Project Title: IoT Road Health Monitoring Platform for Secure Urban Mobility in Smart Communities

Background :

- Urban roads in many ASEAN cities face rapid deterioration due to reactive **and outdated maintenance practices**. Reliance on **manual inspections** and public complaints leads to unsafe roads and disrupted mobility.
- Authorities **lack real-time road health data**. Monitoring focuses on highways while city and local roads are overlooked, causing delays, high repair costs, and safety risks.
- The absence of continuous, reliable road data hinders **secure and smart community development**. Integrating IoT-based IRI measurement and crowdsourced data enables proactive maintenance and sustainable urban mobility.

Targets:

- ✓ Develop an **IoT-based platform** using accelerometer and GPS data for IRI measurement, road defect detection, and maintenance prioritization with real-time deep learning analytics.
- ✓ Build two **Class 3 IRI devices**: a microcontroller-based unit for authorities and a smartphone-based tool for crowdsourced data collection.
- ✓ Deliver an **interactive dashboard** that visualizes road health levels and supports data-driven decisions for safer, smarter, and more sustainable urban mobility.

Speaker:
Hadyan Hafizh
School of Computing and Artificial Intelligence
Sunway University, Malaysia

Project Title: IoT Road Health Monitoring Platform for Secure Urban Mobility in Smart Communities

Project Members :

Name	Institution
Hadyan Hafizh	Sunway University, Malaysia
Rosdiadee Nordin	Sunway University, Malaysia
Anwar P.P. Abdul Majeed	Sunway University, Malaysia
Febri Zukhruf	Institut Teknologi Bandung, Indonesia
Lihour Nov	Cambodia Academy of Digital Technology, Cambodia
Ah Nge Htwe	University of Computer Studies Yangon, Myanmar
Ye Naing	University of Computer Studies Yangon, Myanmar
Nay Win Aung	University of Computer Studies Yangon, Myanmar
Zin May Oo	University of Computer Studies Yangon, Myanmar

Project Duration : 24 Months

Project Budget: USD 45,020

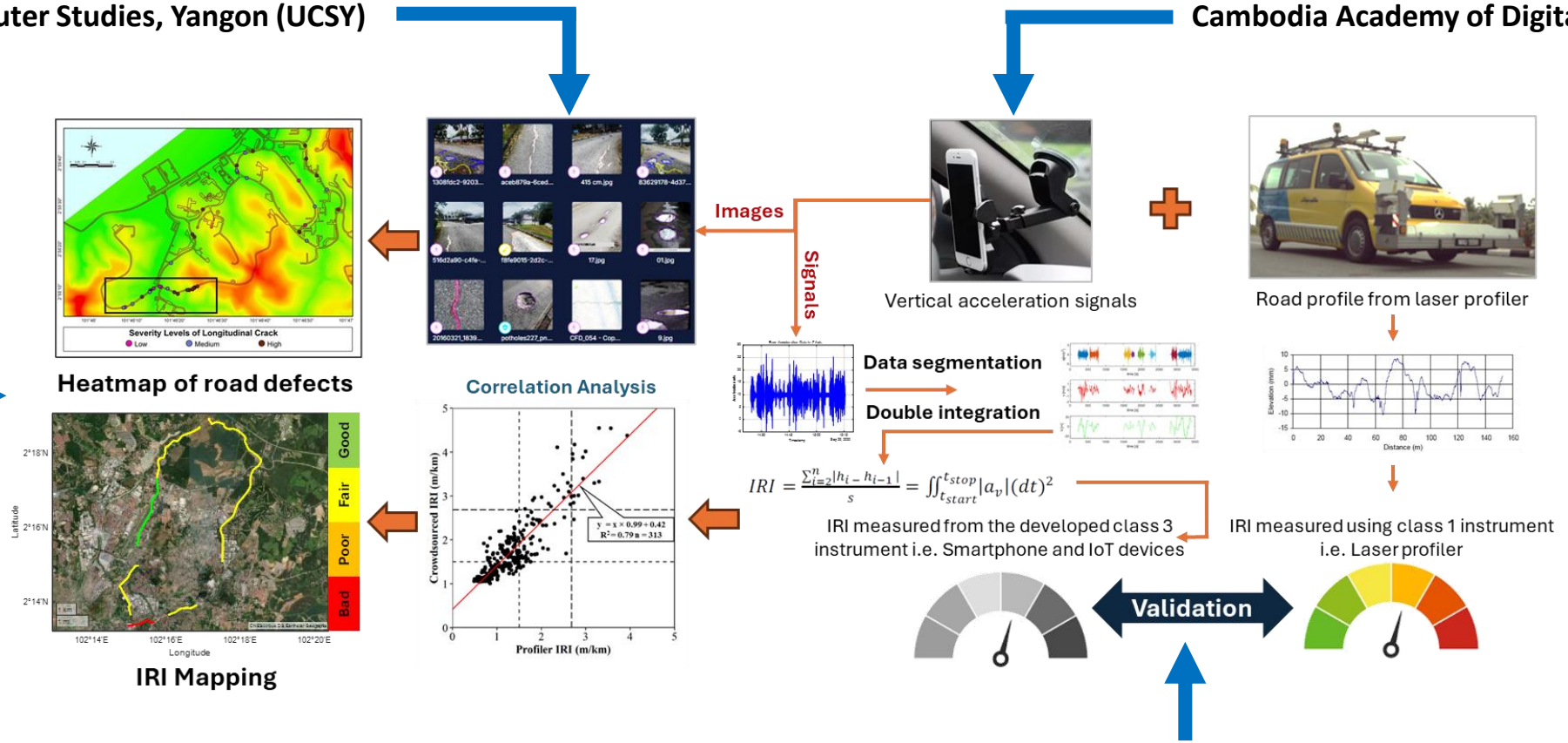
Project Activities: Task Distribution and Assignment

- Develop **deep learning models** for real-time road defect classification.
- Perform **model evaluation and validation** for real-time deployment in smartphone-based IoT devices.

