National Foundation for Science & Technology Development

PHENIKAA UNIVERSITY

SMART SENSING AND APPLICATIONS

IRIFF 2026 - Panel 1:
Promoting Excellent Fundamental Research in the Digital Era

Applying AI and Data Science in Electronics, Biomedical Engineering, and IoT: Bridging Basic Research and Practical Solutions

Duc-Tan Tran

Phenikaa University, Vietnam

Hanoi, 05 Nov. 2026

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Outline

- **Introduction & Ecosystem:** Phenikaa University & SSA Lab
- **The Digital Era Context:** The Bridge from Data to Value
- **Core Research Foundations:** Computational Science & Advanced AI
- **Bridging to Practical Solutions (Case Studies):**
  - Biomedical Engineering (Healthcare)
  - Smart Agriculture & IoT
  - Safety & Environment (Firefighters, Landslides)
- **From Lab to Market:** Impact, Ecosystem & Global Collaboration

Phenikaa university at a glance

*With approximately **35,000** students and over **140,000 m²** of green campus space, Phenikaa University features state-of-the-art laboratories, a smart library, modern dormitories, and a multi-functional sports complex, forming a **comprehensive education ecosystem** where learning is closely integrated with experience and innovation.*











SMART SENSING AND APPLICATIONS



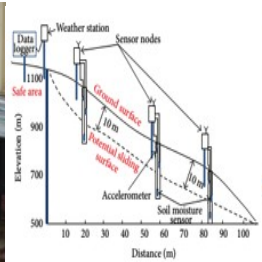
Prof. Duc-Tan Tran

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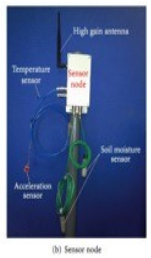
Expertise:
IoT Sensors and their applications utilizing Signal Processing and Artificial Intelligence
https://ssalab.phenikaa-uni.edu.vn/

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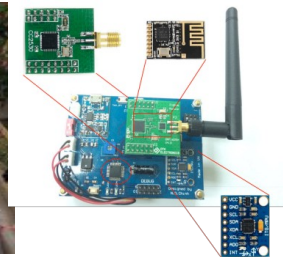
















Smart Sensing and Applications

SMART SENSING
AND APPLICATIONS












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The Digital Era Context

- The Core Challenge: From Data to Value
  - **The Digital Era** generates massive amounts of raw data from multi-sensor systems and IoT devices.
  - **The Gap:** Raw data alone is not knowledge. We need **Computational Science and AI** to decode it.
  - **Our Approach:** Excellent fundamental research must serve as the bridge connecting deep mathematical algorithms with real-world societal challenges (Healthcare, Agriculture, Environment).

Core Research - Computational Science & Signal Processing

- Foundations of Basic Research: Computational Science
  - **Advanced Mathematical Inversion:** Algebraic Helmholtz Inversion, Tikhonov Regularization, and Adaptive Algorithms applied to Ultrasound Tomography, Shearwave Imaging…
  - **Compressive Sampling:** Enhancing image reconstruction quality for biomedical applications.
  - **Impact:** Published in reputed journals

Core Research - Advanced AI & Machine Learning

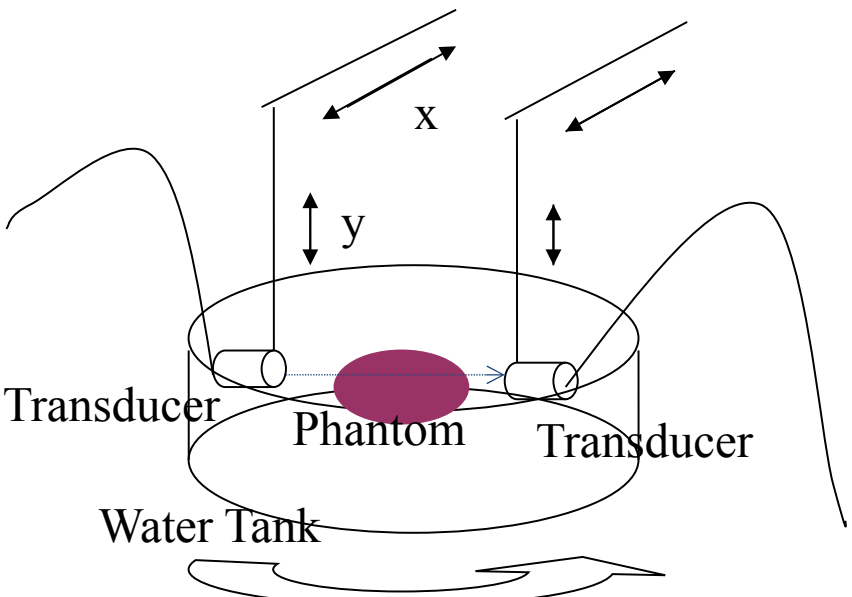
- Mastering the Core: AI and Machine Learning Models
  - **Deep Learning:** SD-YOLO (for small and dense object detection), CGB-Net (Convolutional Gated Bidirectional Network).
  - **Optimized ML:** GA-SPARF (Genetic algorithm-tuned Random Forest for sensor data).
  - **Edge Computing:** Deploying AI models on low-end, low-cost hardware for real-time processing.

