty and repurchase intention. Additionally, brand loyalty also exerts a positive effect on repurchase intention. Trust and brand loyalty are found to partially mediate the relationship between ESG perception and repurchase intention.

These results highlight the importance for insurance companies to enhance ESG practices and information transparency to foster consumer trust and loyalty, ultimately increasing repurchase intentions. The findings offer practical implications for brand management and sustainable strategy planning within the insurance sector.

**Evaluation of electrical performance of biodegradable/biocompatible triboelectric nanogenerator based on a chitosan–glycine–polyvinyl alcohol composite**

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**Keywords:** Triboelectric nanogenerator, Biodegradable materials, Energy harvesting, Self-powered sensors, Wearable electronics

**Abstract:**

In response to the increasing demand for sustainable and wearable energy-harvesting devices, triboelectric nanogenerators (TENGs) have emerged as viable solutions for converting mechanical energy into electrical energy. We developed an environmentally friendly TENG utilizing biodegradable and biocompatible materials, such as chitosan, glycine, and polyvinyl alcohol (PVA), and evaluated its electrical performance. The device exploits the triboelectric properties of PVA, chitosan, and glycine biopolymers to form a tribopositive composite layer, with polydimethylsiloxane (PDMS) serving as the tribonegative layer. The film was fabricated using a straightforward casting technique under ambient conditions and assembled in the vertical contact-separation mode. Electrical performance analysis revealed that the TENG generated an open-circuit peak-to-peak voltage of up to 110V and a current of 14.5  $\mu$ A. The peak power and current density are 0.2188 W/cm<sup>2</sup> and 1.65  $\mu$ A/cm<sup>2</sup>, respectively. The TENG, containing 50 wt% glycine exhibited superior electrical performance at a tapping frequency of 10 Hz. Our biodegradable TENG device has the potential to detect dynamic human motion and can be used in sports wearables. In addition, the use of biodegradable and biocompatible materials not only reduces the environmental impact but also paves the way for wearable and implantable health-monitoring systems. This study demonstrates a sustainable approach for self-powered sensing devices for next-generation green electronics.

EC250056

## AI-Based Precision Medicine: Deep Learning for Differentiating Atopic Dermatitis and Cutaneous T-Cell Lymphoma

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**Keywords:** Atopic Dermatitis, Cutaneous T-Cell Lymphoma, Machine Learning

### Abstract:

Atopic Dermatitis (AD) is a common chronic inflammatory skin disease that affects approximately 10% of the global population, with a prevalence that continues to rise. In recent years, a number of moderate-to-severe AD patients treated with Dupilumab have been observed to develop Cutaneous T-Cell Lymphoma (CTCL). However, this phenomenon may be attributed to misdiagnosis caused by the high similarity between early-stage AD and CTCL in clinical presentation. To address this issue, we propose a deep learning-based approach for the automated differentiation between AD and CTCL using medical skin images. The proposed method employs Convolutional Neural Networks (CNNs) for feature extraction, combined with machine learning classifiers such as decision trees, k-nearest neighbors (KNN), and random forests to enhance classification performance. Data augmentation techniques are applied to address class imbalance in the dataset. Our results show that the combination of DenseNet201 and Linear Discriminant Analysis (LDA) achieved an accuracy of 97.47% on the test set, demonstrating outstanding discriminative capability and the potential to serve as a valuable clinical decision support tool in dermatology. This model enables rapid differentiation between AD and CTCL at early clinical stages, reduces misdiagnosis rates, and provides a robust foundation for optimizing treatment strategies involving biologic agents, ultimately advancing the application of artificial intelligence in dermatological diagnostics.

## Design and Optimization of Magnetic Circuits in Electric Scooter Motors

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**Keywords:** Permanent Magnet Synchronous Motor, motor design, rotor optimization, Taguchi method

### Abstract:

This study investigates stator–rotor structure optimization for a commercial electric scooter motor through geometric modeling and comparative analysis of various magnet configurations and arrangements. The objective is to achieve an improved magnetic circuit distribution, thereby enhancing output performance, efficiency, and overall motor characteristics. Sensitivity analysis was first conducted to identify the dominant design parameters. Magnetic bridges were then incorporated on both outer sides of the rotor magnets to increase magnetic flux density and reduce leakage flux. The Taguchi method was subsequently applied to determine the optimal parameter set. Comparative simulations between the optimized and baseline commercial motor revealed that, at a rated current of 87 A and rated voltage of 96 V, the optimized design achieved an efficiency improvement from 89.14% to 90.28% (+1.28%), a torque increase from 22.84 Nm to 23.29 Nm (+0.45 Nm), and a power output enhancement from 7104.78 W to 8053.44 W (+948.65 W). The results confirm that the proposed rotor design yields superior performance across efficiency, torque, and power output compared with the commercial reference motor.

## A Game-Theoretic Framework for Coordinating Mixed Traffic for Emergency Vehicle Passage

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**Keywords:** Emergency Vehicle Preemption, Vehicle Priority, Nash Equilibrium

### Abstract:

Coordinating diverse vehicle traffic, particularly with the presence of a high-priority emergency vehicle (EV), at unsignalized intersections remains a significant challenge. To address this, we propose a game-theoretic decision-making model that treats each vehicle as a rational player in a static, non-cooperative game. Players choose "Go" or "Yield" strategy to maximize a personalized utility function, which integrates critical factors like passage efficiency, collision risk, and individual driving styles. We utilize the Iterated Best Response (IBR) algorithm to compute the Pure Strategy Nash Equilibrium (PSNE), which represents an optimal and stable coordination strategy. Our model is rigorously validated in a MATLAB-SUMO co-simulation environment, demonstrating its practical effectiveness. The results confirm that our equilibrium-based approach significantly outperforms the baseline in terms of safety and efficiency, and most importantly, it substantially reduces the transit time for the emergency vehicle.

## In-Vehicle Communication Challenges for Urban Emergency Vehicles

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**Keywords:** VANET, Resource Allocation, Emergency Vehicle, Intelligent Transportation System, Smart City

### Abstract:

Ensuring high-speed and reliable communication for emergency vehicles (EVs) is critical for public safety within the Vehicular Ad Hoc Network (VANET) environment of smart cities. Traditional communication technologies, such as Dedicated Short-Range Communications (DSRC) and radio transmissions, face significant challenges in meeting the stringent demands for low latency and high reliability, especially in resource-constrained scenarios with mixed vehicle traffic. To address these limitations, this study proposes a novel power allocation scheme designed to prioritize EVs. Our method effectively guarantees sufficient transmission power and bandwidth for EVs, thereby securing their urgent communication needs without compromising the quality of service for regular vehicles. Performance analysis and simulations demonstrate that, compared to existing resource allocation strategies, our proposed scheme significantly outperforms them in terms of outage probability and sum rate across various channel conditions and signal-to-noise ratios. This work offers a robust and efficient communication solution for urban emergency services.

EC250062

## AI-Driven Dietary Recommendations in Elderly Care: An Empirical Study with a Large Language Model-Based Chatbot in a Day Care Setting

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**Keywords:** Conversational Artificial Intelligence, Claude 3.5 Haiku Model, Elderly Day Care Center, Personalized Nutritional Recommendation, Intelligent Health Management

### Abstract:

This study investigates the application of chatbots in elderly day care centers by integrating the Claude 3.5 Haiku large language model to provide personalized dietary recommendations based on individual health conditions. The chatbot is designed to ask health-related questions associated with various chronic diseases, and through fixed prompts combined with semantic understanding, it generates differentiated meal plate suggestions. A total of 20 test sessions were conducted to examine the relationship between input questions and food selection. Results indicate that the elderly participants' health conditions (e.g., chronic diseases and dietary restrictions) significantly influenced the composition of the recommended menus. For empirical validation, the system was deployed at the Chiang-Ching Lingya Day Care Center in Kaohsiung, involving five elderly participants over the age of 85 (two females and three males). Findings demonstrate that the system can dynamically adjust meal planning to individual needs, enhance elderly engagement in dietary planning, and that participants expressed a high level of satisfaction, noting that the recommendations were practical and easy to understand. This study highlights the potential of chatbots powered by the Claude 3.5 Haiku model as valuable tools in elderly care settings, contributing to improved nutritional health management and quality of life.

EC250063

## Integration of InP Quantum-Dot LEDs and Organic Photodetectors for Planar PPG Sensor Applications

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**Keywords:** PPG Sensor, QD-LED, OPD, Integrated biomedical sensor, Wearable healthcare device

### Abstract:

Photoplethysmography (PPG) sensors are widely used in non-invasive physiological monitoring, enabling optical detection of blood volume changes in microvascular tissue. In this work, we fabricated a planar PPG sensor by integrating an indium phosphide (InP) quantum-dot light-emitting diode (QD-LED) with an organic photodetector on the same substrate. The QD-LED had the structure ITO glass / PEDOT:PSS (hole injection layer) / TFB (hole transport layer) / InP QD emission layer / ZnO (electron transport layer) / Al (electron injection layer), and was designed to emit at a wavelength suitable for PPG measurement. The photodetector was based on a PTB7-Th:PC<sub>71</sub>BM bulk heterojunction active layer. Both devices were produced using low-temperature, solution-based processes, including sequential spin-coating of organic and quantum-dot layers, followed by vacuum deposition of the metallic cathode. After fabrication, optical emission and electrical characteristics of the QD-LED were measured, and the responsivity of the photodetector was evaluated at the QD-LED emission wavelength. The results confirmed that both devices operated as intended on the same plane, demonstrating the feasibility of integrated PPG sensor fabrication using InP QD-LEDs and organic photodetectors. This integrated device concept can contribute to the development of compact and flexible biomedical sensors for continuous vital sign monitoring. Such systems have potential applications in wearable healthcare devices, remote patient monitoring, and preventive health management.