University of Computer Studies, Yangon (UCSY)

- Develop **microcontroller-based IoT devices** for IRI measurement.
- Integrate state-of-the-art **wireless communication** for long-range, low-power data transmission.

Cambodia Academy of Digital Technology (CADT)



Sunway University (SU)

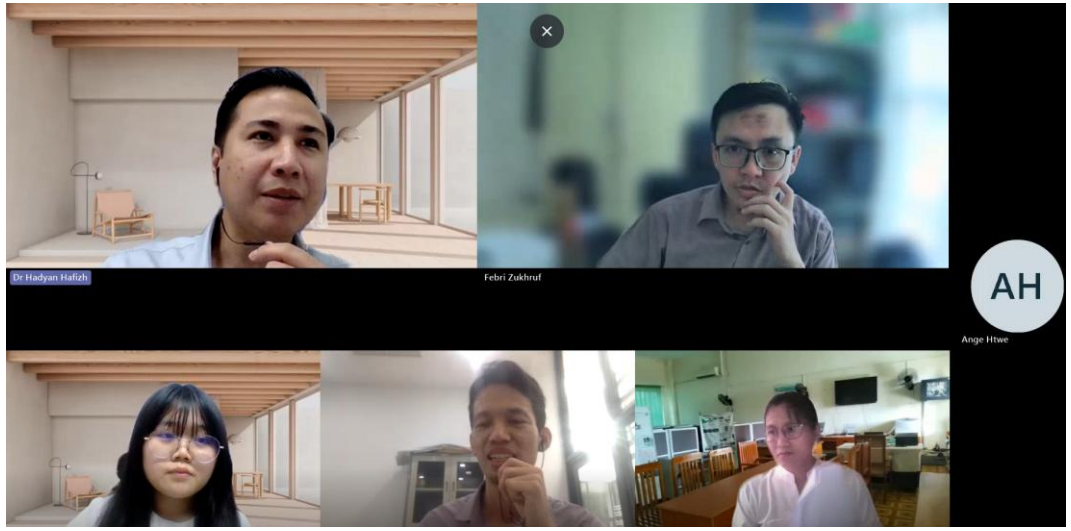
- Develop **vision-based AI devices** for road defect recognition
- Develop **smartphone-based IoT devices** for IRI measurement.

Institut Teknologi Bandung (ITB)

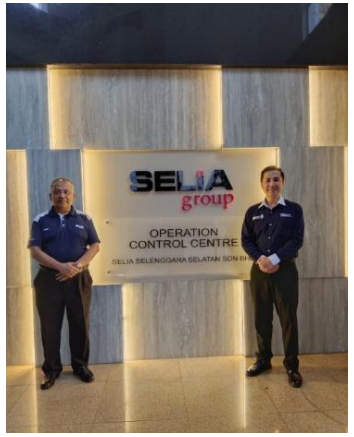
- Perform **data validation** and **field testing** with Class 1 instrument.
- Provide **civil engineering expertise** for road maintenance standards and workflows.

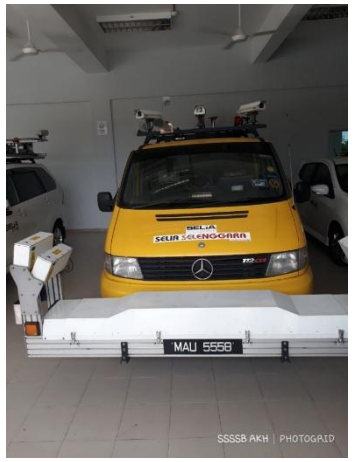
Project Activities: Meetings and Stakeholder Consultation

Technical Meetings (SU, ITB, CADT, UCSY)



Company Visit (SU, Malaysia)





SELIA SELENGGARA SELATAN SDN BHD is the federal road concession holder for the southern region of Peninsular Malaysia.

Project Activities: AI Model Development and Data Collection (UCSY)







Dataset Information

- Training Set: 139 images
- Validation Set: 40 images
- Test Set: 20 images

Parameter	Value
Number of Classes	4
Class Names	0: 'Alligator Cracks'
	1: 'Lateral Cracks'
	2: 'Longitudinal Cracks'
	3: 'Pothole'