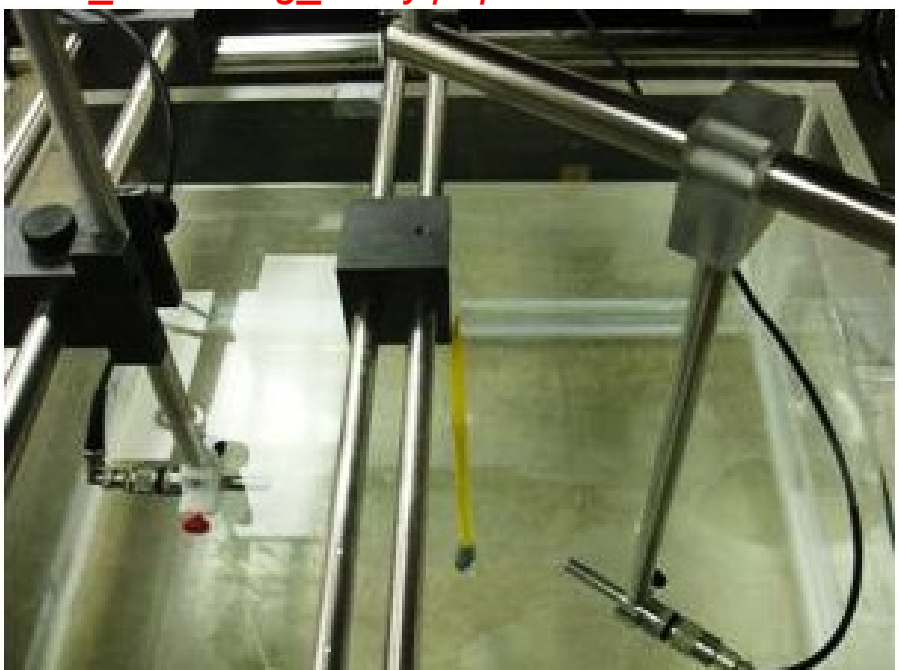
Case Study 1 - Biomedical Engineering

- Practical Solutions: AI in Biomedical Engineering
  - **High-Resolution Ultrasound Imaging:** NAFOSTED Funded Project (2021-2023) for early tumor detection using frequency-jumping and beamforming.
  - **Shear Wave Imaging:** Utilizing Extended Kalman Filters for soft tissue analysis.
  - **Smart Healthcare:** Lightweight AI models for **Sleep Position Classification** using wearable accelerometer data.

Case Study 1 - Biomedical Engineering

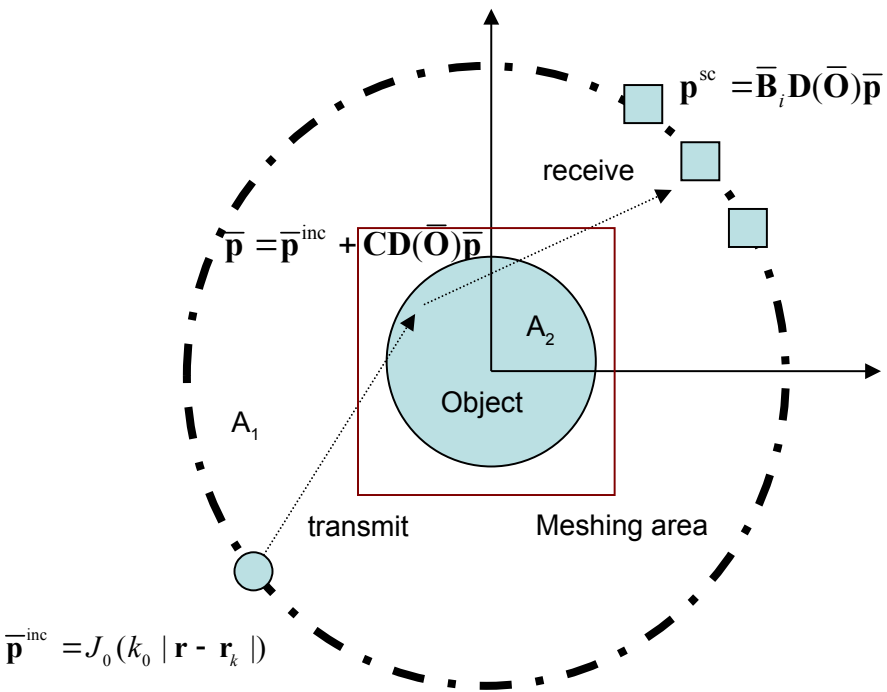
http://www.brl.uiuc.edu/Projects/inverse_scattering_study.php





Quang-Huy, Tran, et al. "Frequency-hopping along with resolution-turning for fast and enhanced reconstruction in ultrasound tomography." *Scientific Reports*

Case Study 1 - Biomedical Engineering





Huy, Tran Quang, et al. "Deterministic compressive sampling for high-quality image reconstruction of ultrasound tomography." *BMC medical imaging*