## Implicitly Empathy Prompting Features to Improve Empathetic Chatbot Performance in Lightweight Language Models

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**Keywords:** Mental Healthcare, Implicitly Empathy Prompting, Four Features Empathy Decomposition, Lightweight Language Multi-Agents, LLM-Agents

### Abstract:

Empathetic chatbot is an essential component of intelligent mental healthcare. We proposed Implicitly Empathy Prompting (IEP) by decomposing empathy into four features, supportive dialogue, paraphrased response, emotional understanding, and attitude expression, referred to as the Four Features Empathy Decomposition. IEP is based on Lightweight Language Multi-Agents (LLM-Agents) to generate empathy dialogue. Our approach contrasts with the explicitly defined empathy of simply prompting a model to be “empathetic”. Three datasets for Four Features Scenario were generated by using the gpt-4o model, with cases in finance, family, and health issues. For each dataset, 30 examples were randomly selected and examined as input prompting onto six lightweight language models. These models include Mistral (7B), Phi-4 (14B), StableLM2 (12B), Tulu3 (8B), Neural-chat (7B) and Llama3.1-Instruct (8B). After that, the output was evaluated by using gpt-4o to calculate Empathy Perception Scores (EP Scores). The average EP Scores on three datasets for implicit/explicit empathy prompting were ranged from 1 to 10. The final evaluation results are described as follows

(1) Implicitly Empathy Prompting (IEP)

Mistral : 8.83, Phi-4: 8.96, StableLM2: 9.03, Tulu3: 7.24, Neural-chat: 8.03, Llama3.1-Instruct : 8.74;

(2) Explicitly Empathy Prompting (EEP)

Mistral: 7.52, Phi-4: 8.55, StableLM2: 7.78, Tulu3: 7.67, Neural-chat: 8.35, Llama 3.1-Instruct : 8.76.

Among these values, three models (Mistral, Phi-4 and StableLM2) achieve higher and stable EP Scores obviously. The other models (Tulu3, Neural-chat and LlamaA3.1-Instruct) keep comparable EP Scores. Our experiment findings had shown that the prompt engineering method with IEP approach could significantly outperform EEP.

EC250065

## Multi-step Action Recognition for Long-term Care Using TCN-DTW-FSM and MediaPipe

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**Keywords:** LSTM, MediaPipe, Healthcare Education, Human activity recognition

### Abstract:

This study presents an intelligent multi-step action recognition system designed for long-term caregiver training and assessment. Leveraging MediaPipe for precise and real-time human pose estimation, the system extracts detailed spatiotemporal body and hand keypoints. Temporal Convolutional Networks (TCN) are employed to effectively capture temporal dependencies and complex features from sequential motion data. Dynamic Time Warping (DTW) provides robust sequence alignment, allowing flexible comparison between performed actions and standard templates despite temporal variations in execution speed or style. A Finite State Machine (FSM) further imposes logical constraints by modeling expected action step sequences, enabling accurate detection of sequence anomalies or deviations. This hybrid architecture supports comprehensive evaluation and real-time feedback, facilitating improved caregiver skill acquisition, process adherence, and quality control within long-term care settings. The system aims to advance digital transformation in healthcare education by providing a scalable, precise, and adaptive training solution.

EC250066

## REM Sleep Staging: A Machine Learning Approach Using Vital Signs

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**Keywords:** REM, Machine Learning, Sleep disorders, health promotion

### Abstract:

A physiologically healthy sleep cycle alternates between non-rapid eye movement (NREM; stages 1–3) and rapid eye movement (REM) sleep, with each complete cycle typically lasting between 90 and 120 minutes. Polysomnography (PSG) remains the gold standard for the clinical diagnosis of sleep disorders. At present, PSG assessments are confined to specialized sleep laboratories, where trained clinicians evaluate sleep architecture by monitoring parameters such as electroencephalographic activity, respiratory patterns, cardiac rhythms, and ocular movements. However, the requirement for overnight observation in such facilities may inadvertently disrupt natural sleep patterns, introducing a confounding variable known as iatrogenic sleep disturbance. Sleep disorders represent a significant public health concern, contributing substantially to the burden of chronic diseases across all age demographics. In response to these challenges, the authors propose a machine learning-based framework for REM stage classification, leveraging PSG-derived features in conjunction with non-invasive modalities such as video or thermal imaging and physiological signals (e.g., respiration and heart rate). This approach aims to facilitate unobtrusive sleep monitoring, thereby preserving sleep integrity while enhancing diagnostic capabilities.

EC250067

## Development of an Android-Based Mobile Application for Menstrual Health and Sports Performance Tracking in Female Athletes

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**Keywords:** menstrual health, female athletes, mobile health, sports performance, Android application

### Abstract:

Female sports science has historically relied on evidence derived largely from male cohorts, despite known menstrual-cycle-related hormonal effects on thermoregulation, metabolism, and performance in women. This project reports the development of an Android application to support female athletes in documenting menstrual health alongside self-rated sports performance, addressing an area underexplored in current mobile health tools. The app was built in MIT App Inventor following a Rapid Application Development process (requirements determination, user design, construction, and implementation). Implemented features include period-date recording with prediction, health and performance logging, record review, basic personalization, and general training tips. Unit tests verified core functions such as date recording, period prediction, navigation, and record retrieval, and a small-sample usability assessment (n=5) using the System Usability Scale indicated above-average usability. Reported limitations include the need for more accurate cycle prediction, attention to data privacy/security, and potential expansion of content and features. In conclusion, the application offers a practical tool for period-date and symptom tracking with integrated performance self-logging.

## Evaluation of Dual-Wavelength LED Light Irradiation on Skull for Alleviating Neck and Shoulder Pain and Improving Heart Rate Variability

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**Keywords:** Red light, Near-infrared light, Shoulder and neck pain, Heart rate variability, Thermal imaging, Surface electromyography, Safe

### Abstract:

Neck and shoulder pain are common chronic discomforts in modern society. While traditional treatments such as medication, physical therapy, and acupuncture have demonstrated efficacy, non-pharmacological and non-invasive auxiliary techniques have gained increasing attention in recent years. This study aims to assess the effects of dual-wavelength LED light irradiation on the skull in alleviating neck and shoulder pain and improving heart rate variability. The galea aponeurotica of the skull is connected to the cervical, thoracic, and lumbar vertebrae through the myofascial chain. Poor posture often leads to uneven tension on both sides of the spine, forming nodules on the skull. Irradiating the corresponding aponeurotic regions stimulates pressure and tactile receptors in the muscles, promoting relaxation and blood circulation. This study utilized low-energy dual-wavelength LED light (660 nm red light and 940 nm near-infrared light), arranged in two groups with four LEDs each. Both sides of the skull were irradiated at designated nodule regions for 15 minutes per session. Pain Assessment: Pain levels were evaluated using the Numeric Rating Scale (NRS). Muscle Relaxation: Muscle relaxation was measured using thermal imaging and surface electromyography. Autonomic Function: HRV indicators were analyzed using electrocardiography. Pain Reduction: Post-irradiation, the NRS score decreased by 2 points. Temperature Increase: Skin temperature on both sides of the cervical spine increased by an average of 1.25°C. Heart rate variability Improvement: A significant increase in the root mean square of successive differences (RMSSD) in Heart Rate Variability (HRV) indicates enhanced parasympathetic nervous system activity, and that the body is in a state of relaxation and recovery. Dual-wavelength LED light irradiation on the skull effectively relaxes the muscles on both sides of the cervical spine, alleviates pain, and improves autonomic nervous system function. This technique shows potential as a safe and non-invasive method for muscle relaxation and autonomic regulation, with broad clinical application prospects.

## Prototype Development and Preliminary Evaluation of a Smart Health Education Mobile App

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**Keywords:** Mobile Health Application, AI-assisted Health Education, Technology Acceptance Model (TAM)

### Abstract:

Taiwan is rapidly entering a super-aged society, with older adults increasing and the working-age population declining, creating long-term pressure on primary care systems. The adoption of smart care technologies has become an inevitable trend. This study presents the prototype development and preliminary evaluation of two mobile applications: (1) a smart health education (HE) app providing AI-assisted health information retrieval and interactive Q&A, and (2) a companion app to enhance social engagement, including indigenous-language greetings for local cultural contexts.

Both prototypes were developed using a user-centered approach involving caregivers (including community volunteers) and older adult participants. The HE app integrates document retrieval with an on-device Large Language Model (LLM) for localized knowledge-based Q&A. The companion app offers daily greetings in an indigenous language to foster emotional connection and cultural inclusion; due to language corpus limits, the prototype supports only one indigenous language as a demonstration.

The applications were tested at 11 sites, including rural cultural health stations in Pingtung and residential long-term care facilities in Kaohsiung and Chiayi. Evaluation used structured questionnaires and semi-structured interviews. Quantitative analysis employed the Technology Acceptance Model (TAM), focusing on perceived usefulness, ease of use, attitude toward use, and behavioral intention. Qualitative feedback explored user experience and suggestions.

Preliminary results showed positive reception. Participants valued the HE app for timely, clear health information via AI-powered Q&A, while the companion app's greetings improved mood and engagement. Suggested enhancements included adjustable font size, voice navigation, and more indigenous-language options.

This preliminary study supports the feasibility of deploying dual mobile apps in community and institutional care. Future work will expand trials, integrate into broader digital health systems, and assess long-term effects on health information accessibility, user engagement, and cultural inclusion.

EC250070

## Deep Learning–Driven Online Tool for Automated Strabismus Diagnosis

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**Keywords:** Strabismus Diagnosis, Deep Learning, YOLOv8, Online Tool

### Abstract:

Strabismus, characterized by ocular misalignment and loss of binocular fixation, can result in impaired eye movement, blurred vision, asthenopia, abnormal head posture, reduced stereopsis, and, if untreated in early childhood, amblyopia. Current diagnosis relies largely on in-person ophthalmologic examination, limiting early detection in resource-constrained settings. This study proposes an online, YOLOv8-based deep learning tool for automated strabismus detection, offering a simple user interface and achieving 95.4% diagnostic accuracy, thereby enabling accessible screening in underserved regions.

## Smart Technology for Dementia Prevention: Community-Based Robot-Assisted Board Game Intervention to Improve Cognitive Function in Older Adults with MCI

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**Keywords:** Robot-Assisted Intervention, Mild Cognitive Impairment (MCI), Community-Based Program

### Abstract:

**Background:** Mild cognitive impairment (MCI) is a critical stage for interventions to delay dementia onset. Digital cognitive training is effective and accessible, yet community-based evidence remains limited, warranting further evaluation.

**Objective:** To assess the impact of the “Robot-Assisted Cognitive Board Game Program” on cognitive function in older adults with MCI.