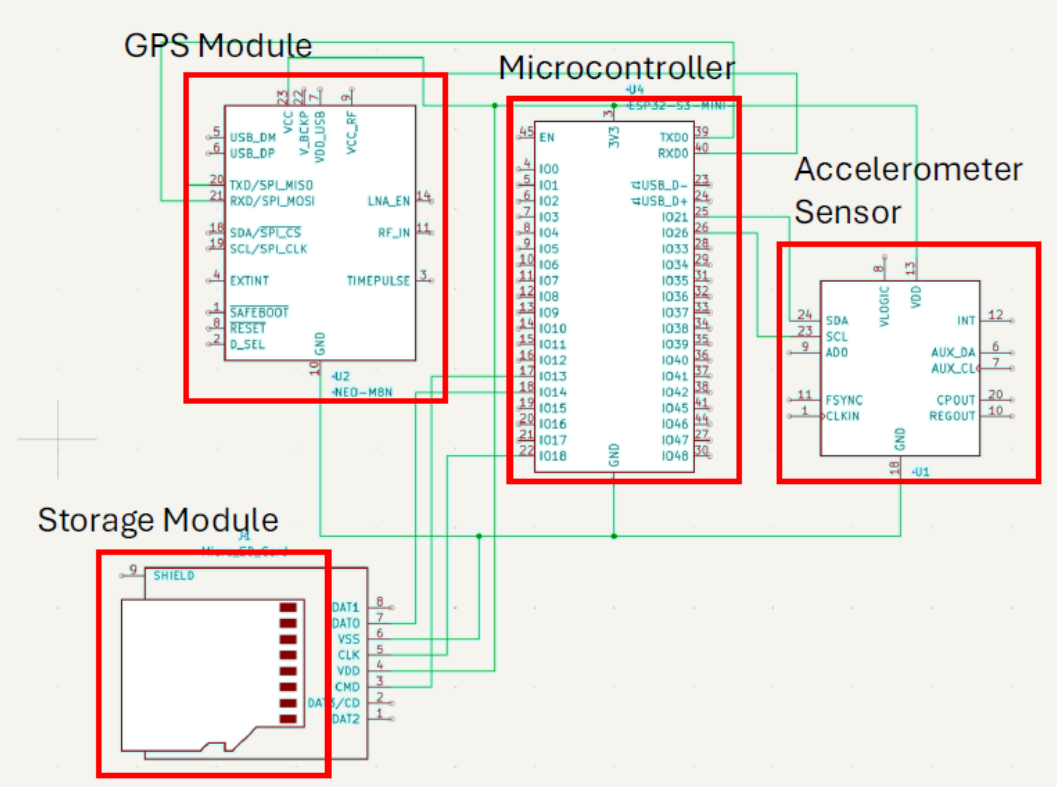
Tools

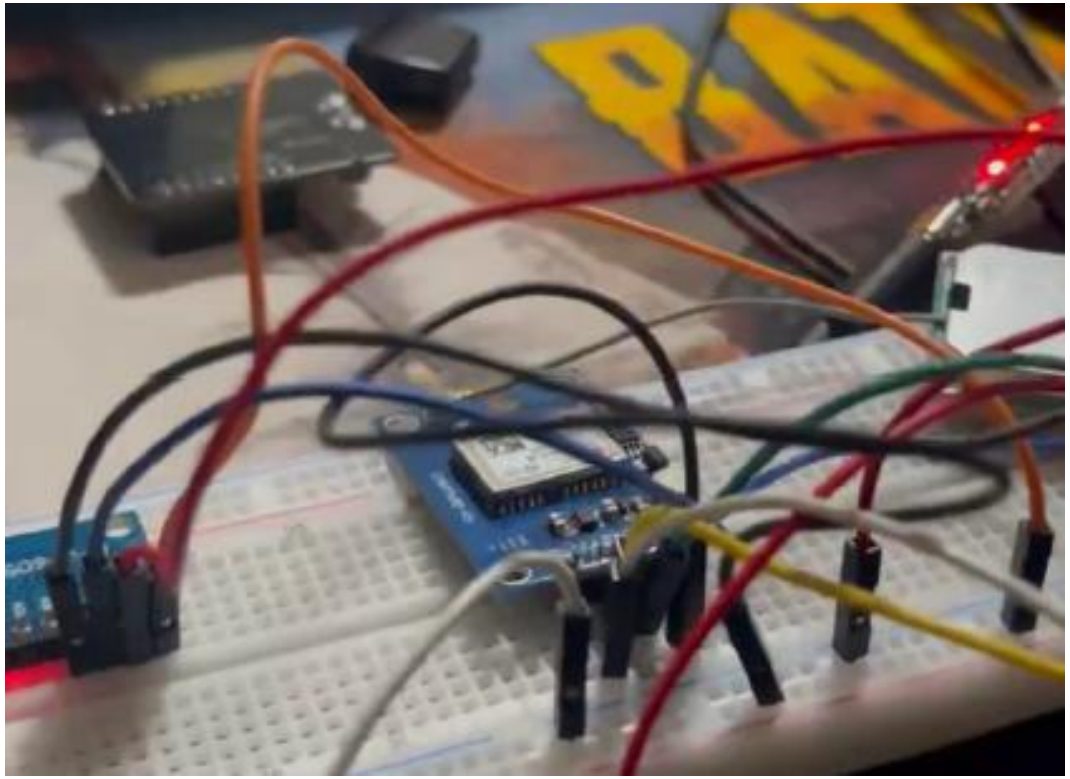
ultralytics YOLOv8

python™

Google colab

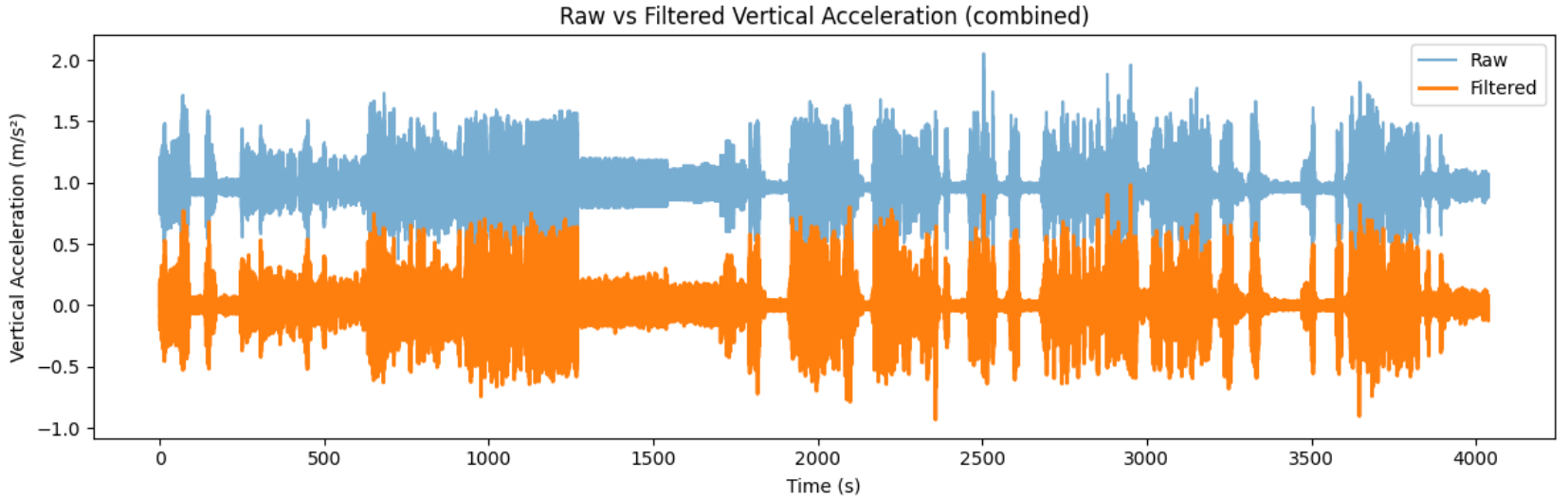
Project Activities: IoT Prototype Development & Lab Testing (CADT)

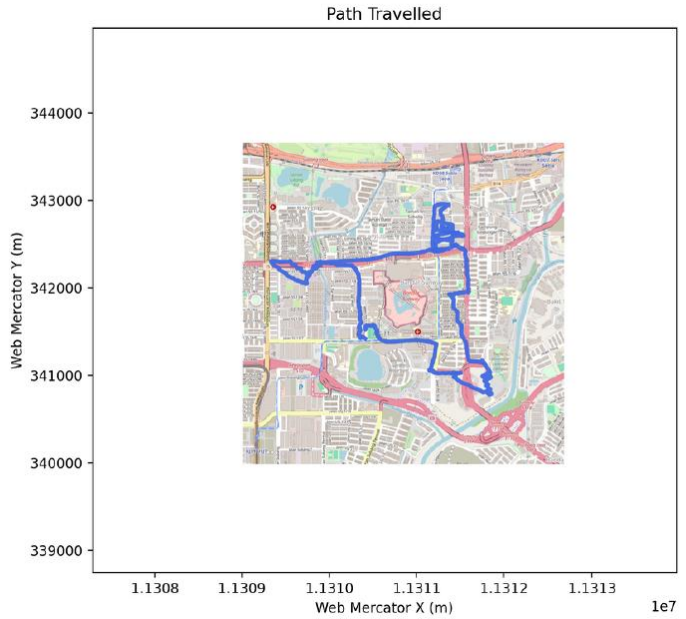




- CADT leads the development of the microcontroller-based Class 3 prototype for International Roughness Index (IRI) measurement.
- Prototype built on ESP-series microcontroller with integrated accelerometer and GPS modules.

Project Activities: AIoT Platform Development & Field Testing (SU)

