Project Title: Context-Aware Disaster Mitigation using Mobile Edge Computing and Wireless Mesh Network

Background :

Natural disasters occur frequently around the world. Internet of things (IoT) sensors can detect such cataclysmic events and initiate rescue actions. In existing IoT framework, data are transmitted to the remote cloud via wired connection for further analysis. Several issues remain to be addressed, including massive deployment effort, unavailability of vicinity communication infrastructure, data transfer over limited bandwidth, high latency in communication networks, and redundancy in disaster content.

Targets:

To develop a context-aware disaster mitigation system (CAMS) that utilizes mobile edge computing (MEC) and wireless mesh network powered by NerveNet. Specifically, the overall project goal can be divided into:

1. Edge-Level Disaster Detection
2. Mesh-Network Database Synchronization
3. Evacuation Route Strategy Optimization

Speaker:

Ir. Dr. Tham Mau Luen @ Universiti Tunku Abdul Rahman, Malaysia

Project Title: Context-Aware Disaster Mitigation using Mobile Edge Computing and Wireless Mesh Network

Project Members :

Name	Institution	Name	Institution
Ir. Dr. Tham Mau Luen	UTAR, Malaysia	**Dr. Yasunori Owada**	NICT, Japan
Ir. Dr. Chang Yoong Choon	UTAR, Malaysia	**Dr. Goshi Sato**	NICT, Japan
Ts. Dr. Ezra Morris	UTAR, Malaysia	**Mr. Hachihei Kurematsu**	BHN Association/JTTA, Japan
Dr. Lee Ying Loong	UTAR, Malaysia	**Mr. Nobuyuki Asai**	Ready Affiliate Japan Co., Ltd, Japan
Mr. Lim Wei Sean	UTAR, Malaysia	**Prof. Myint Myint Sein**	UCSY, Myanmar
Mr. Teoh Han Wei	UTAR, Malaysia	**Prof. Thin Lai Lai Thein**	UCSY, Myanmar
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Dr. Tuan Ahmad Zahidi Tuan Abdul Rahman	MIMOS, Malaysia	**Ms. Emmon Maw**	UCSY, Myanmar
Mr. Sakda Sakorntanant	PIT, Thailand	**Dr. Suvit Poomrittigul**	PIT, Thailand

Project Duration :

1st April 2020 to 31st March 2022

Project Budget:

$80,000

Project Activities: Budget Plan (Year 1 & Year 2)

Year 1

Party	Purpose	Amount	Remark
NICT	• LoRaPi-HAT • GPS	¥ 494,450	Spent
UTAR	• Bus IoT Node • Building NerveNet Node • NerveNet Gateway • Workstation	RM 117,730.30	Spent
PIT	• Workstation for JGN	THB 62,070	Spent
UCSY	• Workstation for JGN	$ 2,150	Spent
	TOTAL	**~ $ 36,786**	Completed

Year 2

Title	Purpose	Amount	Remark
UCSY	• International Conference	$ 407.24	Spent
	TOTAL	**$ 407.24**	Subject to further budget planning

Project Activities: Project Timeline (Jan – June 2021)

Party	Schedule	Task Description	Remark
UTAR/NICT/BHN	Jan - June 2021	• Setup NerveNet-Wi-Fi testbed • Synchronize image among NerveNet base stations using Wi-Fi	• Done
UTAR/MIMOS		• Fine-tune trained disaster classification model • Optimize the trained model for edge computing	• Done
UCSY/UTAR		• Develop evacuation route estimating method based on Dijkstra algorithm • Collect data including locations of road, street and road conditions	• Done

UTAR/PIT		• Develop backend service of disaster monitoring dashboard
		  • MQTT for NerveNet node status and number of victims
		  • HTTP for detected disaster image
			• Done

Project Activities: Project Timeline (July – Dec 2021)