**Methods:** Older adults aged  $\geq 65$  years with MCI (MMSE 16–24) from six community centers participated in a quasi-experimental pretest–posttest study with intervention and control groups. The robot-assisted program incorporated dementia prevention education, a cognitive training robot, interactive board games, and physical activities, conducted once a week for 2 hours per session, for a total of eight sessions. MMSE was assessed at baseline (T0) and post-intervention (T1). Data were analyzed using descriptive statistics and GEE.

**Results:** A total of 66 older adults participated in the study, comprising 28 in the intervention group and 38 in the control group. Baseline chi-square tests and homogeneity analyses showed no significant differences between the two groups at T0 for gender, age, MMSE scores, loneliness, social activity, or life satisfaction, except for geriatric depression, which was significantly different ( $p < 0.05$ ).

After controlling for baseline differences in geriatric depression, the GEE analysis revealed a significant group-by-time interaction on MMSE scores ( $\chi^2 = 6.990$ ,  $p = 0.030$ ). GEE analysis revealed a significant group-by-time interaction effect after the intervention ( $B = 2.605$ , 95% CI = 0.674–4.537,  $p = .008$ ), indicating that at the post-intervention (T1) time point, the post-intervention group’s mean MMSE score was significantly higher than that of the control group.

**Conclusion:** The program significantly improved cognitive function in older adults with MCI, offering an effective, accessible, community-based strategy for dementia prevention.

## Enhancing Federated Learning Security with Bloom Filter-Based Malicious Update Detection

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**Keywords:** Poisoning Model, Federated Learning, Bloom filter

### Abstract:

Federated Learning (FL) has emerged as a widely adopted approach owing to its capacity to preserve the privacy of sensitive data and reduce communication overhead. However, the lack of visibility into the data distribution across clients presents a significant challenge for Federated Learning, hindering its ability to effectively identify and filter out malicious updates. In the widely used Federated Averaging (FedAvg) algorithm, the global model can be significantly biased by contributions from malicious clients. This study proposes a Federated Learning (FL) framework with a Bloom filter based malicious update detection, which ensures that only edge clients with valid identifiers are permitted to participate in the aggregation process of the FL algorithm. By employing Bloom filters, our approach significantly reduces the number of malicious updates. The proposed mechanism demonstrates a robust defense against malicious attacks in FL, achieved through the careful design and configuration of the Bloom filter. Our extensive experiments demonstrate that the Bloom filter-based security mechanism significantly mitigates the impact of attacks, thereby enhancing the resilience and reliability of the Federated Learning (FL) framework, even under challenging non-i.i.d. data scenarios.

**Real-Time EEG and Environmental Sound Analysis under Eyes-closed Scenario**

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**Keywords:** single-channel EEG, environmental sound, emotions

**Abstract:**

Human emotions are influenced by environmental factors and sound. Electroencephalogram (EEG) has been recognized as an important tool for identifying human emotions. To investigate the impact of environmental sounds on brainwave activity, this study proposes a real-time monitoring system based on a single-channel EEG. The system integrates multiple sensing modules, including a DHT-11 sensor for measuring temperature and humidity, an LDR for detecting light intensity, and a PD100X module for monitoring environmental sound. All sensor data are transmitted via the Message Queuing Telemetry Transport (MQTT) protocol and stored in an SQLite database on a Raspberry Pi 4. Furthermore, TGAM EEG data and environmental data are visualized through a Flask-based web interface. To access the system's effectiveness, EEG signals were recorded under eyes-closed condition, along with simultaneous measurements of environmental sound, temperature, and humidity. Experimental results demonstrate that the proposed system can effectively capture and integrate environmental sound and EEG data in the eyes-closed scenario.

EC250075

## Application of Spatial Information in Traditional Settlement Resource Assessment and Optimization

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**Keywords:** spatial informatics, traditional settlements, resource optimization

### Abstract:

Traditional settlements represent invaluable cultural heritage, yet they face significant challenges from rapid urbanization and modernization. This study focuses on the application of spatial information technologies to assess and optimize traditional settlement resources, using Meizhou City—a core area of Hakka culture—as a case study. By integrating Geographic Information Systems (GIS), spatial syntax, and kernel density analysis, this research systematically evaluates the spatial distribution, architectural characteristics, and socio-economic conditions of traditional settlements. The study aims to establish a scientifically robust framework for resource assessment while proposing sustainable optimization strategies that balance cultural preservation and regional development.

The methodology combines field surveys, archival research, and spatial data analysis to classify and map traditional settlements in Meizhou. Key factors influencing preservation, such as infrastructure, economic viability, and community engagement, are quantitatively analyzed using spatial modeling techniques. A multi-criteria evaluation model is developed to assess the cultural, historical, and ecological value of these settlements, with an emphasis on Hakka cultural identity. The research further explores adaptive reuse strategies and policy recommendations to enhance the resilience of traditional settlements while fostering tourism and local economic growth.

Expected outcomes include: (1) a geodatabase of Meizhou's traditional settlement resources, (2) a spatial decision-support framework for heritage conservation, and (3) actionable optimization proposals aligned with China's rural revitalization policies. This study contributes to the interdisciplinary discourse on cultural heritage preservation by demonstrating how spatial informatics can enhance the assessment and sustainable management of traditional settlements.

## A Gut Microbiome-Based Predictive Model for Non-Invasive Identification of Advanced Fibrosis in NAFLD and Its Association with BMI

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**Keywords:** Microbiome-based predictive model, Advanced fibrosis, Non-alcoholic fatty liver disease, Gut microbiome, Body mass index

### Abstract:

Advanced fibrosis ( $\geq F3$ ) is the most critical prognostic factor in non-alcoholic fatty liver disease (NAFLD) and metabolic dysfunction-associated steatotic liver disease (MASLD). We aimed to develop a microbiome-based classifier for advanced fibrosis using a biopsy-staged NAFLD cohort (PRJNA373901; F0 to F4) and assess its biological plausibility in two independent BMI annotated cohorts (PRJNA935982 and PRJDB17228). In parallel, we sought potential microbial biomarkers at the level of individual taxa and compositional balances associated with both fibrosis severity and BMI.

Raw sequencing data were uniformly reprocessed to genus-level count tables, with species-level features incorporated when available. Data were transformed using centered log-ratio and balance-based log-ratio approaches. Regularized logistic regression and tree-based models were trained with nested cross-validation, class weighting, and probability calibration. Model performance was evaluated using AUROC, AUPRC, and calibration metrics. In BMI annotated cohorts, we examined the correlation between predicted fibrosis probability and BMI, and assessed the overlap and directional concordance of taxa associated with fibrosis and obesity.

In PRJNA373901, the cross-validated model achieved an AUROC of approximately 0.80, an AUPRC above the prevalence baseline, and good calibration. Feature analysis identified candidate taxa whose abundances increased with fibrosis severity and were consistent with obesity literature, including *Escherichia coli* and *Bacteroides vulgatus*. In PRJNA935982 and PRJDB17228, predicted fibrosis probability was positively correlated with BMI, and the directions of candidate taxa were consistent across cohorts.

A microbiome-based classifier trained on a biopsy-staged NAFLD cohort demonstrated robust performance in identifying advanced fibrosis and revealed taxa with consistent associations to both fibrosis severity and BMI across independent datasets. These findings support the potential utility of microbiome signatures as non-invasive indicators of advanced fibrosis. Further validation in larger and prospectively collected human cohorts is warranted before clinical application.

EC250077

## Calculation of Absorbed Dose Measurements by Fiber-optic Radiation Dosimeters through Particle and Heavy Ion Transport code System (PHITS) Simulations

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**Keywords:** absorbed dose, fiber-optic dosimetry, Monte Carlo simulation, PHITS, radiation therapy

### Abstract:

Monte Carlo simulations provide a powerful method for analyzing radiation interactions at a microscopic level, offering insights beyond experimental limitations. This study examines the absorbed dose deposition in a fiber-optic dosimeter designed for radiation therapy. The dosimeter is constructed in the simulation space, adhering to its geometrical framework shown in Figure 1. The dosimeter consists of Gadolinium oxysulfide ( $Gd_2O_2S$ ) doped with terbium, a scintillating material that converts ionizing radiation into measurable light intensity. Using PHITS, simulations were conducted with a Varian Clinac at 6 MV, utilizing IAEA phase space data converted into PHITS format for efficient modeling. Initial simulations, conducted without a water phantom, applied a scoring mesh across all dosimeter materials, providing an average absorbed dose estimate. New simulations incorporating a  $40 \times 40 \text{ cm}^2$  water phantom modeled clinical conditions, revealing peak dose deposition near the surface, followed by expected attenuation through the phantom. For the scintillating material, mesh scoring recorded an absorbed dose of  $8.1610E-04 \text{ MeV/cm}^3$  per source particle with 1.02% statistical uncertainty, ensuring reliability. Future simulations will refine the scoring mesh to focus solely on the scintillating material and increase particle histories to reduce statistical error, bringing results closer to real-world conditions. These findings support fiber-optic dosimetry as a precise and reproducible radiation therapy dose measurement tool.

EC250078

## Device-Agnostic RBX Facial Imaging via Conditional GANs and Cross-Device Color Calibration for Clinical Diagnostics

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**Keywords:** facial skin imaging, RBX color space, conditional GAN (Pix2Pix), PatchGAN, clinical decision support

### Abstract:

Objective:

To develop and evaluate a cGAN-based technique that converts routine RGB facial photos into RBX-like hemoglobin (R-image) and melanin (B-image) maps, enabling objective, hardware-light dermatologic decision support.

Methods:

We built a Pix2Pix RGB→RBX pipeline with two models: RRIT (RGB→R) and RBIT (RGB→B). A U-N generator preserves anatomy; a PatchGAN discriminator enforces local realism. A paired clinical set of 400 triplets (RGB, R-image, B-image) from a Reveal Imager was split 80/20 for training/testing, with ~10% of training for validation. Augmentations were used; inputs were resized to 1024×1024 and outputs rescaled. For device-agnostic use, we built a polarized rig and calibrated commodity camera RGB to the instrument domain via variable-exponent polynomial color mapping. IRB approval: EMRP-111-060.

Primary Endpoint and Evaluation:

Structural similarity (SSIM) quantified agreement with instrument RBX globally and over stable regions (forehead, left/right cheeks). Visual review confirmed clinical fidelity.