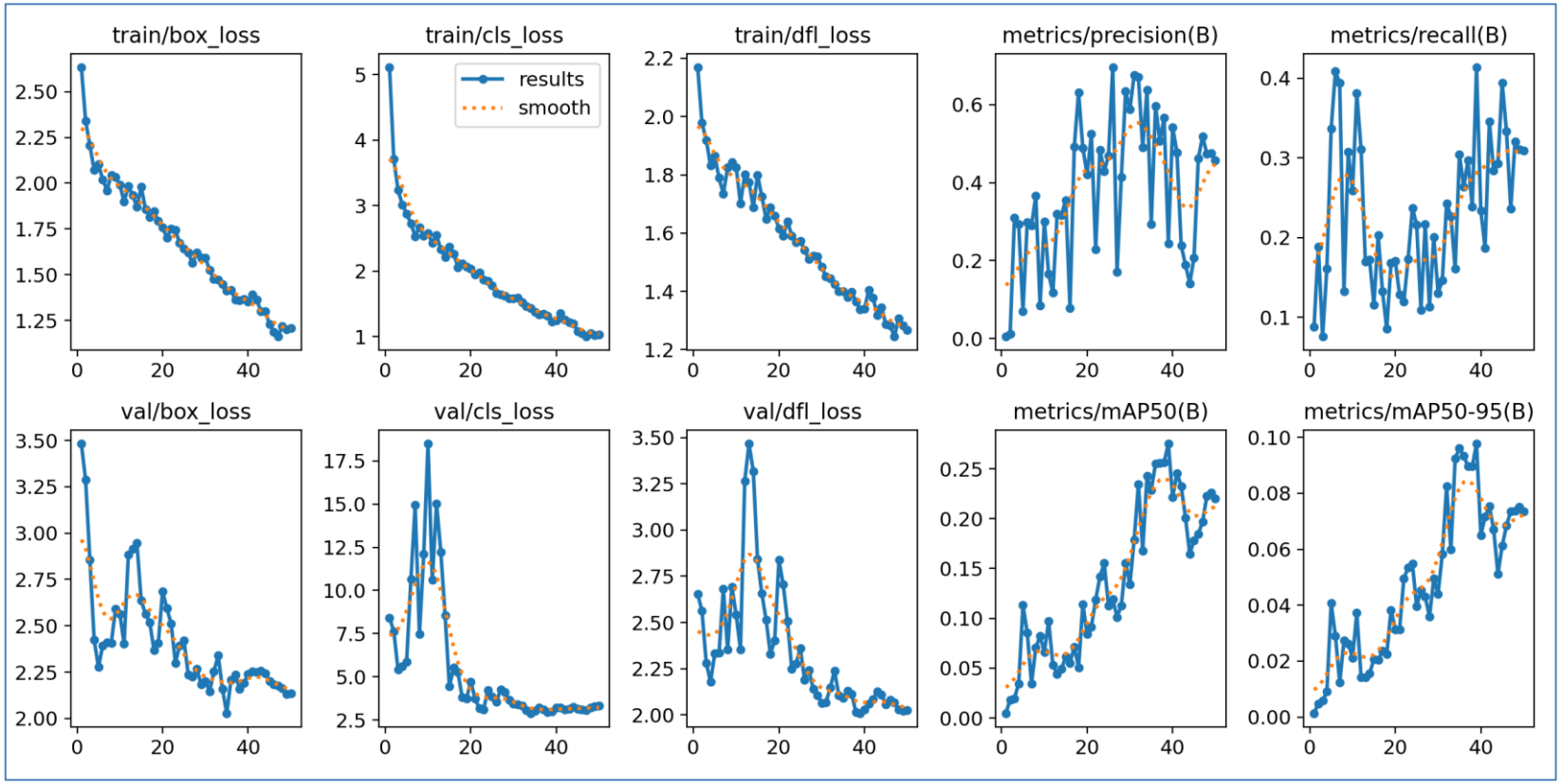


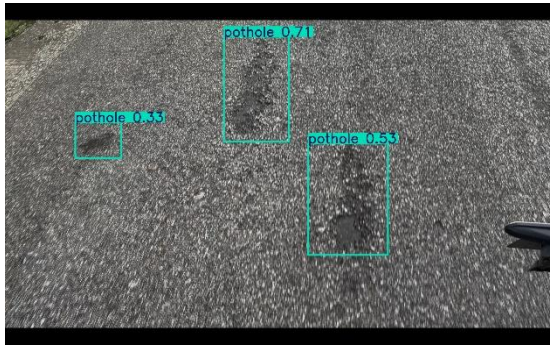


- **Aim:** To evaluate the current app's performance in detecting and recording road surface roughness under real driving conditions.
- **Route:** Sunway University to Bandar Sunway, covering smooth and uneven road segments.
- **Duration:** ± 1 hour of continuous data collection.
- **Data & Setup:** Collected accelerometer (x, y, z), GPS, timestamps, and speed, with the smartphone mounted on the air vent for stability.

R&D results: AI Model Development (UCSY)

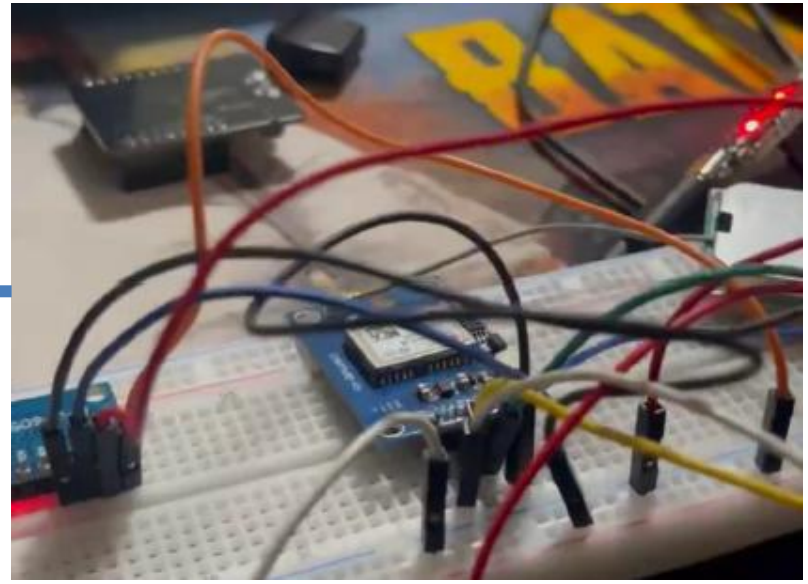
```
Ultralytics 8.3.205 🚀 Python-3.12.11 torch-2.8.0+cu126 CPU (Intel Xeon CPU @ 2.20GHz)
Model summary (fused): 72 layers, 11,127,132 parameters, 0 gradients, 28.4 GFLOPs
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%
                   all         40         79      0.243      0.415      0.275      0.096
       Alligator Cracks         10         12      0.099      0.583      0.263     0.0903
         Lateral Cracks          5          6      0.406       0.24      0.263     0.0925
    Longitudinal Cracks         23         34      0.199      0.206      0.164     0.0753
                pothole         17         27      0.269       0.63      0.411      0.126
```





R&D results: IoT Prototype Development (CADT)

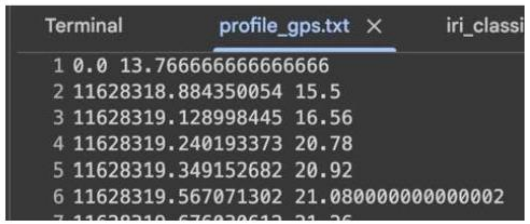
- The prototype was mounted on a test vehicle to evaluate performance under real driving conditions.
- Road profile data were collected along a designated route by recording accelerometer and GPS readings.