Party	Schedule	Task Description	Remark
UTAR/NICT/BHN	July - Dec 2021	• Setup NerveNet-LoRa testbed using docker • Synchronize image among NerveNet base stations using LoRa	• In Progress (70 %)
UTAR/MIMOS		• Develop a joint disaster classification and victim detection using multi-task learning • Attach a disaster classification head model to the backbone of a victim detection model	• Done
UCSY/UTAR		• Evaluate the performance of the proposed route strategy • Develop a web application for visualization	• Done

UTAR/PIT		• Develop frontend service of disaster monitoring dashboard
		  • Location map display
		  • Camera footage
			• Done

R&D results: Goal 1: Edge-Level Disaster Detection

Result 1:

- A disaster classification model was trained using VGG-16 to classify one of the following four disasters: (1) Wildfire, (2) Flood and (3) Earthquake (4) Cyclone.
- To achieve edge computing, OPENVINO was adopted to optimize the inference performance of the trained model.
- As shown in figure 1, by running the inference pipeline asynchronously, the speed was able to achieve up 13.2 frames per second (FPS), which is 2x faster than the original model.

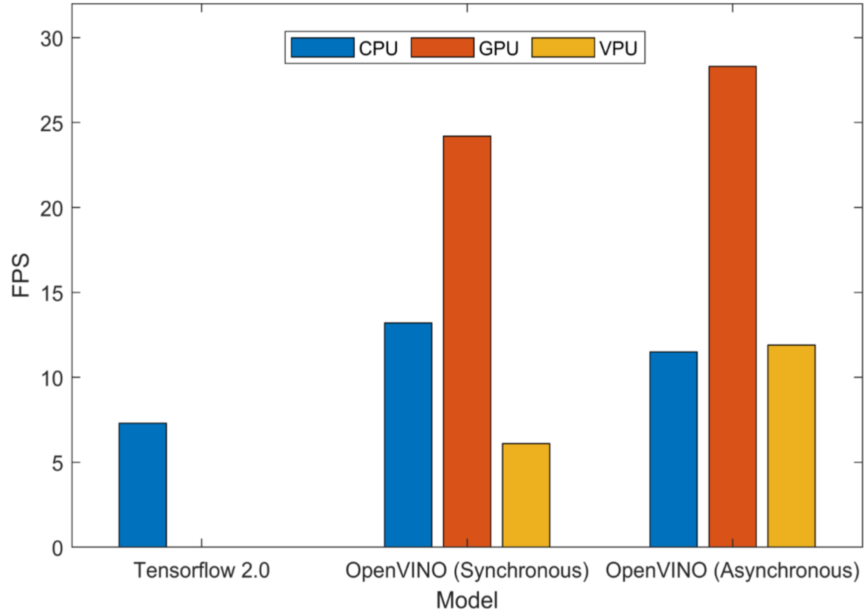


Figure 1. FPS comparison among classification models

VPU (Vision Processing Unit) Movidius Myriad X

R&D results: Goal 1: Edge-Level Disaster Detection

Result 2:

- Result 1 did not consider the detection of victims.
- To this end, a YOLO-based multi-task model which jointly performs disaster classification and victim detection was designed and developed.
- Results reveal that the solution achieves up to 0.6938 and 20.31 in terms of average precision and FPS.
- Figure 2 demonstrates that the person detection is feasible for small target objects.

(a) (b) (c)

Figure 2. Victim detection at different areas. (a) Flood. (b) Landslide. (c) Earthquake.

R&D results: Goal 2: Mesh-Network Database Synchronization

Result 3:

- Figure 3 shows the NerveNet-Wi-Fi setup consisting of two base stations and one Gateway.
- Figure 4 compares the time taken for each image to be synchronized in both BS1 and BS2 .