Results:

RRIT achieved SSIM >0.97 (train) and >0.96 (test) vs. instrument R-images; RBIT reached >0.96 and >0.94 vs. B-images. After calibration, cross-device regional SSIM on forehead/cheeks remained >0.92, indicating near-instrument quality from commodity hardware.

Diagnostic Significance:

R-images quantify vascular/erythema burden; B-images visualize melanin for severity grading and longitudinal tracking. The workflow lowers hardware barriers and fits routine pre/post-treatment evaluation, documentation, and patient education.

Future Work:

We will expand to multicenter data and diverse illumination/camera settings, pursue automated color calibration, and add secondary endpoints (regional red/brown indices, pre-post deltas) to anchor outputs to

clinical scales.

**Conclusion:**

This RGB→RBX translation technique yields robust, reproducible RBX-like facial maps from standard photos, showing high agreement with instrument outputs and generalization across devices after calibration. It supports deployment for biomedical diagnostics and treatment monitoring at low cost and scale.

## **Bridging Perceptual Gaps in Long-Term Care Facility Selection: Prioritizing Key Factors from Care Recipients and Providers**

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**Keywords:** long-term care facility, nursing home, health care service factors, demand-driven health service, health supply chain management

### **Abstract:**

The process of selecting a long-term care facility, such as a nursing home, is multifaceted and shaped by a range of factors stemming from both demand and supply sides. While the consumer perspective has been extensively studied, the provider perspective – particularly the operational and strategic considerations– remains relatively underexplored. This paper aims to identify and compare the factors, based on the 4Cs marketing mix framework, that prioritized by both prospective care recipients and their families, as well as by care providers (nursing home administrators) in the nursing home selection process. By applying a health supply chain management (HSCM) framework, the study examines the perceptual gaps between these two groups – gaps that are often overlooked in existing literature.

A quantitative methodology was employed, utilizing a structured questionnaire. Data were collected from 388 care recipients and their families and 288 care providers. The Mann-Whitney U test revealed a statistically significant difference in perceptions across 31 of the 34 factors, indicating a fundamental misalignment between consumers' demand signals and providers' delivery priorities.

Our findings show that service care recipients place a higher value on health care service factors such as staff competence, personalized rehabilitation programs, and safety. In contrast, care providers tend to prioritize internal operational efficiency and brand image, including services such as chat support and facility tours. This discrepancy highlights the critical need for a better understanding of care recipients to initiate demand-driven health service management approach, supported by effective customer relationship management (CRM). The study concludes by proposing that providers should re-align their service offerings and communication strategies to focus on the key factors valued by users to bridge these perceptual gaps and ensure sustainable service quality.

EC250080

## Vision-Guided Acupoint Detection and Hand–Eye Calibrated Galvanometer for Laser Acupuncture

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**Keywords:** Laser acupuncture, Acupoint detection, Hand–eye calibration, 2-D galvanometer scanner, Vision-guided therapy

### Abstract:

**Objective:** To enable needle-free laser acupuncture with millimeter-level precision, we built a vision-guided system that detects hand acupoints and calibrates a two-axis galvanometer so the laser spot lands on the intended point.

**Methods:** From each real-time RGB frame, the hand is segmented using edge features and convex-hull/convexity-defect geometry; wrist–elbow axes and 12-cun anthropometric ratios define a subject-specific arm coordinate frame. A deformable acupoint template is then fitted to landmarks to output pixel coordinates for 16 predefined points. Eye-to-hand calibration maps pixels to galvo angles using an ArUco-based planar homography; a height fine-tune compensates parallax when the target lies off the calibration plane. Finally, closed-loop mirror correction updates galvo commands from the observed laser-spot centroid until the residual error is  $<3$  pixels ( $\sim 2$  mm).

**Results:** Across 8 volunteers, acupoint localization error before actuation was  $<5$  mm. After calibration, height compensation and mirror correction, the laser–target discrepancy averaged 0.36–1.28 mm across acupoints (best 0.08 mm), enabling reliable dwell-time control and rapid multi-point switching.

**Conclusion:** By combining acupoint detection, eye–hand calibration with parallax compensation, and closed-loop galvo control, our prototype achieves clinically meaningful, millimeter-level targeting on hand acupoints. The approach reduces operator dependence and provides a practical pathway for safe, repeatable and tele-operable laser acupuncture devices suitable for medical electronics applications.

EC250081

## Numerical Simulation of Response of Graphene-based Personnel Dosimeters Under Ionizing Radiation Fields

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**Keywords:** graphene, ionizing radiation, radiation dosimetry, two-dimensional

### Abstract:

Graphene's 2D structure offers excellent mobility and conductivity for radiation dosimetry. In relation to this, graphene and some of its derivatives have already been proven to have feasibility for radiation dosimetry, particularly with ionizing radiation. In this paper, a modified tight-binding Hamiltonian was employed in modeling the effect of gamma rays, beta particles, and neutrons interacting with the graphene atoms. The interaction of these particles with the material was simulated using a deterministic numerical model. This study used standard dosimetric techniques to calculate the absorbed dose, and modified ionization and recombination equations were used to evaluate the charge-carrier dynamics. The study simulated a pristine graphene sheet as the baseline, which exhibited the highest charge collection efficiency. The introduction of multiple vacancies then increased the charges' trapping and recombination effects, and with single vacancies, the charge collection decreased slightly. The Stone-Wales

## Facial Attribute Prediction Using Knowledge Distillation

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**Keywords:** Machine Learning, Facial Attribute Prediction, Knowledge Distillation, ResNet50, MobileNetV2

### Abstract:

The rising need for intelligent applications on resource-limited devices presents a significant challenge: the deployment of big, high-accuracy deep learning models is sometimes impractical due to their processing costs. This thesis examines this issue in the realm of face attribute analysis. We present an approach for multi-attribute prediction (age, gender, ethnicity) via knowledge distillation to develop a model that is both highly accurate and computationally economical. Our methodology comprises a two-phase technique utilizing the UTKFace dataset. A substantial, high-capacity "teacher" model, with a ResNet50 architecture, is trained to attain state-of-the-art precision in predicting age, gender, and ethnicity. Consequently, the extensive, intricate understanding from this educator is conveyed to a considerably smaller and more efficient "student" model utilizing a MobileNetV2 architecture. The transfer is accomplished by instructing the learner using both the accurate labels and the softened probability distributions produced by the teacher. Our findings indicate that the distilled student model attains prediction accuracy nearly equivalent to that of its larger instructor model across all variables, while markedly decreasing model size and inference duration. This study confirms that knowledge distillation is a viable and efficient method for creating high-performance facial analysis systems appropriate for real-world implementation on mobile, edge, and other resource-constrained platforms.

EC250083

## A Comparative Analysis of Machine Learning Models for Forecasting Brain Organoid Morphological Development

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**Keywords:** Brain Organoids, Machine Learning, Growth Forecasting, Time-Series Analysis, Morphological Features

### Abstract:

tial development using only morphological features. We used microscope images of 64 different organoids across two different labs at ten distinct times. Images were taken over 30 days. From each image, we extracted six key measurements of the organoid's shape and size, including area, perimeter, height, width, and positive and negative diagonal lengths. This gave us a time-series dataset for each organoid, showing how it changed over time, over 10 time points. We then tested a wide range of machine learning models to see which could most accurately predict the organoid's future shape. The models were given the first six measurements and asked to predict the final four. We compared classic models like Random Forest (RF) and Gradient Boosting Machine (GBM) against more complex deep learning models, including Recurrent Neural Networks (RNNs) and modern Transformers. Our results showed that the classic machine learning models, specifically GBM and RF, were the most effective and reliable at predicting the future growth of the organoids. Some of the more complex deep learning models, like RNNs, did not perform as well on this specific task. This study demonstrates that machine learning can be a useful tool for automating the analysis of organoid development and to help decide how to proceed in experimental tasks where the growth of organoids is critical. This method offers a quick and objective way to forecast growth, which could greatly advance research in neuroscience and developmental biology.

## Impact Dynamics and Head Injury Criteria Analysis of a Human Head

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**Keywords:** Human head, impact dynamics, Finite element analysis, head injury criteria

### Abstract:

There are often accidents of different sizes in daily life, and it is easy to cause varying levels of damage to the skull and internal brain, leading to serious injuries. Once the head is hit by a strong automobile or motorcycle, or by external injuries, and falls, brain injury can occur. Traffic accidents account for the 11th leading cause of death, of which more than 58% result from head injuries. This study mainly focuses on applying finite element dynamic analysis to head shocks, and on using the Head Injury Criteria (HIC) specifications adopted by the US Road Traffic Safety Administration to measure the degree of head injury. HIC and peak acceleration values are obtained under diverse impact loadings. Both values are compared with literature outcomes, and promising results are achieved. Through comparing whether the human head meets the injury standard, we also hope to reduce the adverse events associated with head injuries. This analysis data can provide a basis for future research on different impacts to allow simulation and analysis so that further measures can be taken to protect the internal brain of the human body. Different external injuries can also be used as a basis for future reference for researchers, medical personnel, or helmet designers in related fields.

## A CNN-based Framework for Decoding Cortical Voltage Responses Elicited by Retinal Neuromorphic Spike-Train Stimuli in the Context of Intracortical Visual Prostheses

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**Keywords:** Intracortical visual prosthesis, Physiological experiment, Retinal neuromorphic spike, Voltage-sensitive dye imaging, machine learning-based decoding

### Abstract:

Intracortical visual prostheses aim to provide artificial vision for individuals with acquired blindness by bypassing the retina and delivering intracortical microstimulation (ICMS) to the visual cortex. Conventional ICMS uses fixed-frequency current-pulse trains lasting several hundred milliseconds, but such protocols may underexploit the millisecond-scale temporal dynamics of cortical circuits. To investigate whether retinal neuromorphic spike timing can serve as a design principle for ICMS, we recently examined neural responses to such stimuli in mouse brain slices using millisecond-resolution voltage-sensitive dye (VSD) imaging. A central question, however, is whether, and to what extent, image information can be transmitted to cortical activity through these spike-train stimuli. One possible strategy to answer this is to apply machine learning (ML) to test whether an ML-based decoder can be trained to extract image information from the spatiotemporal pattern of cortical VSD responses.