12 sleeping position classification system

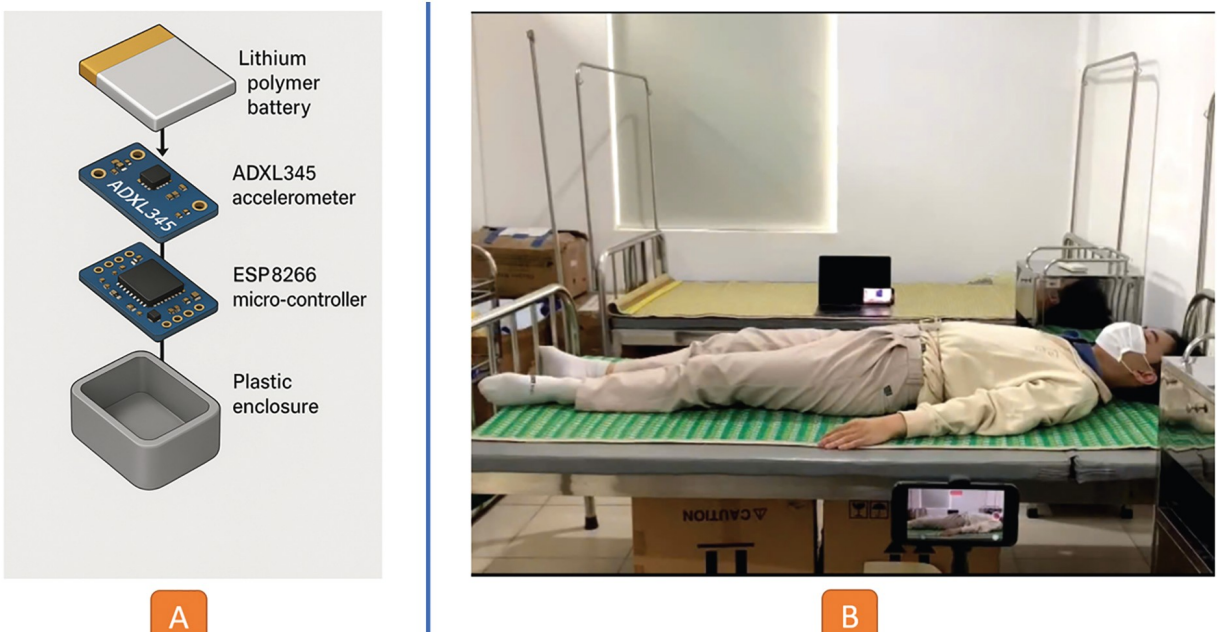


Figure 2: (**A**) Hardware components of the wearable sensing system used in the study; (**B**) experimental setup illustrating the data collection environment for sleep posture monitoring

12 sleeping position classification system

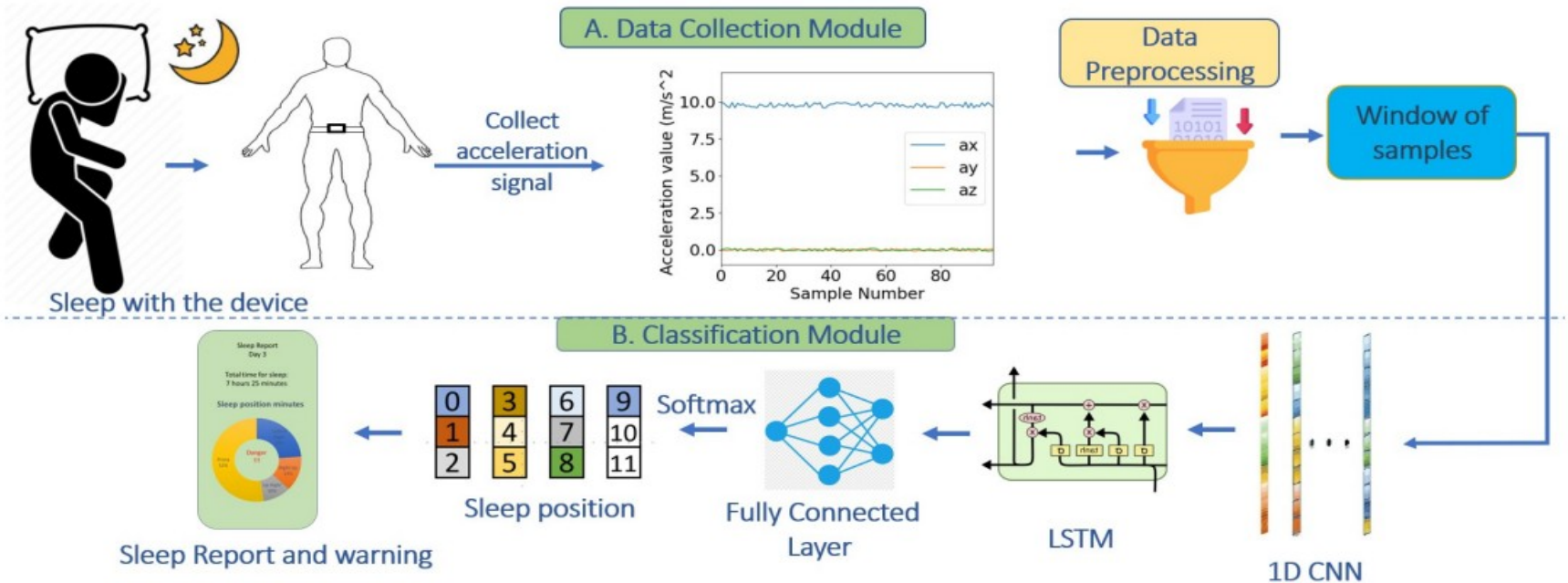


Fig. 1: Two-module system for 12-Sleep-Position Classification (12-SPSC): (A) Data collection module with an accelerometer worn on the abdomen, followed by signal preprocessing. (B) Classification module using a hybrid LSTM and 1D CNN model.

