

IECBES 2026 Workshop Proposal

1. Workshop Title

From Multimodal Biosignals to Personalised Digital Twins: A Hands-On Workshop on Explainable AI for Rehabilitation and Remote Health Monitoring

2. Proposer and Contact Information

Lead Proposer and Workshop Chair

Assoc. Prof. Ts. Dr. Kalaivani Chellappan

Department of Electrical, Electronic and Systems Engineering

Faculty of Engineering and Built Environment

Universiti Kebangsaan Malaysia

43600 UKM Bangi, Selangor, Malaysia

Email: kckalai@ukm.edu.my

Contact number: +60126949371

Industry and Technical Partner: SK Innovation Sdn Bhd.

Industry contact: Theeban Raj Shivaraja

Email: theebanraj@skinnovation.biz

Contact number: +60 17-615 8852

SK Innovation Sdn Bhd is a Malaysian healthcare-technology company involved in the development and integration of biosignal acquisition, AIoT-enabled healthcare systems, intelligent patient monitoring, digital rehabilitation and personalised health technologies. The company also supports the application of PLUX biosignal technologies for research, education and healthcare innovation in Malaysia and the ASEAN region.

3. Length of Workshop

Half-day workshop: Four hours, including a 15-minute break

Recommended capacity: 15–30 participants

Delivery mode: Short technical lectures, live demonstrations, guided practical activities and multidisciplinary system-design exercises.

4. Goals and Motivation

Biomedical engineering is rapidly progressing from isolated physiological measurements towards connected, personalised and intelligent healthcare ecosystems. Technologies such as wearable biosensors, multimodal signal acquisition, artificial intelligence, digital

twins and remote monitoring can support earlier detection, personalised rehabilitation and continuity of care. However, their effective application requires more than collecting physiological data. Researchers and practitioners must understand the complete pathway from sensor placement and signal quality to feature extraction, model interpretation, clinical relevance and safe human oversight. Poor signal acquisition, inappropriate referencing, unsynchronised data, data leakage or unexplained AI outputs can lead to misleading conclusions and limit clinical translation.

This workshop will provide participants with a practical, end-to-end understanding of how multimodal biosignals can be transformed into reliable and explainable digital-health intelligence. Participants will work with physiological signals such as ECG, EMG, EEG and PPG data and examine how these signals may be integrated into rehabilitation, remote monitoring and patient-specific digital-twin applications.

The workshop will also introduce the responsible use of AI and bounded agentic workflows in healthcare. Emphasis will be placed on human-in-the-loop decision-making, explainability, data provenance, patient safety and the distinction between research-grade estimation and clinical diagnosis.

Workshop Goals

The workshop aims to:

1. Introduce the principles and practical challenges of multimodal physiological signal acquisition.
2. Demonstrate appropriate sensor placement, sampling, referencing, synchronisation and signal-quality assessment.
3. Provide hands-on experience in preprocessing, visualising and extracting meaningful features from biosignals.
4. Demonstrate how explainable AI can support classification, estimation and rehabilitation-response monitoring.
5. Introduce patient-specific digital twins as dynamic representations of health and rehabilitation trajectories.
6. Demonstrate how AIoT and bounded agentic workflows can support remote monitoring without replacing clinical judgement.
7. Enable participants to design a preliminary biosignal-to-clinical-insight pipeline for a selected healthcare problem.

Expected Learning Outcomes

By the end of the workshop, participants should be able to:

- Select appropriate physiological signals and sensors for a healthcare or rehabilitation application.

- Identify common sources of noise, artefacts, crosstalk and signal-quality failure.
- Apply a basic preprocessing and feature-extraction workflow to multimodal biosignal data.
- Interpret the output of a simple explainable AI model.
- Map biosignal-derived indicators to a patient-monitoring or rehabilitation pathway.
- Develop a preliminary digital-twin and human-in-the-loop AI workflow.
- Recognise the ethical, privacy, validation and clinical-governance requirements of intelligent healthcare systems.

5. Scope and Workshop Outline

Scope

The workshop will use rehabilitation and remote health monitoring as the principal application domains. Potential examples include stroke rehabilitation, auditory-cognitive rehabilitation, cardiovascular monitoring, muscle-function assessment and home-based healthy-ageing support.

Detailed Workshop Programme

Time	Session	Content and Activity
0:00–0:20	Session 1: From Physiological Signals to Healthcare Decisions	Overview of biosignal-enabled healthcare; current limitations of isolated measurements; transition towards AIoT, personalised monitoring and digital twins.
0:20–1:00	Session 2: Multimodal Biosignal Acquisition and Signal Integrity	ECG, EMG, EEG and PPG fundamentals; sensor selection; sampling rate; electrode placement; reference configurations; synchronisation; artefacts; crosstalk; signal-to-noise ratio; electrical and participant safety.
1:00–1:50	Practical 1: Acquire and Assess Multimodal Signals	Participants work in groups to acquire selected signals, observe physiological changes, identify artefacts and complete a structured signal-quality checklist. ECG, EMG and PPG will form the core practical signals, with EEG demonstrations subject to equipment availability.
1:50–2:05	Break	—