We recently demonstrated that a Wiener-system nonlinear model can be reliably estimated to reproduce cortical VSD responses evoked by ICMS with high temporal precision. In the present study, this model was used to generate training data for an ML-based decoder. We evaluated whether convolutional neural networks (CNNs), widely used in image processing, could be trained on such data to reconstruct images from cortical responses. Specifically, 400 natural images were converted into retinal neuromorphic spike trains, which were then used to simulate cortical VSD responses using the Wiener-system model. A CNN trained on these datasets successfully decoded the spatiotemporal VSD signals into the original images, achieving structural similarity index measures of  $0.86 \pm 0.03$  and  $0.84 \pm 0.03$  (mean  $\pm$  standard deviation) for 320 training and 80 validation datasets, respectively.

This approach provides a novel framework to test whether retinal neuromorphic stimuli elicit cortical voltage responses containing image information. Although the present evaluation is model-driven, the framework can be extended to physiological experimental validation in future work.

EC250090

## DA-MedRGAT: RAG-Evidenced Clinical Knowledge Graphs with Dual-Attention for EHR Multi-Task Prediction

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**Keywords:** Electronic Health Records (EHR), Clinical Knowledge Graphs (KG), Retrieval-Augmented Generation (RAG), Literature- Evidenced, Graph Neural Network (GNN)

### Abstract:

Electronic health records (EHRs) provide comprehensive records of diagnoses, procedures, medications, and visit timing that inform mortality risk detection, readmission stratification, and inpatient resource planning. Improving the accuracy and trustworthiness of EHR-based prediction directly benefits patient safety and hospital operations. However, prevailing approaches rarely capture, within a single framework, both clinical-concept semantics and temporal dependencies. Moreover, knowledge graphs (KGs) automatically constructed with large language models (LLMs) are prone to hallucination and are not systematically corroborated against the peer-reviewed medical literature. To address these limitations, we propose the Dual-Attention Medical Relation Graph Attention Network (DA-MedRGAT), which uses retrieval-augmented generation (RAG) to query UMLS and PubMed for clinical relations, followed by literature-weighted filtering to corroborate triples and curb hallucination. The resulting heterogeneous graph preserves multiple relation types and encodes visit intervals as temporal edge attributes to reflect disease trajectories. DA-MedRGAT employs dual attention—(1) multi-head node–relation-aware attention to integrate node and relation semantics, and (2) temporal prior attention to modulate message passing by visit timing. On the public MIMIC-IV dataset, DA-MedRGAT improves AUROC by 6.11%, 18.06%, and 3.65% over the prior best for mortality, readmission, and length-of-stay (LOS), respectively. For mortality, AUPRC shows a 101.5% relative improvement, indicating stronger discrimination under low event rates. LOS accuracy/F1 improve by 59.6%/92.3%, whereas kappa decreases by 8.4%. Collectively, these results indicate that medical-literature evidenced clinical KGs, coupled with dual attention, outperform existing approaches on most metrics and enhance the accuracy and trustworthiness of EHR-based prediction.

EC250092

## Telemedicine to improve medical care of fishermen in pelagic fisheries

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**Keywords:** Telemedicine, pelagic fisheries

### Abstract:

#### Introduction

Pelagic fishing is high labor intensity and significant health risks. Due to the remote nature of offshore operations, fishermen often face challenges in accessing timely medical care. Traditional telephone communication is prone to misdiagnosis due to cognitive misunderstandings, besides, lack of practical experience, and inadequate cybersecurity are also issues that urgently require resolution. This pilot study aims to establish a satellite-based telemedicine system that enables 24-hour video consultations between crew members and physicians, ensuring real-time medical support and promoting medical equity for offshore workers.

#### Method

Ultrasound and digital otoscope equipment were installed onboard, with satellite signals facilitating remote medical consultations. To ensure cybersecurity, a CISCO VPN was deployed to prevent potential hacker attacks targeting pelagic vessels. First aid training programs were conducted for captains and crew members, covering both theoretical knowledge and practical skills to enhance personal safety. Additionally, a health survey was administered to collect basic demographic and medical data from crew members.

#### Result

Telemedicine tests were conducted in the Hokkaido and around the Falkland Islands. Real-time otolaryngology and sonographic examinations for chest trauma were successfully performed, validating the technical feasibility of remote diagnosis. A proof-of-concept (POC) was successfully executed, demonstrating direct connectivity between a medical center and a pelagic vessel. The CISCO VPN was effectively implemented onboard, achieving the high cybersecurity standards required for designation as a Critical Infrastructure Hospital under national regulations.

#### Conclusion

This pilot study confirms the feasibility of a secure, satellite-based telemedicine system tailored for pelagic fisheries. By overcoming spatial and temporal limitations, the system enhances emergency response capabilities, safeguards crew health, and contributes to the broader goal of medical equity in remote maritime environments.

EC250093

## Edge Inference of Four Hand Motions Using Upper-Arm-Only 4-Channel Surface Electromyograms

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**Keywords:** Myoelectric prosthesis, Upper-arm electromyography, Convolutional neural network, Hand movement inference

### Abstract:

According to the Global Burden of Disease 2021 study, approximately 57.7 million individuals live with traumatic limb amputation, facing severe daily limitations that reduce quality of life. To restore certain degree of limb functions, recent studies have explored high-performance myoelectric hand prostheses, particularly leveraging machine learning (ML) techniques to enable more intuitive control of motions. However, the high computational resource demands of such models often hinder their development for real-time operation on embedded hardware platforms. Furthermore, the real-time viability of many proposed systems is often unclear as their processing times are not explicitly reported.

Our study addresses this gap by evaluating an integrated hardware system for prosthetic hand control. The system uses four-channel surface electromyography (sEMG) signals recorded exclusively from upper arm muscles to classify four hand motions at intervals as short as 128 milliseconds for controlling a 3D-printed, open-source prosthetic hand. Our approach implements the processing pipeline on the Google Coral Dev Board, using its Edge Tensor Processing Unit (TPU) to accelerate convolutional neural network (CNN) inference. In this report, we focused on deploying a pre-trained CNN model onto this edge device and measuring the end-to-end processing time, using inputs from Bitalino MuscleBIT sensors that monitor muscle activity, and translated into command signals for the prosthetic hand's motors. The average inference time of the CNN model deployed on the Edge TPU, including other processing steps on the Dev Board, was approximately 3.9 milliseconds, revealing that most of end-to-end latency arose from wireless transmission of sEMG data to the Dev Board. Through combined hardware and software optimization, this work highlights the feasibility of a low-cost, responsive control system using off-the-shelf components for advanced real-time prosthetic hand control using an edge ML device

## Mixed Reality Shopping Task-Based for Cognitive Engagement in Aging

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**Keywords:** Mixed Reality, Virtual Reality, Cognitive Function, Feasibility Study, Older Adults

### Abstract:

The prevalence of cognitive impairment is increasing globally, with mild cognitive impairment (MCI) affecting 10–20% of middle-aged and older adults. Early interventions using ecologically valid daily life tasks may help delay cognitive decline, yet most immersive system studies focus on isolated cognitive tests or abstract exercises, limiting real-life applicability. To address this, we developed a Mixed Reality (MR) system simulating a supermarket shopping task, combining item searching, price calculation, and purchase decision-making. The design emphasizes ecological validity by targeting activities essential for independent living, reduces cybersickness, and incorporates adaptive difficulty adjustment mechanisms. This feasibility study evaluated task performance and system experience among healthy middle-aged and older adults, and compared outcomes with younger adults to inform future applications in MCI and mild dementia populations. Fourteen adults aged 56–65 years and 14 adults aged 21–30 years completed one VR shopping session. Performance indicators included completion time, errors, and number of hints, automatically recorded. Subjective experience was assessed via the System Usability Scale (SUS), NASA Task Load Index (NASA-TLX), Presence Questionnaire (PQ), and Simulator Sickness Questionnaire (SSQ). All participants completed the task (100% completion rate). Middle-aged and older adults required longer times and made slightly more errors, though both groups completed tasks successfully with hints. SUS and PQ scores indicated good usability and immersion, while SSQ scores were low, suggesting tolerable cybersickness. Participants reported that the shopping scenario reflected real-life contexts and promoted engagement. These results demonstrate the feasibility and acceptability of VR shopping tasks for healthy middle-aged and older adults, supporting further randomized controlled trials to evaluate clinical efficacy in promoting cognitive function and delaying decline.

EC250095

## Designing Projection-Mapped Interview Rooms with Diffusion Models for Sustainable Digital Interaction

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**Keywords:** Virtual Interview, Projection Mapping, Stable Diffusion, Interaction, Sustainability

### Abstract:

This study proposes an integrated pipeline that combines generative AI and 3D modeling technologies to create a realistic virtual interview environment for sustainable digital interaction. The process begins with generating virtual interview room images using Stable Diffusion. Spatial information is then extracted by aligning the XYZ axes and setting the camera perspective manually through FSpY. Based on this information, 3D structures are modeled in the Blender environment, and a corresponding depth map is generated. This depth information, along with text prompts, serves as input to ControlNet, enabling the generation of additional interview room images under various perspectives and conditions. These images are projected onto the 3D models as textures via projection mapping in Blender. The resulting 3D objects are imported into the Unity engine to construct an interactive virtual interview space. This pipeline effectively supports the creation of immersive and realistic environments, demonstrating its applicability not only for interview simulations but also for training, education, and experiential content development.

EC250096

## Leveraging Imbalanced Brain Stroke Classification by Combining a Self-training-based Model with StyleGAN

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**Keywords:** self-training approach, styleGAN, imbalanced data

### Abstract:

In recent years, deep learning models have been widely applied to medical image classification. In these studies, deep learning algorithms can significantly boost the prediction accuracy of disease diagnosis. However, in actual medical scenarios, the number of patients with diseases often far exceeds the number of healthy individuals, as seen in cases such as brain stroke or microarray gene cancer. Under imbalanced data conditions, deep learning models often misclassify minority class instances as the majority class due to insufficient learning. Consequently, incorrect predictions may prevent patients from receiving effective treatment. To address this challenge, we propose a novel oversampling approach, termed ST-StyleGAN, which combines a self-training-based inception deep model with StyleGAN. The proposed approach consists of two modules: (1) Using StyleGAN for generating synthetic brain stroke images to balance the data distribution; and (2) a self-training-based inception model is constructed to predict label(s) of high-confidence synthetic samples. To evaluate the effectiveness of the proposed ST-StyleGAN approach, we conducted several experiments based on the Brain Stroke Prediction Dataset from Kaggle repository, and compared its performance with two baseline methods. Experimental results demonstrate that, at an imbalance ratio of 5, ST-StyleGAN achieves approximately a 10% improvement in recall and F1-score indicators. Overall, the proposed ST-StyleGAN effectively enhances prediction performance in imbalanced brain stroke classification.