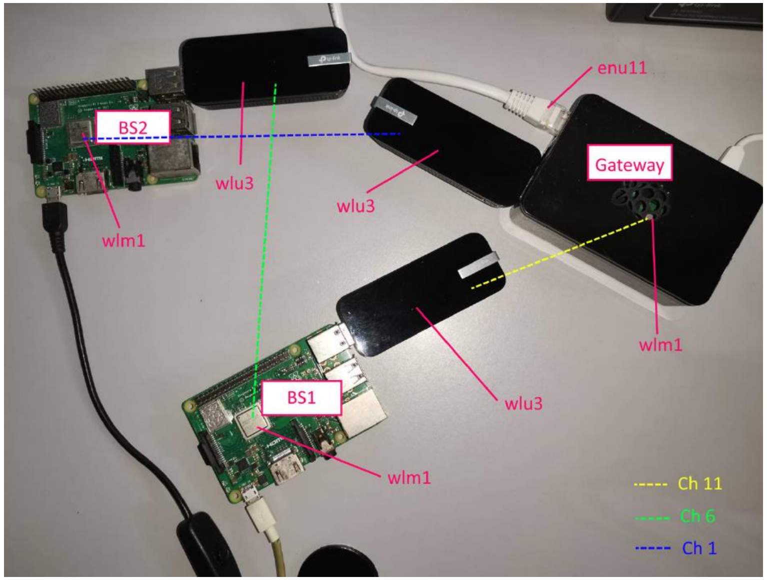


Figure 3. NerveNet testbed.

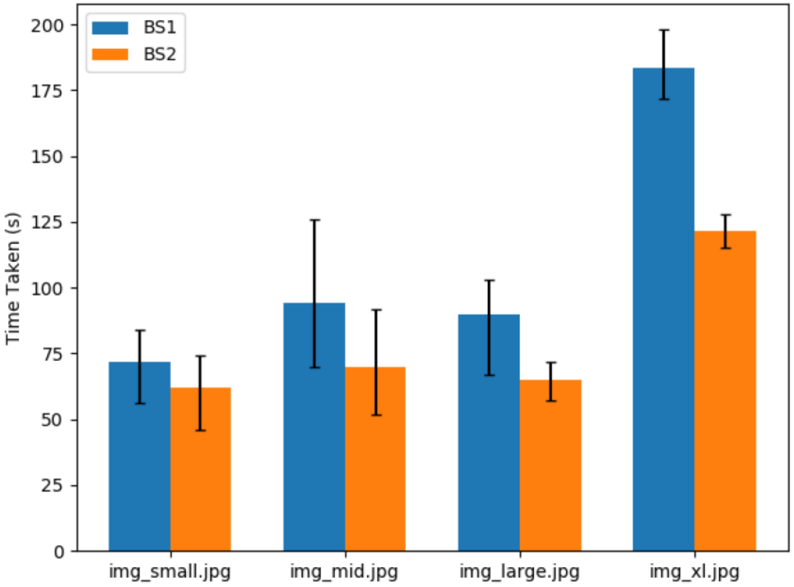


Figure 4. Time taken for different sized images to be synchronized from GW to BS1 and BS2 Respectively.

R&D results: Goal 2: Mesh-Network Database Synchronization

Result 4:

- A monitoring dashboard called “NerveDASH” was developed.
- Figure 5 displays the screenshot of NerveDASH.