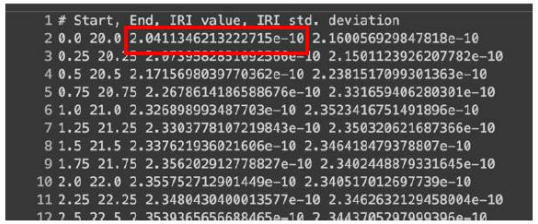
Data Acquisition

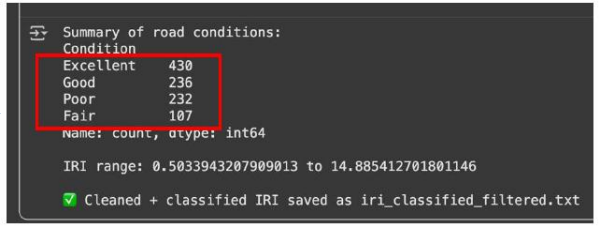
A1 Latitude

	A	B	C	D	E	F	G
1	Latitude	Longitude	Altitude	Speed	AccelX	AccelY	AccelZ
2	0	0	0	0	-1.61	-0.26	-9.65
3	11.508646	104.88189	20.6	0.15	-1.6	-0.26	-9.6
4	11.508645	104.881888	20.7	0.28	-1.6	-0.26	-9.59
5	11.508646	104.881888	20.7	0.2	-1.61	-0.27	-9.6
6	11.508646	104.881887	20.8	0.2	-1.6	-0.25	-9.59



Extracted GPS Profile for Subsequent IRI Calculation

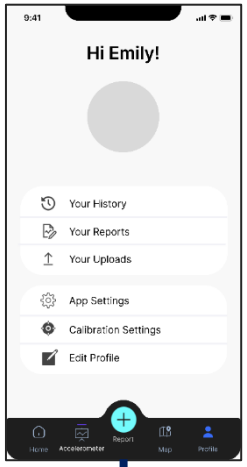




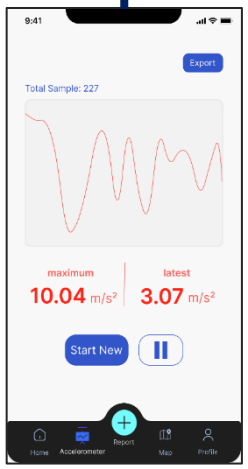
Computed IRI Values to Categorize Road Surface Condition