Vu, Hoang-Dieu, et al. "GA-SPARF: Genetic algorithm-tuned random forest for sleep position monitoring using accelerometer." *Sleep and Breathing*

12 sleeping position classification system

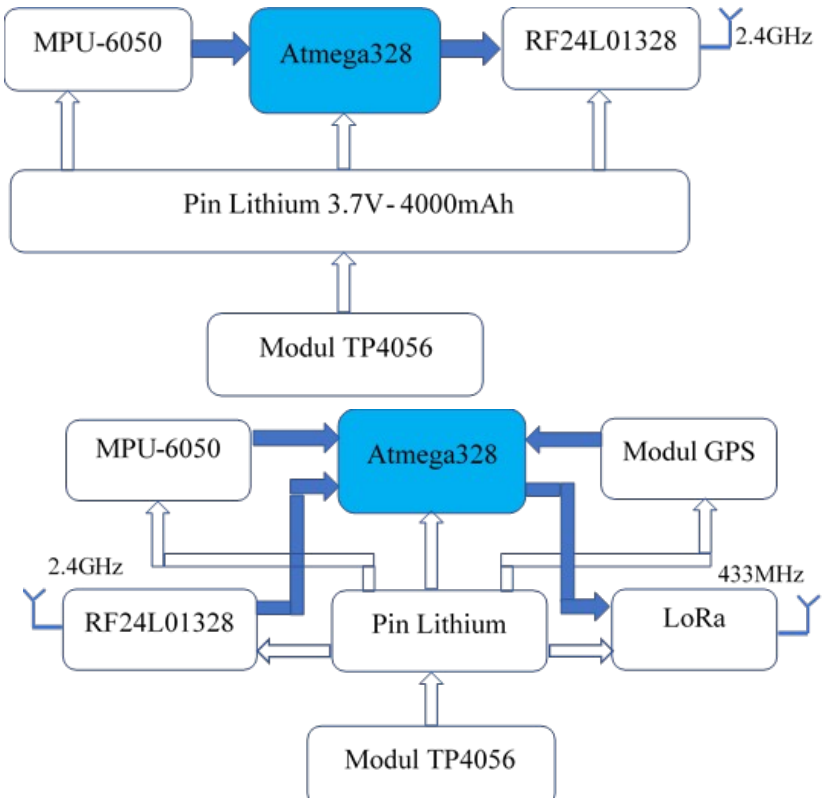
Method of	Year	Sensor Placement	Quantity	No of postures	Sampling Rate (Hz)	No of participants	Accuracy (%)	Model
Jiang et.al [64]	2016	chest	2	4	100	20	–	Threshold
Fallman et.al [65]	2017	chest, ankles	3	10	52	6	83.62	GML VQ
Poyuan et al. [66]	2017	chest, wrist	2	4	–	–	–	Threshold
Jeon et al. [67]	2017	wrist	2	3	100	–	88.02	CNN
Emer et al. [37]	2020	chest, abdomen	2	5	125	11	83.00	Logistic Regres-sion
Jeng et al. [68]	2021	wrist, chest	2	4	60	–	85.00	SVM, RF
Rawan et al. [38]	2022	neck	1	4	60	–	99.00	Extra-Tree
Vu et al. [44]	2023	abdomen	1	4	50	–	99.60	LSTM
Rawan et al. [39]	2023	neck	1	4	5,10,25, 50	18	98.00	LSTM
12-SPCS (Ours)	**2024**	**abdomen**	**1**	**12**	**50**	**15**	**91.86**	**Hybrid CNN-LSTM**

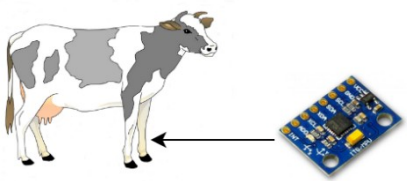
Vu, Hoang-Dieu, et al. "Human sleep position classification using a lightweight model and acceleration data." *Sleep and Breathing* 29.1 (2025): 95.

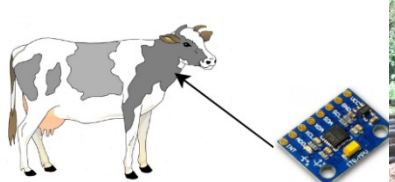
Case Study 2 - Smart Agriculture & IoT

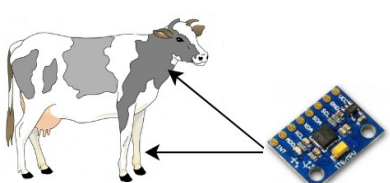
- Practical Solutions: IoT and AI in Smart Agriculture
  - **Problem:** Monitoring livestock behavior requires low-cost, scalable solutions (*NAFOSTED Funded Project*)
  - **Solution:** 3-DoF accelerometers attached to cows to classify behaviors in real-time.
  - **Tech:** Wireless Sensor Networks + Classification Model (Published in *IEEE Sensors Journal*, Q1).
  - **Outcome:** Granted 2 Patents (Intellectual Property Department of Vietnam).