EC250099

## Interpretable Deep Learning Models for Cancer Diagnosis Using Tumor-Educated Platelet Transcriptomes

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**Keywords:** Tumor-educated platelets (TEPs), RNA-seq, CNN-LSTM, Attention-LSTM, SHAP

### Abstract:

Tumor-educated platelets (TEPs) have emerged as promising biomarkers for liquid biopsy-based cancer diagnostics. However, the intrinsic challenges of transcriptomic data, including high dimensionality, small sample size, and strong nonlinearity, hinder robust classification. In this study, we propose a deep learning framework that integrates four architectures—LSTM, BiLSTM, CNN-LSTM, and Attention-LSTM—to classify cancer and healthy samples from the GSE68086 dataset (235 cancer, 50 healthy). Experimental results demonstrate that all models achieve competitive performance, with overall accuracies approaching 0.88, while the Attention-LSTM and CNN-LSTM further enhance interpretability and local feature extraction. Moreover, SHAP analysis confirms that selected genes contributing to classification align with biologically meaningful signals, providing both predictive accuracy and clinical interpretability. These findings highlight the potential of deep sequential models in advancing platelet-based cancer diagnostics.

EC250100

## Explainable Deep Learning for Stress and Performance Analysis in Professional Tennis Matches

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**Keywords:** Sports analytics, Tennis performance, Stress classification, TabNet, SHAP

### Abstract:

Tennis match analysis is a critical component of sports science, offering insights into player performance, workload management, and competitive stress. This study proposes a data-driven framework to classify tennis matches as high-stress or low-stress using ATP match statistics. High-stress matches are characterized by extended duration or frequent break points, both representing elevated physical and psychological demands. We implement TabNet and compare its performance with recurrent deep learning models, including long short-term memory (LSTM), bidirectional LSTM (BiLSTM), attention-enhanced LSTM, and convolutional LSTM (CNN-LSTM). Experimental results show that TabNet achieves the best accuracy (98%), while the recurrent models maintain accuracies above 93%, demonstrating consistent predictive capability. To enhance interpretability, SHAP analysis identifies break points faced, break points saved, and match duration as the most influential determinants of match stress, with serving and returning features providing secondary contributions. These findings confirm the effectiveness of interpretable deep learning in sports analytics and highlight its potential for guiding training and match preparation.

## Proposing Ketamine Bridge Therapy for Acute Suicidality

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**Keywords:** Depression, Ketamine,, Psychotherapy, Selective serotonin reuptake inhibitors (SSRIs), Suicide

### Abstract:

Suicide remains a leading cause of preventable death in the United States, with rates of suicide increasing consistently over the past two decades. Selective serotonin reuptake inhibitors (SSRIs) and psychotherapy are first-line treatments (FLT) for depression and suicidality, with acute suicidality often resulting in hospitalization. While SSRIs result in long-term improvement in symptoms for up to 60% of patients who initiate treatment, effects are first felt between 2 to 6 weeks after beginning the medication (IQWiG, 2020). Due to the emergent nature of suicidality, there is need for treatments that provide more rapid relief, controlling symptoms in the interim period needed for FLT to take effect. In fact, patients hospitalized for acute suicidality face a heightened risk of suicide shortly after hospitalization, particularly within a critical 1–3 month window following discharge (Chung et al. 2017; 2019)

Per recent studies, ketamine infusions rapidly and significantly reduce suicidal ideation (Abbar, 2022). We contend that ketamine therapies should be considered as potential treatment for acute suicidality in conjunction with SSRIs and psychotherapy.

Aims of study: (1) to investigate the potential effectiveness and safety of ketamine when used as a bridge between psychiatric hospitalization discharge and the time needed for first-line therapies to take effect; (2) to determine the risks and benefits of using ketamine as a bridging therapy; and (3) to inspire future projects that directly test this assertion and expand on the use of ketamine for acute suicidality.

Methods: (1) review safety and efficacy literature on ketamine therapies for suicidality; (2) draw comparisons to other areas of medicine such as chemotherapy, where bridging therapies are the standard of care; (3) present models on how to integrate ketamine bridging into existing treatments for suicidality; (4) Contextualize the risks of ketamine therapies and clinical safety profile.

We suggest ketamine such as SPRAVATO® be used to treat acute suicidality during the lead-time needed for SSRIs and psychotherapy to take effect. However, ketamine is not for use in place of hospitalization.

**Deep Learning for Emergency Department Sustainability: Interpretable Prediction of Revisit Risk**

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**Keywords:** deep learning, model interpretability, unscheduled return visit, sustainability of emergency operations

**Abstract:**

The sustainability of emergency department (ED) operations is a critical issue worldwide, as it directly impacts the timely delivery of medical support. However, ED overcrowding imposes excessive workloads on clinicians and reduces the diagnostic survey per patient, which compromises the quality of urgent care.

While long-term strategies for mitigating overcrowding may take time to yield tangible results, this study provides a more immediate solution by proposing a CNN-based clinical decision support system to predict the likelihood of ED readmission, a major contributor to overcrowding. The proposed system achieves a recall of 0.717 and an AUROC of 0.853, demonstrating its potential to relieve overcrowding in the short term.

To enhance interpretability, the proposed system incorporates SHAP to quantify the contribution of each variable, thereby indicating their positive or negative impact on the model's predictions. The SHAP analysis reveals that unstructured data, such as medical notes, exerts a dominant influence on predictive performance, while structured variables provide complementary value. These findings strengthen both the interpretability and the credibility of the model.

## AI-Based Handwriting Analysis for Cognitive Load Assessment in Indigenous and Non-Indigenous Children

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**Keywords:** Sensor Based Pen, Handwriting, Cognitive Load, Indigenous People, Machine Learning

### Abstract:

Health and educational inequities among Indigenous children, shaped by cultural, linguistic, and environmental barriers, impose hidden cognitive burdens that affect learning and mental well-being. Cognitive load, the mental effort required to process and retain information, influences both academic performance and cognitive health, with excessive load potentially causing stress and halting learning. Traditional measurement tools, such as EEG, eye-tracking, or skin sensors, are often impractical in remote or underserved Indigenous communities due to cost, complexity, and expertise required. Handwriting, a familiar and widely practiced activity, offers a non-invasive, culturally adaptable, real-time method to monitor cognitive strain.

In this study, a sensor-based pen captured the handwriting dynamics of Indigenous and non-Indigenous children aged 6–10 during two writing tasks of differing cognitive demand: a low-load task of copying words and a high-load task of recalling letters from memory, both restricted to lowercase letters to control for fine motor skills differences. Thirteen handwriting features, including speed, pressure, and jerk, were extracted to operationalize cognitive load and cognitive stress.

AI-based models classified high versus low cognitive load. For non-Indigenous children, the best-performing model was Optimized LightGBM with all 13 features, achieving 78.85% test accuracy, 0.780 ROC-AUC and  $0.842 \pm 0.0202$  cross-validated ROC-AUC. For Indigenous children, the default LightGBM with 9 features selected using Feature Importance achieved 82.69% test accuracy, 0.813 ROC-AUC, and  $0.909 \pm 0.0131$  cross-validated ROC-AUC. These results show that handwriting-based AI can reliably capture cognitive load patterns, reflecting differences in mental effort across cultural groups.

This study highlights that accessible, handwriting-based AI systems can serve as practical tools for monitoring cognitive health in children, providing insights into mental effort during learning and guiding adaptive teaching strategies, culturally responsive curriculum design, and policies to support cognitive well-being while reducing educational disparities.

## Handwriting Analysis for Autism Detection Using a Sensor-Based Pen with Interpretable Machine Learning

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**Keywords:** autism spectrum disorder, handwriting analysis, interpretable machine learning, sensor-based pen, autism detection

### Abstract:

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that often manifests in early childhood through atypical motor and behavioral patterns and is typically diagnosed through behavioral observations and clinical assessments. While early detection enhances intervention outcomes, existing diagnostic methods may delay identification, particularly in resource-limited settings with restricted access to specialized diagnostic services.

This study presents a machine learning-based approach that analyzes handwriting features captured by a sensor-based pen during standardized tasks from the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2), and the Test of Visual Motor Skills (TVMS). Handwriting data were collected from 23 children with ASD and 23 neurotypical peers, yielding 13 spatial and temporal handwriting features. These features were used to train multiple classifiers, with LightGBM achieving the highest performance at 79.44% accuracy, followed by Random Forest (78.63%) and Gradient Boosting (77.02%).

To improve interpretability, Shapley Additive exPlanations (SHAP) quantified the contribution of individual features to model predictions. Results showed that air time, stroke duration, pen pressure variability, and in-air movement were the most influential in distinguishing ASD from non-ASD. These align with known motor and visual-motor integration challenges in ASD, where prolonged pauses (air time), inconsistent stroke execution (stroke duration), and irregular force control (pen pressure variability) reflect difficulties in fine motor planning and sensorimotor regulation. Retraining the model with the top seven SHAP-ranked features preserved accuracy at 85%, showing that a reduced, interpretable feature set maintains predictive strength while clarifying the motor aspects most affected in ASD.

The findings demonstrate that sensor-based handwriting analysis, combined with interpretable machine learning, can serve as a non-invasive and scalable digital marker for early ASD screening, supporting clinicians in identifying subtle motor patterns and enabling timely intervention.

**Comparison of different therapies for occupational low back pain: a network meta-analysis of randomized controlled trials**

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**Keywords:** low back pain, occupational, rehabilitation, quality of life, meta-analysis

**Abstract:**

**Objective:**

To summarize and evaluate evidence for the clinical efficacy of different therapies for occupational low back pain by network meta-analysis.