R&D results: Scalable AIoT Platform for Crowdsensing (SU) - 1

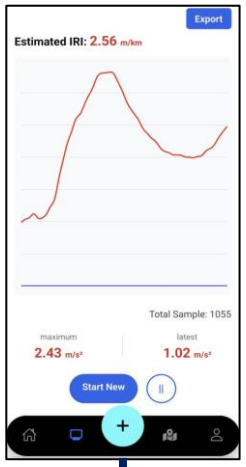
IoT Sensors



User Profile Page

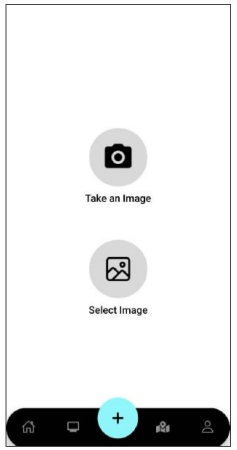


Accelerometer Calibration Page

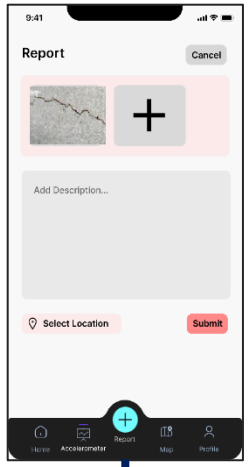


IRI Value and Display Page

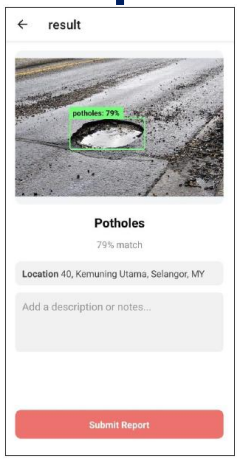
AI Model



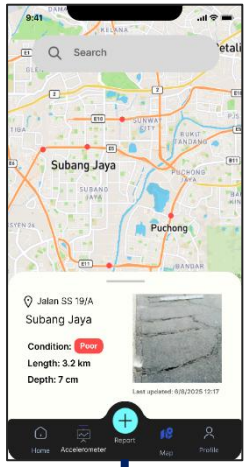
Capture or Select Image



Defect Reporting Page



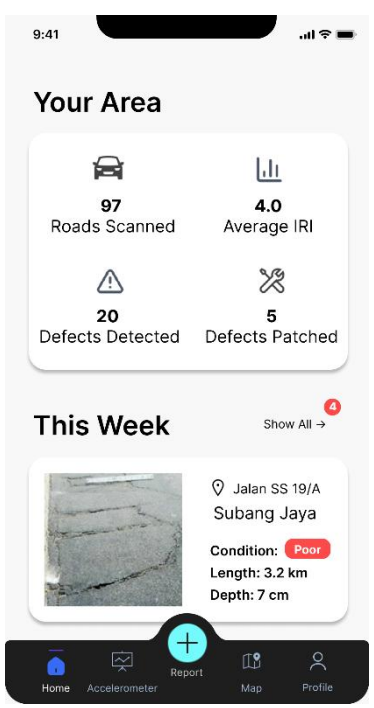
Detection Result Page



Map and Location Page

R&D results: Scalable AIoT Platform for Crowdsensing (SU) - 2

Homepage



CONTAINERIZATION

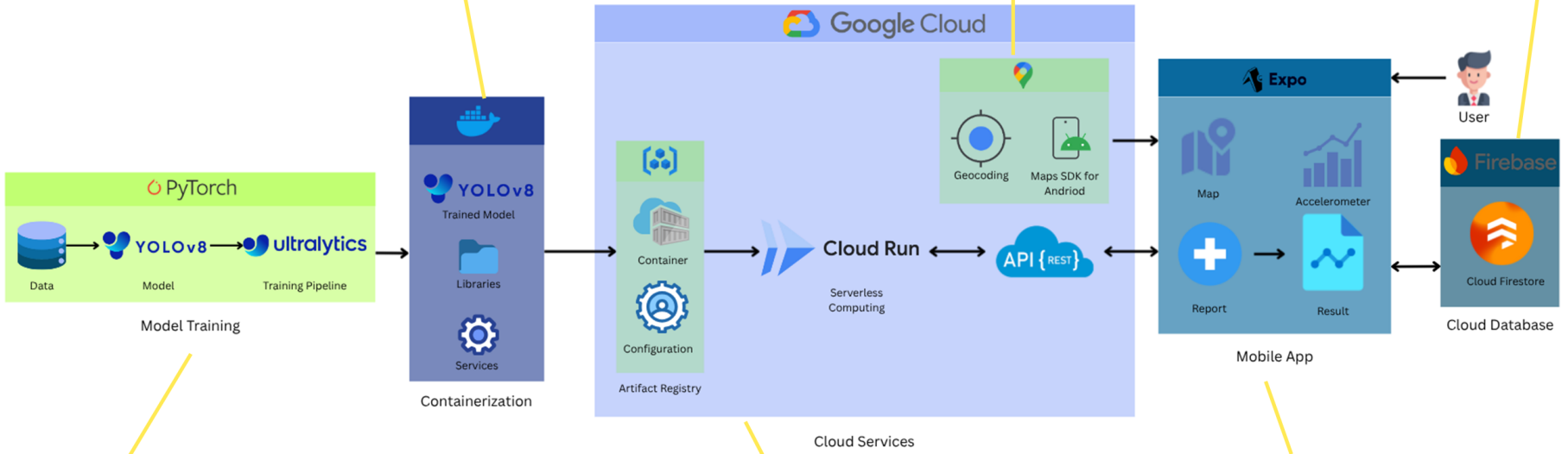
The trained YOLOv8 model, along with required libraries and services, is containerized using Docker for portability and efficient deployment.

GOOGLE MAP SDK

Cloud functions integrate geolocation services to map detected road anomalies onto real-world coordinates.

CLOUD DATABASE

Collected sensor data and processed results are stored in Firestore for centralized, real-time data management.



MODEL TRAINING

Road defect images are used to train a YOLOv8 model using the Ultralytics framework in PyTorch for object detection and classification (e.g., potholes, cracks).

CLOUD SERVICES

The container is uploaded to Google Cloud's Artifact Registry and deployed on Cloud Run, enabling serverless, scalable inference.
The REST API serves detection results to the mobile app.

MOBILE APP

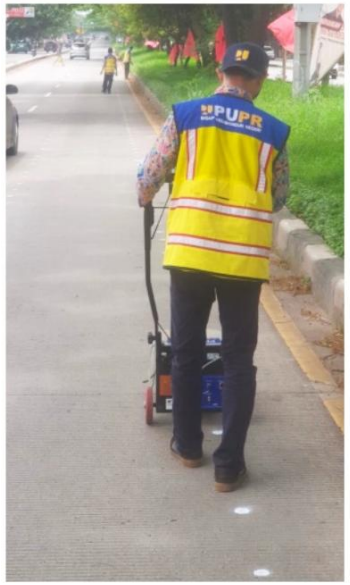
The app captures accelerometer, GPS, and image data, displaying the map interface and detection results to the user.
Users can visualize road roughness levels and road defects location.