Case Study 2 - Smart Agriculture & IoT











Tran, Duc-Nghia, et al. "An IoT-based design using accelerometers in animal behavior recognition systems." *IEEE Sensors Journal*

Case Study 3 - Safety & Environment

- Practical Solutions: AI for Community Safety & Environment
  - **Disaster Prevention:** Site-specific Rainfall-Induced **Landslide Early Warning** and Monitoring Systems (Nam Dan case study).
  - **Firefighter Support:** Multi-sensor data fusion for real-time activity recognition using wearable accelerometers.

[1] Gian, Quoc Anh, et al. "Design and implementation of site-specific rainfall-induced landslide early warning and monitoring system: a case study at Nam Dan landslide (Vietnam)." *Geomatics, Natural Hazards and Risk*

[2] Nguyen, Chinh D., et al. "Flexible and efficient wireless sensor networks for detecting rainfall-induced landslides." *International Journal of Distributed Sensor Networks*

[3] Hung, Dinh Tien, et al. "A Confident Configuration for an Environmental Radiation Monitoring System." *IEEE Transactions on Nuclear Science*

Case Study 3 - Safety & Environment

Wearable devices



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https://ssalab.phenikaa-uni.edu.vn/demo-videos

Case Study 3 - Safety & Environment

Motor Safe

Fall Detection

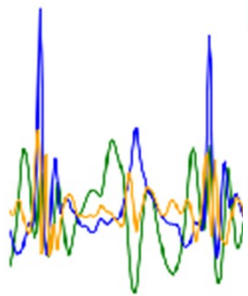
Activity Classification

Step Counting

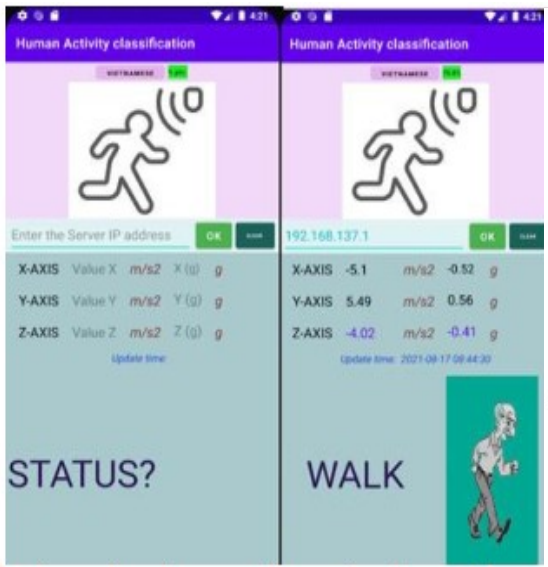
Respiration Rate Monitoring

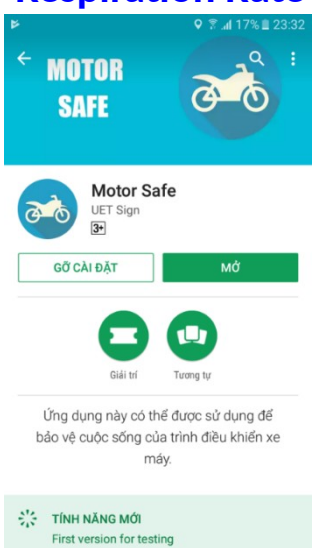


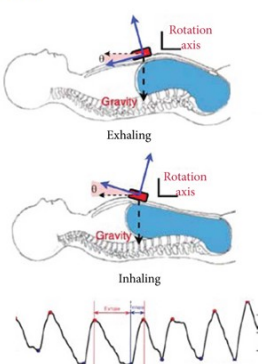
Wearable devices

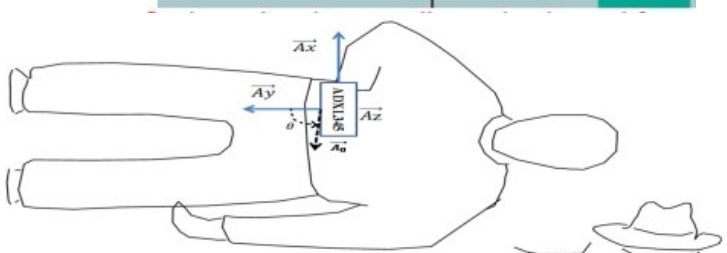


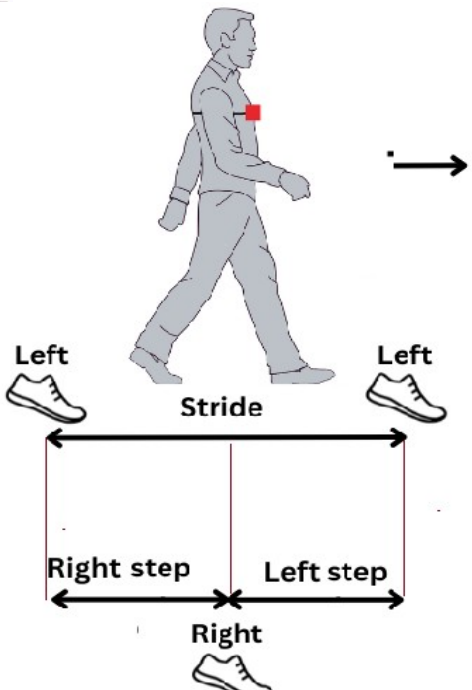
signal





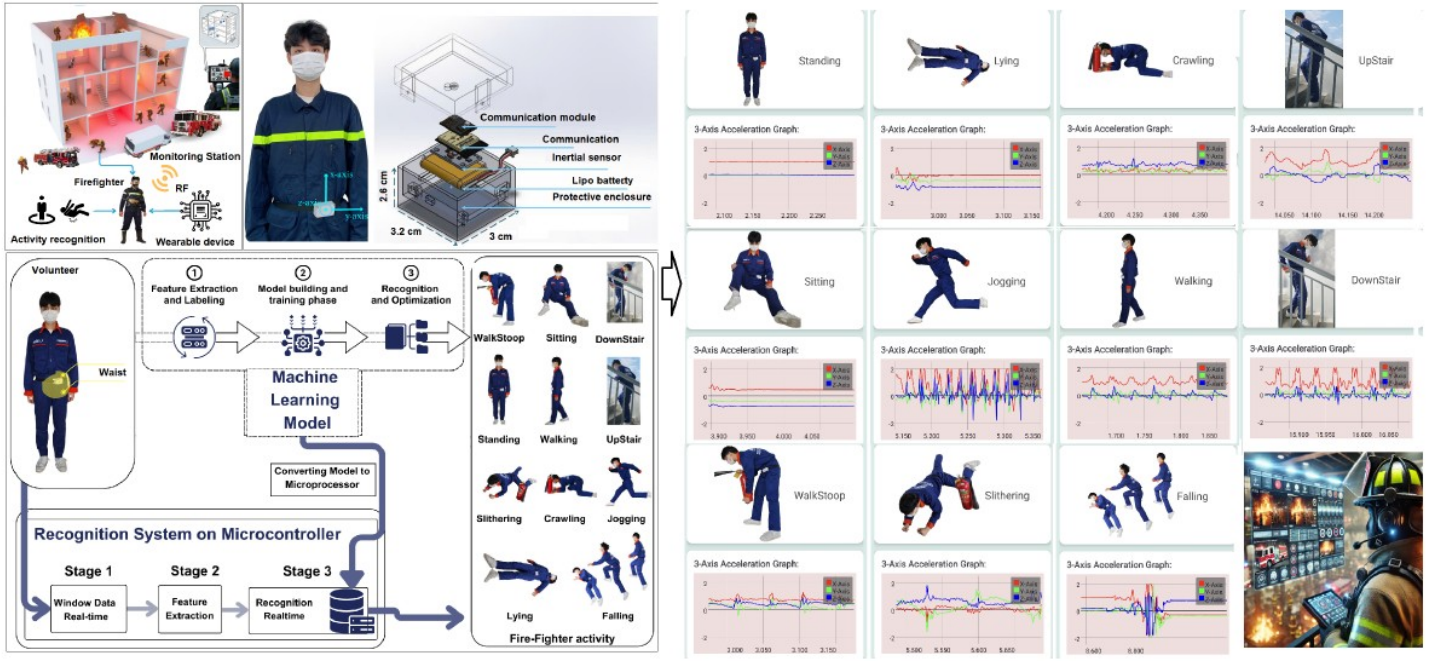






TAN, Tran Duc, et al. Streamlining the design of MEMS devices: An acceleration sensor. *IEEE Circuits and Systems*