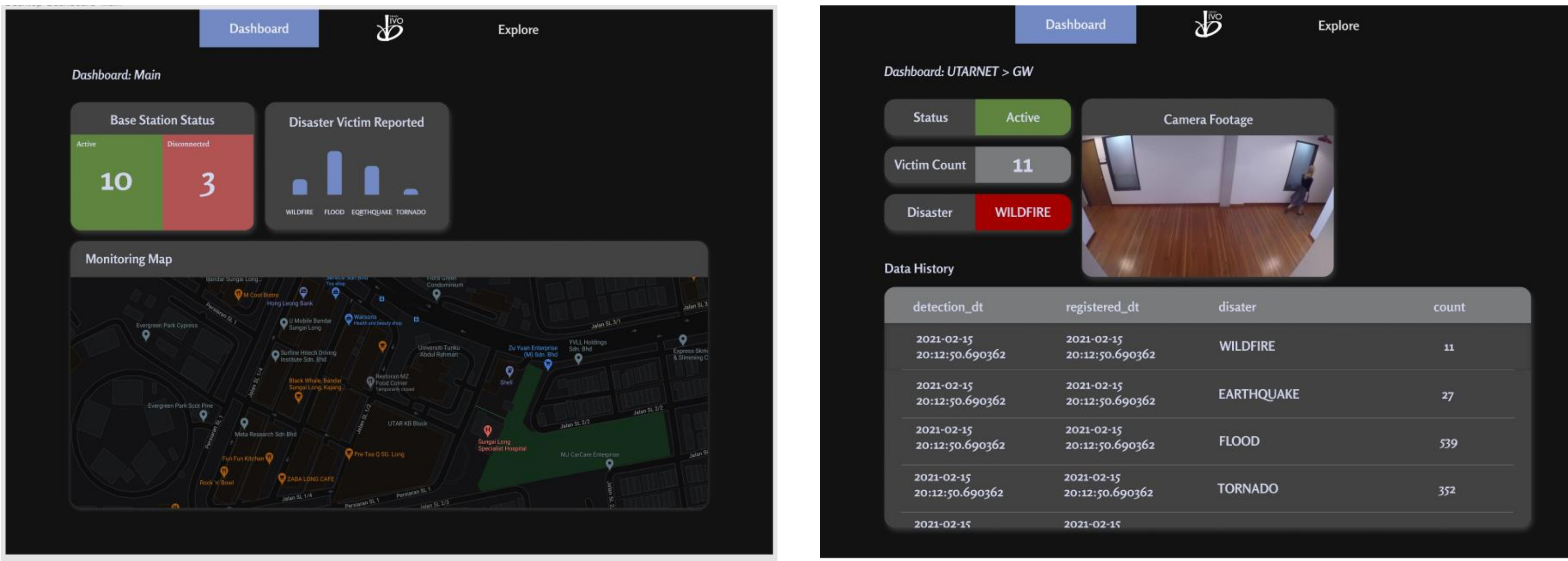


Figure 5. NerveDASH system.

R&D results: Goal 3: Evacuation Route Strategy Optimization

Result 6:

- Figure 6 shows the proposed optimal route-finding system.