**Methods:**

Seven databases were searched by computer for randomized controlled trials (RCTs) of occupational low back pain from the establishment of the database to July 2025. Final RCTs were selected based on inclusion and exclusion criteria, and the data on low back pain intensity (Visual Analogue Scale, VAS), disability and quality of life (QoL, SF-36) were used to evaluate the clinical efficacy of the study. A meta-analysis was conducted on data using the RevMan5.4 software and Stata 16.0 software.

**Results:**

A total of 12 RCTs involving 2149 participants were included, involving seven interventions. Meta-analysis showed that rehabilitation treatment appeared to be more effective than control group on QoL, as assessed by SF-36 (mean difference, 10.38; 95% confidence interval [CI], 1.87-18.89;  $P < 0.05$ ). There was no statistically significant difference in the VAS scores ( $p > 0.05$ ).

**Conclusions:**

Although there is some evidence for an effect of rehabilitation treatment on occupational low back pain, the results are inconclusive. Further studies with more subjects and more high-quality clinical trials are needed to provide medical evidence.

## Technical Feasibility Assessment of Applying Small-Scale Battery Energy Storage Systems to Stabilize Power Demand of Industrial Mechanical Equipment

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**Keywords:** battery energy storage system, power consumption stabilization, load forecasting, contract capacity

### Abstract:

In conventional industrial settings, mechanical equipment is predominantly powered by electric motors, which convert electrical energy into various forms of mechanical work — such as driving conveyor systems, compressed air machinery, and chilled water units. However, the power consumption of these machines is inherently variable due to frequent start-stop operations and fluctuating loads. These sudden changes in demand often lead to sharp peaks in the load curve, compelling facility operators to contract for higher demand capacities in order to avoid penalties, thus increasing base electricity charges.

To mitigate this issue, this study proposes the integration of a small-scale Battery Energy Storage System (BESS) to compensate for load surges during peak operation periods of mechanical equipment. The objective is to flatten the facility's power demand profile, reduce contracted demand capacity, and enhance energy efficiency. A representative mid-sized industrial site was selected as a testbed, where a lithium-based energy storage unit was installed at the power inlet of key mechanical systems. The system includes a bi-directional smart meter and an industrial-grade computer to form a comprehensive monitoring and control infrastructure.

By continuously collecting real-time power consumption data and analyzing operational patterns, the system performs short-term load forecasting. Based on the predictions, the power conversion system (PCS) of the energy storage unit is dynamically controlled to either discharge or recharge, effectively smoothing out demand fluctuations. Experimental results demonstrate that the proposed solution significantly reduces

demand spikes and peak loads, enabling a lower contracted capacity and hence reduced base electricity charges. Additionally, the system contributes to improved power quality of power grid. This approach offers a viable technical reference for future applications in smart manufacturing and distributed energy management systems.

## Designing an AI Agent System to Execute the Biodesign Debate Process

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**Keywords:** biodebate, biodesign, ai agent

### Abstract:

#### Background:

The Biodesign process for medical device innovation includes Identify, Invent, and Implement. The Identify stage—focused on unmet clinical needs—is critical but often hindered by premature solutions, communication gaps, and power dynamics. Large language model (LLM)–based multi-agent systems may enhance rigor and transparency.

#### Objective:

We present BioDebate, an AI agent system that simulates interdisciplinary debate for Biodesign, applied to chronic disease management. The system aims to generate, evaluate, and converge on need statements and solutions with traceability and efficiency.

#### Methods:

The system, built on LangGraph, coordinates agents representing Clinician, Engineer, Business, and optional Regulatory roles. Debate proceeds in Identify → Score → Invent loops until scoring variance stabilizes. A retrieval layer (FAISS/Qdrant) supports evidence citation from literature and patents, reducing hallucination. Logs, scores, and citations are stored for audit and education. Simulations tested need generation, debate flow, and solution ideation.

#### Results:

Agents produced diverse needs (e.g., home monitoring for multimorbidity), debated iteratively, and converged into structured Biodesign-format statements. Benefits observed include reduced bias and hierarchy effects, more efficient debate, transparent records, and enhanced creativity from multi-role perspectives.

#### Discussion:

Compared to human-only teams, BioDebate promotes balanced participation, structured convergence, and audit-ready outputs. Limitations include dependence on model quality and databases, and the requirement for human validation.

#### Future Work:

Next steps include randomized comparisons of AI- vs. human-led teams, integration of broader data sources, and application to real-world Biodesign projects.

#### Conclusion:

BioDebate demonstrates the feasibility of applying LLM-based multi-agent systems to Biodesign. It supports systematic need identification, creative solution generation, and transparent decision-making, serving as both a research accelerator and educational tool.

## A Study of Multimodal Generative AI Agent for In-Home Elderly Monitoring Assistant

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**Keywords:** Multimodal, Generative AI, Agent, Elderly Monitoring, Assistive Technology

### Abstract:

As global aging accelerates, there is an urgent need for in-home technologies that address loneliness, missed medication, and undetected health issues in elderly populations. Traditional monitoring systems are often passive and lack interactivity, limiting their ability to provide proactive behavioral support or emotional engagement. This study proposes a multimodal, generative AI-driven in-home conversational agent system that supports elderly individuals through natural daily dialogue. The system integrates a large language model (e.g., ChatGPT API) as a voice-enabled chatbot via smart speakers. It incorporates ambient sensors (motion, door, and bed pressure) along with visual inputs (facial expressions and posture) to enable context-aware, multimodal interaction. Three core challenges are addressed: (1) adaptation of LLMs for elderly-friendly dialogue, (2) real-time integration of sensor data into language generation, and (3) dynamic, personalized intervention logic. To address these, the following methods are proposed: (1) LLM fine-tuning using dialogue datasets tailored to elderly users, ensuring a gentle, non-directive conversational tone. (2) Multimodal data fusion module that preprocesses sensor input to infer states (e.g., waking, eating) and provides context for LLM-driven interactions. (3) Personalized intervention engine that selects the timing and type of prompts (e.g., medication or meal reminders) based on behavior history and real-time state estimation. The current system remains at the prototype level, and several considerations must be addressed before implementation. Key among them is verifying the effectiveness of multimodal context in improving dialogue continuity and personalization. Additionally, the acceptability of system interventions, particularly their frequency and emotional tone, must be evaluated to avoid user fatigue or discomfort. Privacy and ethics are also central issues. Establishing a transparent data handling framework and informed consent procedures is essential, particularly for continuous sensing and conversational logging.

EC250119

## Medical Evaluation of Delayed Offloading and Throughput in Mobile Cloudlet

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**Keywords:** Medical Evaluation, Delayed Offloading, Throughput, Mobile Cloudlet

### **Abstract:**

Medical Mobile edge is strongly influenced by its battery life contemporary it holds tiny embedded capacity and energy dissipation. also leads to an issue. Since surge count in the usage of mobile computing and cloud technology introduced with titled Mobile Cloud Computing (MCC). The offloading and throughput are emerged in MCC to attain low latency completion of computations along with considerable extent endorse of remote servers. The performance of such task is degraded due to delayed offloading in completion of task. This proposed threshold based multilevel offloading algorithm scheme and throughput were used for accelerating to offloading procedure simultaneously experiment network traffic and power dissipation. of embedded mobile and alignment concept simulated using python programming. This article presents throughput analysis for mobile cloudlet.

## Applying Generative AI to an Interactive CKD Patient Health Education System

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**Keywords:** Generative Artificial Intelligence, Chronic Kidney Disease (CKD), health education system, Perceived Kidney Knowledge Survey (PiKS)

### Abstract:

Most patients with chronic kidney disease do not really figure out their condition well enough to manage it effectively. This knowledge gap creates real problems for their health outcomes. Standard educational materials tend to be generic, which do not account for what individual patients already know or what specific areas they struggle with most. This problem was tackled by building an interactive system that uses artificial intelligence to create personalized health education. The system works by first assessing what patients know using the Perceived Kidney Knowledge Survey (PiKS), then combines this information with their medical records and current treatment guidelines. Healthcare educators can use touch-screen displays or tablets to generate educational content that's specifically tailored to each patient's knowledge gaps and clinical situation. What significantly useful about this approach is that patients can both read and hear the information, which helps accommodate different learning styles and literacy levels. We conducted rigorous validation of the medical content accuracy of system against established clinical guidelines and performed expert evaluation to assess the naturalness of generated materials. The results suggest this approach works well. Healthcare educators found the system especially helpful for explaining complex topics like medication management—areas where patients typically have the most questions. The interactive format seems to keep patients more engaged, and meaningful improvements are performed in their understanding across different educational backgrounds. This study appears to offer a practical way to deliver more personalized patient education efficiently.

## DroneDeepVision (DDV): A Traffic Congestion Control Strategy Using Lightweight Vision And Feedback Based Learning

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**Keywords:** Traffic Management, Large Language Model, Edge Computing, Deep Reinforcement Learning, Smart Cities

### Abstract:

Traffic congestion is one of the most difficult problems in urban transportation, requiring real-time control and intelligent decision-making to reduce delays and enhance road efficiency. In this work, a hybrid traffic management system is proposed that combines the coordination of Large Language Model (LLM) agents, drone-based edge computing, and Deep Reinforcement Learning (DRL). Drones are dispersed across a large number of urban areas in the suggested system to gather vehicle counts and flow rates of traffic, which are edge-processed to derive traffic density levels (low, medium, high). The aggregated flow levels are processed by the LLM agent, prioritizing key congestion points in a way that only the most relevant and high-impact information is transmitted to the central server. Such selective communication reduces network overhead and latency. The prioritized information is fed into a DRL model, which calculates in real time optimal traffic control policies, i.e., adaptive signal timing, rerouting, and lane priority. With semantic reasoning enabled by LLMs and learning-based decision optimization enabled by DRL, the system is communication-efficient and minimizes traffic waiting times. Experimental tests demonstrate that congestion detection and resolution are enhanced and communication cost is reduced in this method. The results demonstrate the potential for integrating LLM agents and intelligent control systems for large-scale real-time traffic management in smart cities.