A Real-Time Support System for On-Duty Firefighters

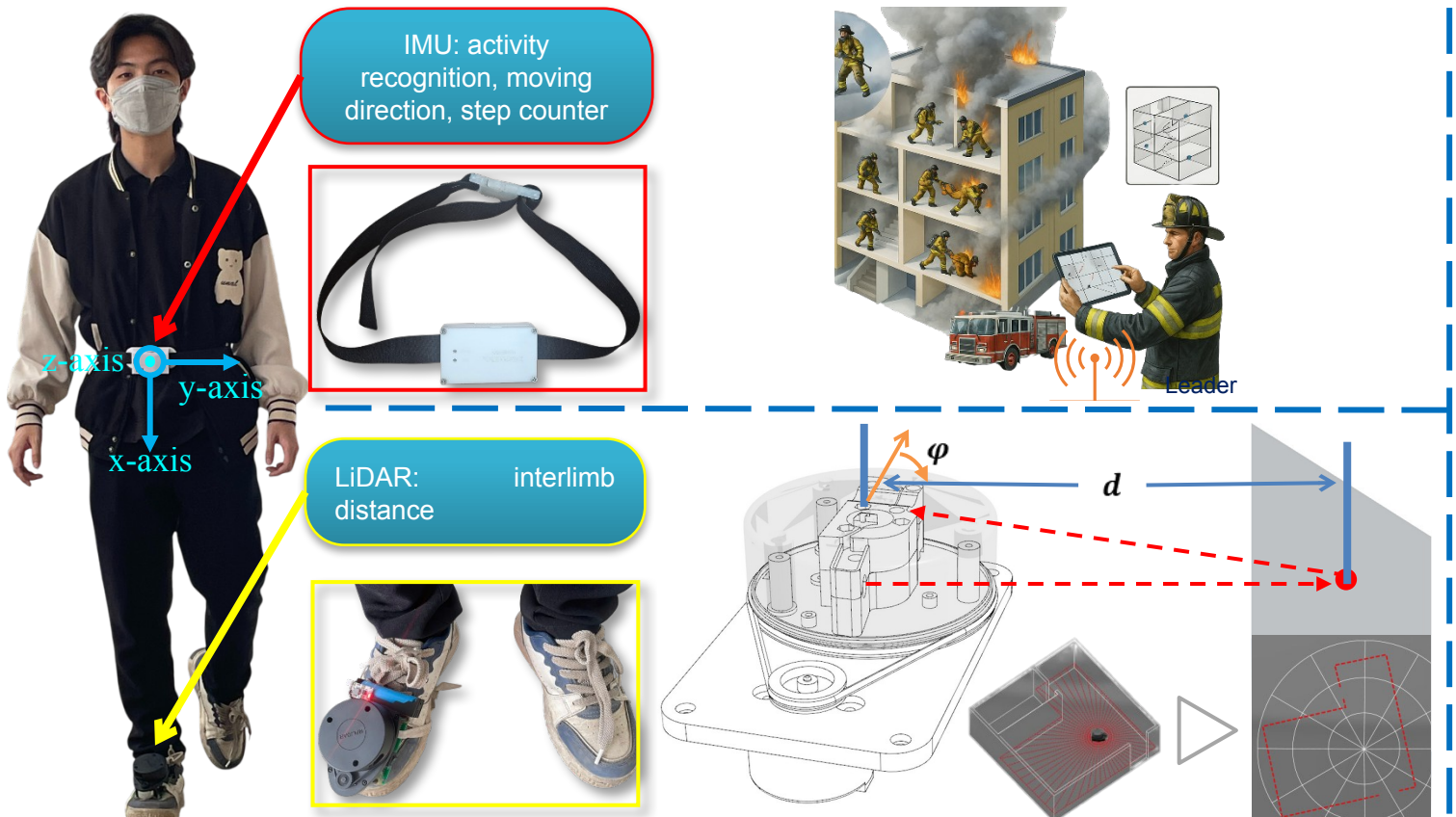


System for recognizing activities of firefighters through a waist-worn device, interacting with the command screen via radio frequency wave

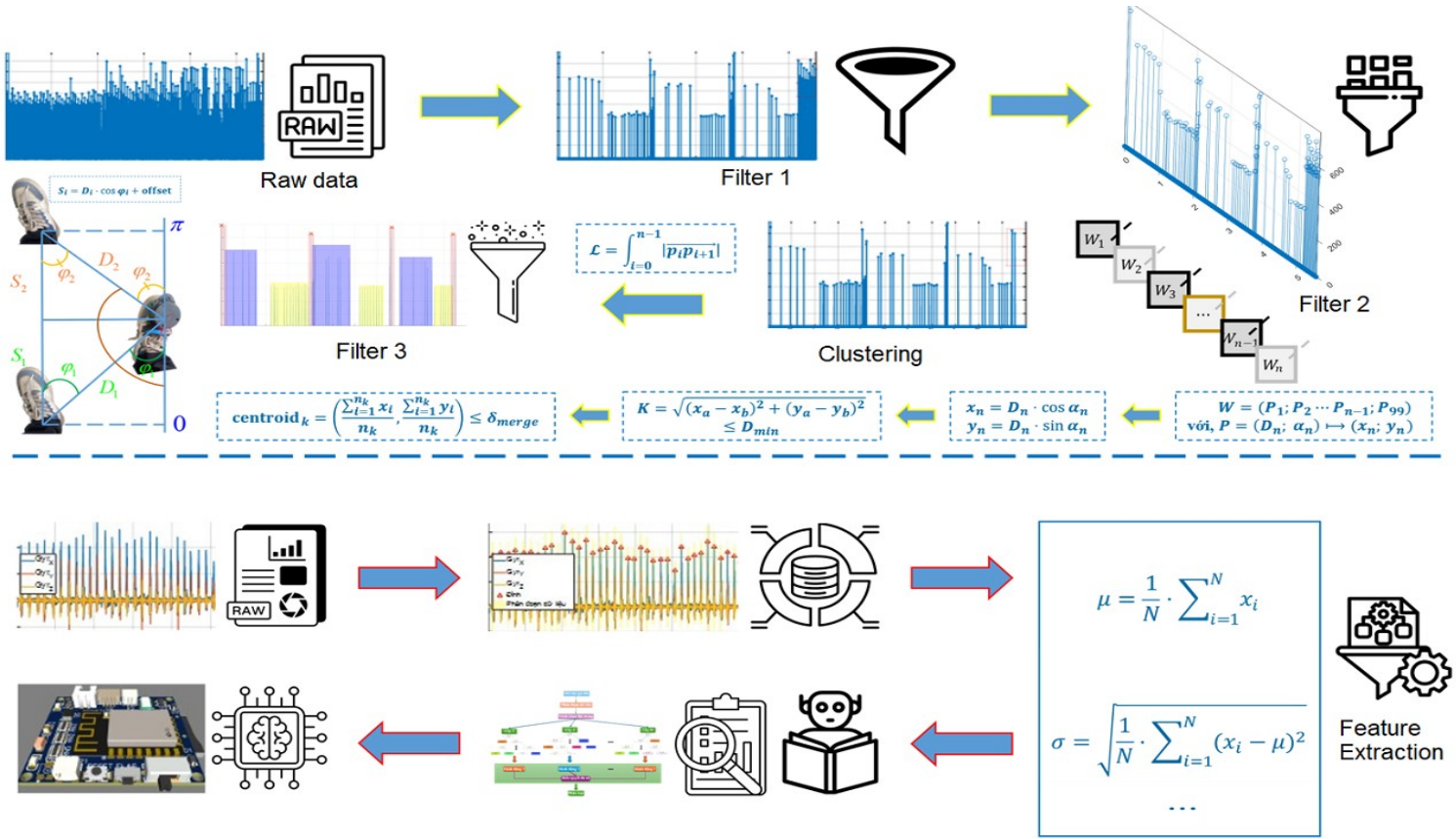
[1] Dao, To-Hieu et. al.(2025). , "RFAR: A Real-time Firefighter Activity Recognition System Using Wearable Accelerometer," in *IEEE Sensors Journal*.