Next Step: Data Validation (ITB)

Road IRI Measurement with ROMDAS

No	Item	Unit	
1	Survey Equipment Rent	45 km	2 lane
2	Operational Cost	3 persons	2 days
3	Car rental	1 unit	2 days

18-Jan
Arrival (SU, CADT, UCSY)
19-Jan
Data Collection Day 1 with ROMDAS
20-Jan
Data Analysis and Validation
21-Jan
Evaluation and Optional Data Re-Collection
22-Jan
Departure



Sample Road Data Collection Activity by **PT. Nusa Antara Jayatama**

Scientific Contribution

Presentations at International Conferences:

No	Paper title	Author names	Affiliation	Conference name	The date of the conference	The venue of the conference
1	AIoT Platform for Intelligent Road Defect Recognition with Smartphone and Edge Vision	[1]Hadyan Hafizh, [2]Yee Zhing Liew, [1]Gan Caqin, [1]Anwar PP Abdul Majeed, and [1]Rosdiadee Nordin	[1]School of Computing and Artificial Intelligence, Sunway University, Bandar Sunway 47500, Selangor, Malaysia [2]School of Intelligent Manufacturing Ecosystem, Xi'an Jiaotong-Liverpool University, Taicang Street, Suzhou, 215412, China	The 3rd International Conference on Intelligent Manufacturing and Robotics (ICiMR 2025)	11 – 12 November 2025	Sunway University, Malaysia

Societal Impact

- The automated AIoT system enables a transition from reactive to predictive road maintenance, improving infrastructure efficiency.

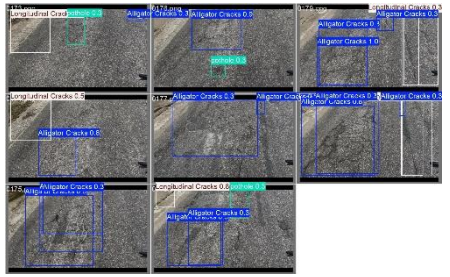
- By providing data-driven insights for repair prioritization, municipal authorities can allocate resources equitably and enhance urban mobility.

- Improved road quality enhances public safety, reduces road-related accidents, and lowers vehicle repair and fuel costs, promoting safer, secure, and more sustainable transport.

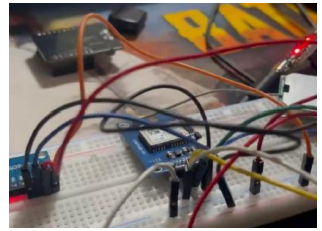
- The road defect image dataset, collected by the project team and through crowdsourcing, will be publicly shared on the Roboflow platform to promote open research and innovation in intelligent road monitoring

Conclusion

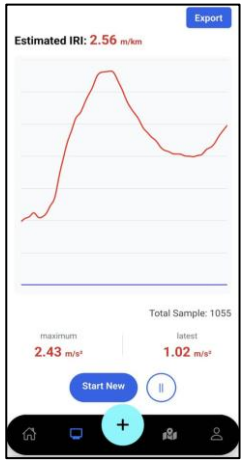
- Benchmarked and deployed a YOLOv8 deep learning model on Google Cloud Run, achieving real-time defect classification with high accuracy and low latency, confirming the feasibility of the serverless, container-based architecture. (UCSY, Myanmar)

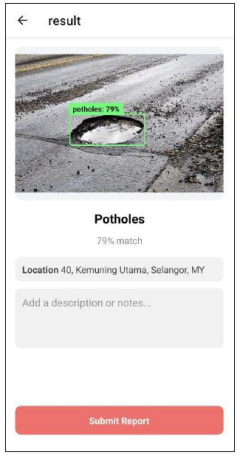


- Developed and tested a class 3 instrument for IRI measurement by means microcontroller equipped with accelerometer sensors and GPS module. (CADT, Cambodia)



- Integrate the IoT sensors data with AI model through the developed and tested a fully operational end-to-end pipeline AIoT platform for passive and active crowdsourced road condition data collection through a dual-function mobile app for road roughness sensing and defect reporting. (SU, Malaysia)





- Established a scalable framework for automated road defect detection and IRI data integration, forming the foundation for future inclusion of edge vision data streams and validation with class 1 instrument. (ITB, Indonesia)

Future works

Phases	PIC	Year 1			Year 2			
		Q2	Q3	Q4	Q1	Q2	Q3	Q4
		4-6	7-9	10-12	13-15	16-18	19-21	22-24
Requirement analysis and stakeholders' consultations	All							
Design of IoT devices and DL Model								
Microcontroller-based class 3 instrument design and configuration	CADT							
Smartphone-based class 3 instrument design and development	SU							
Deep learning model development	UCSY							
System integration and laboratory testing	All							
Testing and Validation								
Validation of both developed class 3 instrument with class 1 instrument at Bandung, Indonesia	SU+ITB							
Correlation analysis	All							
IRI calculation and map generation	All							
Validation of both developed class 3 instrument with class 1 instrument at Melaka, Malaysia	All							
Crowdsourced Data Collection								
Use case 1 (at Sunway City, Malaysia)	SU							
Use case 2 (at Bandung city, Indonesia)	ITB							
Impact analysis and project completion	All							

85%

Visit to Road Maintenance Company in Malaysia and Indonesia

Developed and tested ESP32-based IRI measurement devices

Developed and tested an AIoT platform for sensing and defect reporting

Trained and tested a YOLOv8-based model for defect recognition

Deployed a fully functional AIoT pipeline for defect reporting

Future Works:

- **Validation with Class 1 Instrument** will be conducted in **Bandung, Indonesia** in **January 2026** to verify the accuracy and reliability of the developed IoT-based IRI measurement system.
- **Crowdsensing Use Case Deployment** will be carried out at **Sunway University, Malaysia**, and **Institut Teknologi Bandung, Indonesia**, to evaluate real-world performance, user participation, and data quality in diverse urban environments.