## Deep Learning for Image Recognition and Worker Protective Equipment Detection

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**Keywords:** deep learning, construction site safety, YOLOv8, image recognition

### Abstract:

This study aims to enhance safety monitoring efficiency at construction sites by addressing the occupational risks associated with workers failing to wear personal protective equipment (PPE). To this end, we propose a real-time image recognition system that integrates deep learning with edge computing. An empirical case study was conducted at a construction site in Taiwan, where a detection system was deployed by combining the YOLOv8 object detection algorithm with a Raspberry Pi 5 device for edge computing. The developed system is capable of real-time identification of whether workers are wearing safety gloves, thereby improving automated on-site monitoring and reducing safety hazards caused by human negligence. To further improve the recognition performance of lightweight models under edge computing conditions, the system is designed to achieve both high efficiency and low latency.

## Development of the ROS2 Artificial Intelligence Module

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**Keywords:** ROS2, GPT-OSS, ISAAC

### Abstract:

Bridging natural language with reliable low-level control remains a central challenge for autonomous robotics. In this work, we introduce the ROS2 AI Module, a framework that integrates localized large language models (LLMs) with the Robot Operating System 2 (ROS 2) Navigation stack through a Mode Context Protocol (MCP) server, validated in a digital twin environment built on NVIDIA Isaac Sim. The module enables natural language commands issued via a chat interface to be converted into structured MCP tool calls, which are then mapped to ROS 2 primitives (e.g., `geometry_msgs/Twist` and `geometry_msgs/PoseStamped`) for navigation. By maintaining standardized ROS 2 interfaces, the ROS2 AI Module ensures seamless transferability between simulation and physical robots.

To systematically evaluate the ROS2 AI Module, we conducted five navigation experiments, summarized in Table 1. The first four tasks involved navigating to distinct cabinet locations (A–D) along a corridor, while the fifth tested robustness with an invalid goal (Cabinet E) placed outside the navigable region. Multiple LLM backends were tested, including GPT-OSS, Qwen2.5-VL (7B/32B), LLaMA 3.2 (3B), QwQ (32B), and Mistral variants (7B/22B). Results show that while most models successfully generated valid MCP messages for reachable targets, their reliability varied in handling invalid instructions: some models extrapolated false coordinates, while others correctly refrained from issuing unsafe commands.

## Digital Twin-Enhanced Tactile-Vision-Language-Action Model for Intelligent Robotic Control

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**Keywords:** Digital Twin, Tactile-Vision-Language-Action Model, Sim-to-Real Learning, Robotic Manipulation

### **Abstract:**

This paper presents a digital twin-enhanced tactile-vision-language-action (TVLA) model aimed at achieving adaptive robotic manipulation through multimodal perception and reasoning. The proposed TVLA framework integrates tactile sensing, visual perception, and natural language understanding within a large language model (LLM) architecture, enabling robots to interpret human-like instructions and perform context-aware actions. Specifically, tactile sensors capture grasping force and material resistance, while a vision transformer extracts key environmental features. Language inputs, processed through a tokenizer and encoder, are semantically aligned with visual-tactile representations within the LLM. Furthermore, a digital twin framework is incorporated with the TVLA model to facilitate continuous learning and virtual-to-real adaptation, optimizing manipulation strategies for diverse materials and object geometries. Experimental results demonstrate that the proposed method achieve significant improvements in grasping precision, adaptability, and reasoning accuracy compared with conventional vision-language-action models.

## Combining Fuzzy Rule Model and Vision-Language-Action Models for Robotic Arm Control

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**Keywords:** Vision-Language-Action Model, Fuzzy Rule Model

### Abstract:

The Vision–Language–Action (VLA) model is a class of multimodal artificial intelligence (AI) frameworks that integrates visual perception, natural language understanding, and action execution within a unified architecture. Such models have found broad applications in robotic learning and autonomous agent systems. A VLA model enables a system to process visual inputs or spoken commands, comprehend the corresponding instructions, and subsequently generate the appropriate action responses.

The key advantage of VLA models lies in their ability to interpret sensory information (e.g., images), process linguistic directives, and transform high-level reasoning into physical actions. By bridging the gap between instructional intent and motor execution, these models facilitate more effective computer-controlled operations and demonstrate potential for extension to domains beyond conventional robotics.

In this study, we propose the integration of a Fuzzy Rule–based Model into the conventional VLA framework to enhance the **\*\*precision of action execution\*\***, thereby improving the overall performance and robustness of the system.

EC250130

## Preliminary Development of a Three-Finger Bio-Adhesive Gripper with Quick-Exchange Interface and Coordinated Control for Adaptive and Learning-Based Manipulation

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**Keywords:** bio-inspired adhesion, three-finger gripper, quick-exchange mechanism, coordinated control, adaptive manipulation

### Abstract:

This study presents the preliminary development of a three-finger bio-adhesive gripper designed as a foundational platform for adaptive and learning-based robotic manipulation. The gripper features a modular quick-exchange interface that enables rapid attachment and replacement of bio-adhesive pads, facilitating flexible testing of different adhesive materials. Each finger is individually actuated and coordinated through a basic position-controlled system to achieve stable and synchronized grasping. The design was modeled and fabricated using CAD-based simulation and rapid prototyping to verify motion range, mechanical integrity, and adhesive contact area. Preliminary experiments were conducted to evaluate grasping stability, detachment repeatability, and operation consistency on planar and curved objects. The results demonstrate reliable adhesion and smooth detachment performance under repeated trials, confirming the feasibility of the proposed mechanism for lightweight object handling. The developed gripper establishes a modular and controllable foundation for subsequent integration of tactile sensing, time-sequence learning algorithms, and digital-twin-based control, supporting the long-term goal of achieving intelligent and adaptive manipulation in dynamic environments.

## Preliminary Study on Lightweight Vision–Language Model Deployment for Edge-based Customer Service Applications

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**Keywords:** Vision–language model, quantization, knowledge distillation, edge inference, model compression

### Abstract:

Customer service systems increasingly depend on multimodal understanding and re-al-time dialogue generation. However, deploying large vision–language models (VLMs) in such scenarios is limited by memory and computation constraints on edge devices. This study presents a preliminary investigation into lightweight deployment strategies for VLMs through model quantization and knowledge distillation. The proposed framework employs LLaMA.cpp to convert and quantize both the visual and language components of SmolVLM2-2.2B-Instruct, establishing an OpenAI-compatible local API server for performance evaluation using VLMEvalKit. Quantitative results on MME and SEED-Bench show that the visual mode under q8\_0 precision retains nearly identical accuracy while reducing file size to 34% of the original. The language model quantized to q4\_k\_m achieves comparable performance with a fivefold increase in inference throughput and only 15% of the storage requirement. Complementary distillation experiments using CIFAR-100 and WikiText-2 demonstrate that student models maintain 80–90% of teacher accuracy with roughly half the parameters. These findings confirm the practicality of lightweight VLM compression for responsive customer service agents operating on resource-limited devices. Future work will incorporate Quantization-Aware Training (QAT) and hybrid distillation frameworks to enhance precision, portability, and adaptability across real-world multimodal service environments.

**Fabrication of Bio-inspired adhesives via AI-assisted design and their application to adaptive robot grippers**

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**Keywords:** bio-inspired, AI-assisted, biomimetic adhesives, robot grippers, decision-making platform

**Abstract:**

Drawing inspiration from the surface structures of gecko feet and octopus tentacles, we have developed advanced biomimetic adhesives. The process of creating such biomimetic materials inherently involves iterative refinement, with inevitable failures contributing to eventual optimization—this is achieved through experience and systematic trial-and-error. The technology is supported by an interdisciplinary decision-making platform designed for the development of biomimetic adhesives. Initially, text-mining techniques are employed to extract relevant keywords and parameters from over 1,200 academic publications, supplemented by observation and simulation of adhesion mechanisms and associated structural surfaces. The resulting biomimetic adhesion model undergoes validation and calibration using empirical data and is further analyzed with various machine-learning methods to establish an expert decision-making support platform. With insights derived from artificial intelligence analysis, we fabricate a series of biomimetic adhesives featuring micro/nano-scale patterned surfaces. These adhesives are tailored for specific applications, including high load-bearing capacity, long-term durability, resistance to wet conditions, compatibility with rough surfaces, and suitability for other challenging environments. When integrated into a bionic gripper, this technology enables a robotic arm to lift thin plate objects without the need for a vacuum pump. Additionally, it allows prosthetic fingers to perform nuanced actions such as turning pages or counting banknotes, closely replicating natural finger movements. In summary, this technology encompasses both a decision-making assistance platform and a material development platform, facilitating the design and production of high-performance biomimetic adhesives for a wide range of specialized applications.

**Fingerprint-inspired tactile sensor for directional sensing applications**

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**Keywords:** bio-inspired, fingerprint, laser-induced graphite, tactile sensor, wearable sensor

**Abstract:**

In recent years, there has been growing interest in bioelectronic diagnostics and tactile sensing, particularly for applications in wearable sensors and bionic grippers. To enhance the feasibility of flexible electrodes during fabrication, improve their stability and repeatability in practical applications, and enable highly sensitive measurements, we developed a convenient method for fabricating sensing patches. This method utilizes laser-induced graphite (LIG) methods to assist carbonization of polymers on surfaces, combining with residue-free adhesives to create sticky sensors with fingerprint-inspired micropatterns. Through this process, wave circuits with conductive graphene layers were directly generated on the adhesive silicone. Experimental results demonstrated that adjusting the processing conditions allows laser-induced carbonization to rapidly produce loose, wrinkled, graphitized fingerprint microstructures. These electrodes are capable of efficiently detecting electrical signals in contact with the skin. Regarding performance, the wave electrodes can withstand large strains while maintaining low sheet resistance (15.45  $\Omega$ /sq). The sensor exhibits a strain detection range of 0.5% to 15%. Within this range, resistance changes show a strong linear relationship with strain (with a regression coefficient of 98%). Furthermore, the patches maintained stable electrical signal outputs after more than 1000 repeated cycles, demonstrating excellent sensitivity, stability, and repeatability. The skin electrode patch was attached vertically and parallel to the testing muscle to obtain the resistance measurement. Moreover, the LIG techniques are extended to carbonize some more aromatic or metal composites to enhance sensor's conductivity. Also, complex design are performed to fit the directional measurements of tactility via resistance changes. This technology provides a promising approach for fabricating highly sensitive tactile sensors. This sensor is capable of detecting subtle muscle movements and tactile responses in robotic grippers, and due to its unique wrinkled/wave microstructures, it holds potential value in directional sensing applications.

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