[2] Hong, N. T. T., et. al.(2023). A low-cost real-time IoT human activity recognition system based on wearable sensor and the supervised learning algorithms. *Measurement*, 218, 113231.

Firefighter Positioning and Action Recognition



Firefighter Positioning and Action Recognition

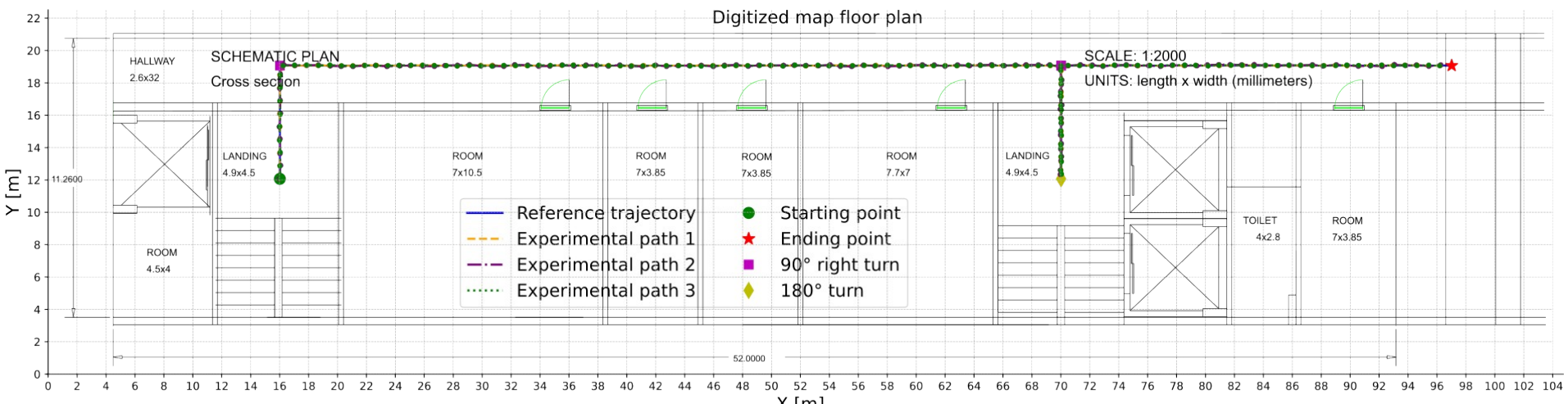


Firefighter Positioning and Action Recognition

Experiment with 130 steps (actual distance 101.5 m)

Trial number	1	2	3	4	5
Estimated distance (m)	101,99	102,23	101,93	102,39	100,79
Error (m)	0,49	0,73	0,43	0,89	0,71

Error per step	
MAE	5,0 cm
SD	4,36 cm



https://www.youtube.com/watch?v=S4hAzgEo-NA

From Lab to Market (Impact & Ecosystem)

Bridging the Gap: From Lab to Market

- **Proven Track Record:** Successfully led multiple National Grants (NAFOSTED, Ministry of Transport, VNU).
- **Intellectual Property:** Granted patents for practical IoT systems.
- **Talent Development:** Mentored 50+ Bachelor theses, 15+ Master theses, and 7 PhD theses (building the next generation of AI/IoT engineers).
- **Leadership:** Head of Faculty of Electrical & Electronic Engineering, Phenikaa University.

Call for International Collaboration

- The Future: Opportunities for Global Collaboration
  - **Joint Research:** Expanding Edge AI and Biomedical IoT applications for global health and climate change.
  - **Academic Exchange:** Establishing PhD pathways and postdoctoral programs
  - **Tech Transfer & Funding:** Partnering with international funds and enterprises to scale low-cost, high-impact technologies in developing countries.

Conclusion

- **Excellent Fundamental Research** in the digital era requires mastering both mathematical algorithms and AI.
- **Bridging** these algorithms with low-cost IoT hardware creates **scalable, practical solutions** for healthcare, agriculture, and disaster management.
- **Vietnam** and Phenikaa University are ready for deep international collaboration.

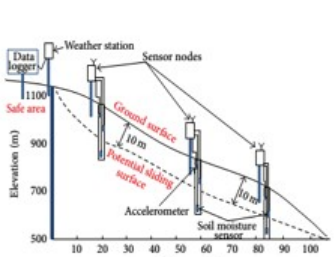
Thank you very much for your attention !

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(a) Inside a sensor node



(b) Sensor node