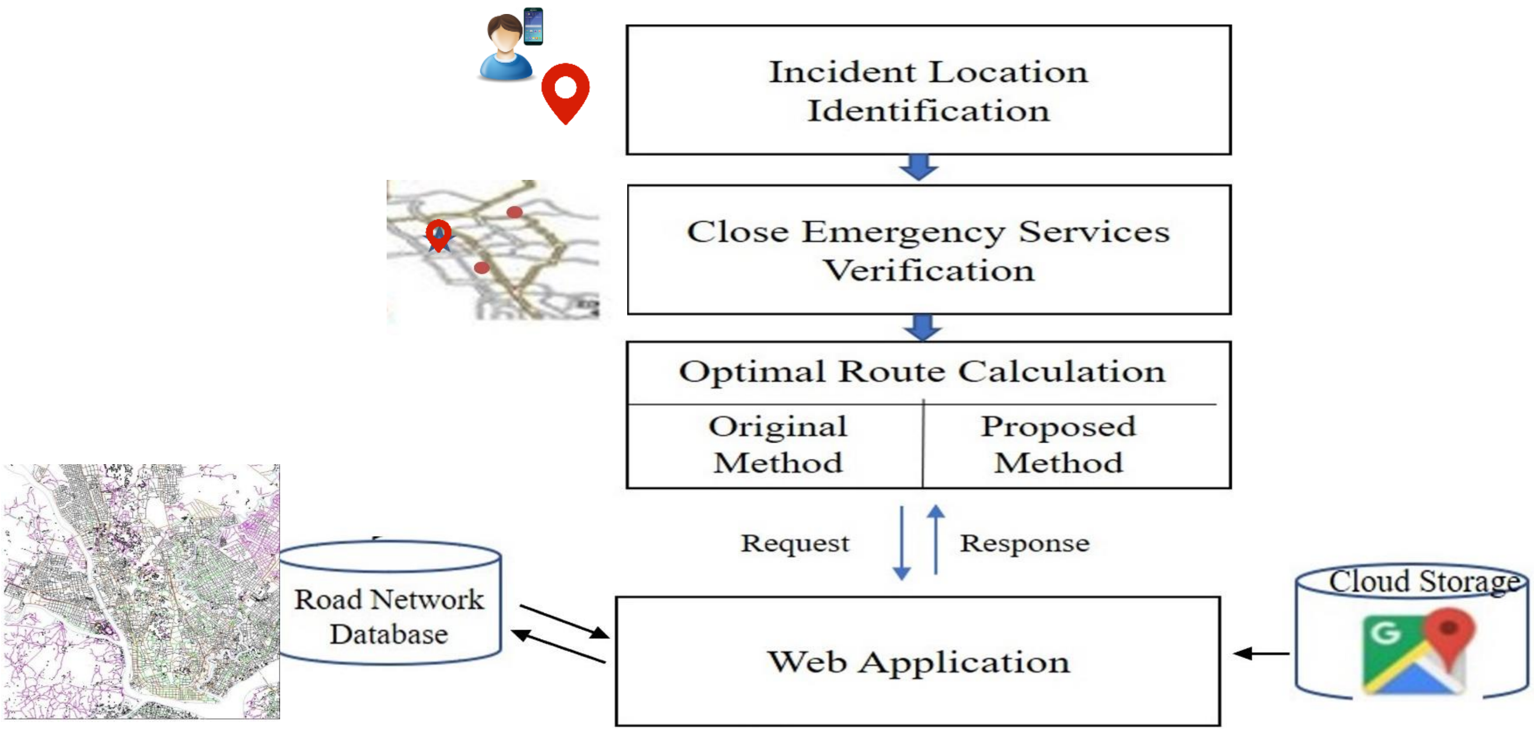
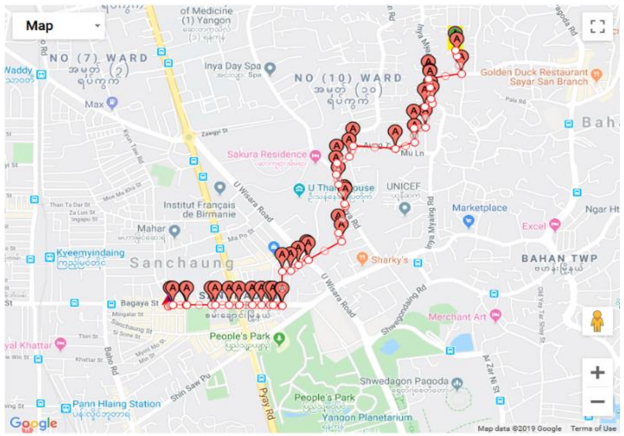


Figure 6. Proposed System

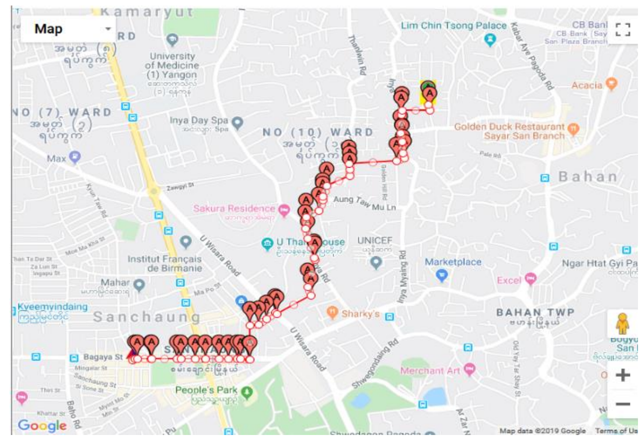
R&D results: Goal 3: Evacuation Route Strategy Optimization

Result 6:

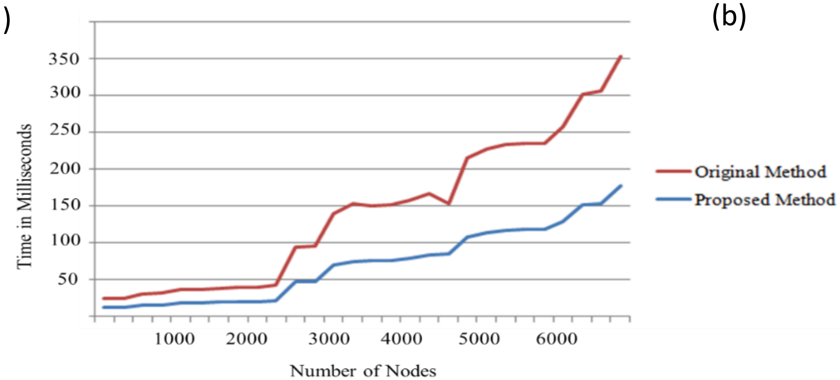
- Figure 7 compares the performance of optimal route calculation for a fire vehicle to reach incident location.



(a)



(b)



(c)

Figure 7. The optimal route between the Fire Department and incident location. (a) Original modified Dijkstra's algorithm. (b) Modified Dijkstra's Algorithm (c) Runtime Complexity.

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.	Effective Evacuation Route Strategy for Emergency Vehicles	Myint Myint Sein, K-zin Phyo(UCSY), Tham Mau Luen (UTAR), Yasunori Owada (NICT), Nordin Bin Ramli (MIMOS), Suvit Poomrittigul (PIT)	University of Computer Studies, Yangon (UCSY) Universiti Tunku Abdul Rahman (UTAR) MIMOS National Institute of Information and Communications Technology (NICT) Pathumwan Institute of Technology (PIT)	2021 IEEE 10th Global Conference on Consumer Electronics (GCCE)	12-15/10/2021	MIELPARQUE Kyoto, Kyoto, Japan

Societal Impact:

Disaster Recovery: In disaster scenarios, multiple affected areas may need the immediate help of emergency response unit. Based on the number of victims, activity of disasters and optimized evacuation routes, emergency response unit can dispatch manpower more efficiently, which could save more lives.

Network Scalability: NerveNet is a wireless capable node that can be a part of ad hoc network or mesh network that can be scaled for large coverage area or large number of devices easily by increasing number of nodes in mesh.

Monitoring Scalability: Mobile edge computing (MEC) enables camera to process the video and transmit only critical in formation to the cloud. NerveNet and MEC both complement each other to boost the disaster mitigation performance.

Collaboration: MEC is the core idea of 5G standard. Utilizing this concept in disaster mitigation aligns with the state-of-the-art technology. It encourages collaboration from academia, research institutes and industries from different ASEAN countries, based on a common MEC based IoT platform.

Conclusion:

Goal 1:

- The FPS of 13.2 shows the feasibility of real-time disaster detection.
- A multi-task model eliminates the straightforward approach of running multiple individual AI models, especially on low-powered embedded systems.

Goal 2:

- The NerveNet-Wi-Fi was deployed to enable image synchronization.
- To allow nationwide monitoring and control, NerveDASH was developed to visualize data collected from multiple regional mesh networks.

Goal 3:

- The estimating of effective emergency route strategy was proposed for complexed road network of Yangon.
- The proposed work will help emergency rescue teams to reach the incident location in a short time save the lives and properties.

Future works:

Party	Schedule	Task Description
UTAR/NICT/BHN	Jan - March 2022	• Deployment of IoT nodes in UTAR campus • Large-scale field testing of NerveNet-Wi-Fi and NerveNet LoRA
UTAR/MIMOS		• Integrate disaster detection models with NerveNet-Wi-Fi and NerveNet LoRA
UCSY/UTAR		• Integrate with real time road traffic condition obtained by sensor
UTAR/PIT		• Large-scale field testing of the NerveDASH dashboard