2:05– 2:50	Practical 2: From Raw Signal to Physiological Feature	Guided preprocessing, filtering, segmentation and visualisation; extraction of representative temporal, frequency and movement features using a prepared notebook and de-identified dataset.
2:50– 3:25	Session 3: Explainable AI for Monitoring and Rehabilitation	Classification versus estimation; training and validation separation; overfitting and data leakage; performance metrics; feature importance; confidence and uncertainty; clinician-in-the-loop interpretation. Participants examine the output of a simple model.
3:25– 3:50	Practical 3: Digital-Twin and Agentic-Workflow Design Studio	Each group selects a use case and maps its signals, patient state, AI outputs, safety boundaries, clinician decision points and feedback actions onto a patient-specific digital-twin canvas.
3:50– 4:00	Session 4: Translation Roadmap and Closing	Group reflections, validation requirements, regulatory and ethical considerations, potential research directions and closing summary.

Participant Outputs

Each participant group will produce:

- A multimodal signal-quality assessment;
- A processed feature table or visualisation;
- An interpretation of an explainable AI output;
- A preliminary patient-specific digital-twin workflow; and
- A short validation and clinical-safety checklist.

6. Workshop Requirements

Participant Requirements

Participants should bring:

- A laptop computer with Wi-Fi capability;
- A modern web browser;
- Access to a spreadsheet application;
- Python/Jupyter or Google Colab access for the guided practical session.

MATLAB may be used by participants who prefer it, but it will **not** be compulsory. Prepared code, sample datasets and step-by-step instructions will be provided. Prior programming experience is helpful but not essential.

Venue and Conference Requirements

The workshop room should provide:

- Flexible seating for group work;
- Tables accommodating three to five participants per group;
- Projector, screen and audio system;
- Stable internet access;
- Adequate electrical outlets and extension sockets;
- Whiteboard or flip charts;
- Registration and technical-support area; and
- Sufficient space for sensor demonstrations.

Equipment Provided by the Organisers

The workshop organisers will provide, subject to final confirmation:

- EEG demonstration equipment;
- De-identified biosignal datasets;
- Prepared analysis notebooks and worksheets;
- Signal-quality assessment templates; and
- Digital-twin and clinical-workflow design canvases.

Any live acquisition will be limited to non-invasive educational demonstrations involving informed volunteers. The workshop will not perform clinical diagnosis or collect patient data.

7. Target Audience

The workshop is designed for:

- Biomedical, electrical, electronic and computer engineers;
- Postgraduate students and advanced undergraduate students;
- Researchers working with physiological signals, wearable devices or medical instrumentation;
- Healthcare professionals, including rehabilitation practitioners, physiotherapists and audiologists;
- AI, data-science and software researchers entering healthcare applications;
- Medical-device developers and health-technology entrepreneurs;

- Clinical engineers and healthcare innovation teams; and
- Industry practitioners working in remote monitoring, digital rehabilitation or personalised healthcare.

The workshop is suitable for both beginners seeking an end-to-end introduction and experienced researchers interested in integrating sensing, explainable AI and patient-specific digital twins. Participants will work in multidisciplinary groups so that engineering, computational and clinical perspectives can be combined.

8. Short Biography of the Lead Speaker

Assoc. Prof. Ts. Dr. Kalaivani Chellappan is an Associate Professor in the Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. She specialises in healthcare engineering, with research interests spanning cardiovascular engineering modelling, biomedical signal processing, Internet of Things in healthcare, data modelling and analytics, artificial intelligence and integrated healthcare systems. She holds a Bachelor of Engineering in Electrical and Electronic Engineering from Universiti Sains Malaysia, a Master of Computer Science from Universiti Kebangsaan Malaysia and a PhD in Engineering from Universiti Kebangsaan Malaysia. Her professional experience of more than 30 years encompasses engineering, information technology, education, research, innovation and human-capacity development in both private and public sectors. Her research has included EEG-based neurological analysis, EMG-based stroke assessment, non-invasive vascular-function monitoring, wearable and mobile healthcare technologies, auditory-cognitive rehabilitation, medication management and virtual diagnostic systems. She has led multidisciplinary and industry-linked projects involving machine learning for acute stroke triage, non-invasive vascular assessment, virtual cognitive training and healthcare-system integration. Her distinctive contribution lies in connecting physiological measurement and computational intelligence with practical, human-centred healthcare delivery. She is also actively involved in teaching, professional training, mentoring, innovation development and university–industry collaboration.

9. Industry Facilitators

Technical facilitators from **SK Innovation Sdn Bhd** will support the practical biosignal-acquisition and system-integration activities. The facilitators' expertise will include biosignal instrumentation, sensor configuration, AIoT integration, physiological-data processing and the development of intelligent monitoring and rehabilitation applications.

Individual facilitator names and short biographies will be added following confirmation of the SK Innovation technical team.

10. Workshop Value Proposition

Unlike workshops that address sensors, signal processing or AI as separate topics, this workshop integrates the complete biomedical-engineering translation pathway. Participants will not only acquire and analyse physiological signals; they will also determine how the resulting information can be interpreted, governed and incorporated into a safe, personalised healthcare workflow.

The combination of academic healthcare-engineering expertise and SK Innovation's applied biosignal and intelligent-health capabilities will provide participants with a practical bridge between biomedical research, prototype development and responsible clinical translation.