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 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:

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

Speaker:
Ir. Ts. Dr. Tham Mau Luen
Universiti Tunku Abdul Rahman (UTAR)
Malaysia

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

Project Members :

Name	Institution	Name	Institution
Ir. Ts. 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
Ir. Dr. Nordin Bin Ramli	MIMOS, Malaysia	**Prof. Zin May Aye**	UCSY, Myanmar
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 2023

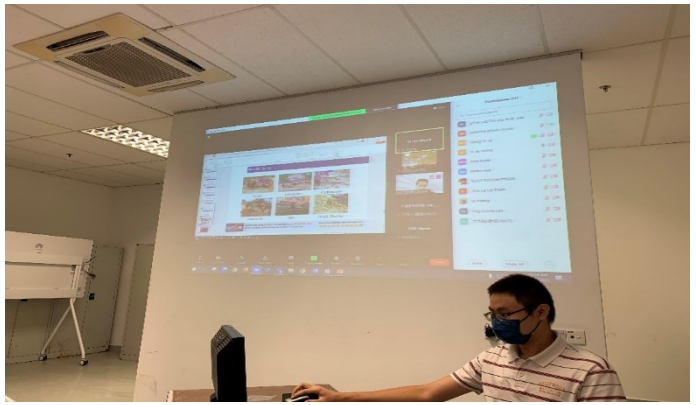
Project Budget: $80,000

Project Activities: Final Expenditure

Item	Amount (USD)
Equipment	38,920
International Conference x 6	6,957
Journal x 2	4,471
Grand Total	**50,348**

Project Activities: Group Meeting

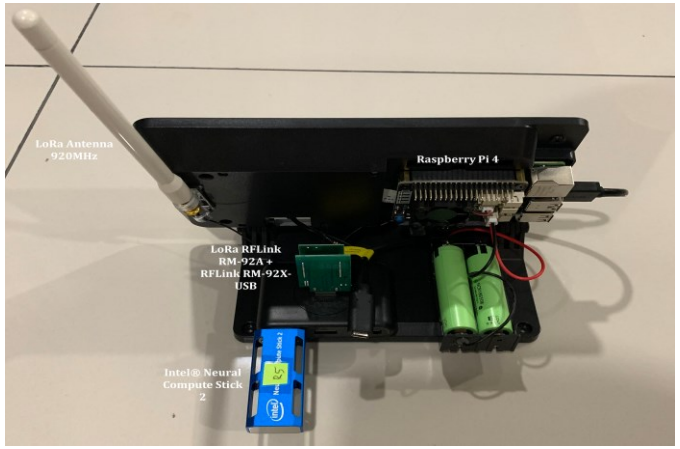
Date	Description	Venue
24 Apr 2020	Kickoff Meeting	WEB
8 May 2020 12 May 2020 19 May 2020 24 June 2020 5 Mar 2021 19 Jan 2022 28 Oct 2022	Project Meeting x 7	WEB
13 Dec 2022	Closing Meeting	UTAR and WEB



Project Activities: Testbed

(a)

(b)



(c)

(d)

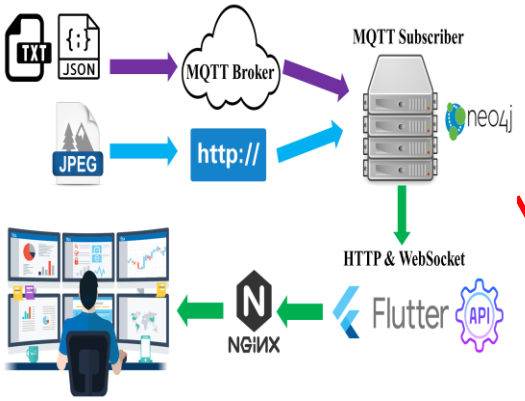
(e)

(f)

(a) NerveNet base station node. (b) NerveNet monitoring node (front view). (c) NerveNet monitoring node (rear view). (d) Long-range Wi-Fi adapter and antennas. (e) Building to bus transmission. (f) Setup inside bus.

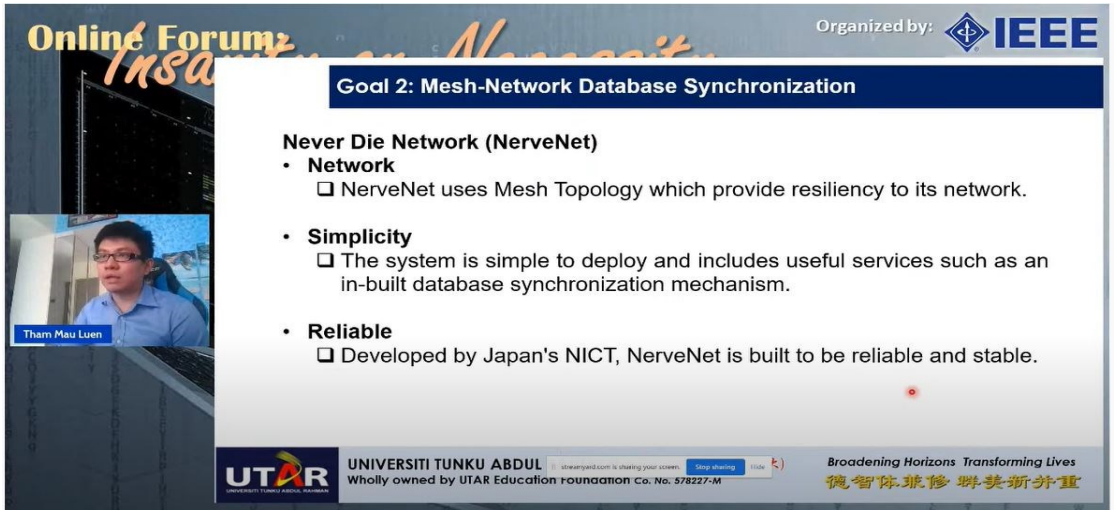
Project Activities: Experiment

UTAR KB Block
GPS coordinate
(3.03960, 101.79418)



Project Activities: Invited Speakers

52nd Asia Pacific Advanced Network (APAN), 5 Aug 2021



IEEE Malaysia ComSoc/VTS Joint Chapter, 21 Oct 2021

The 3rd Symposium on Railway Infrastructure & Engineering, 13 Oct 2022

World BOSAI Forum 2023, 10-12 Mar 2023

Project Activities: Best Presentation Awards

R&D results (**GOAL 1&2**): Disaster Classification and Victim Detection using NerveNet Wi-Fi Mesh

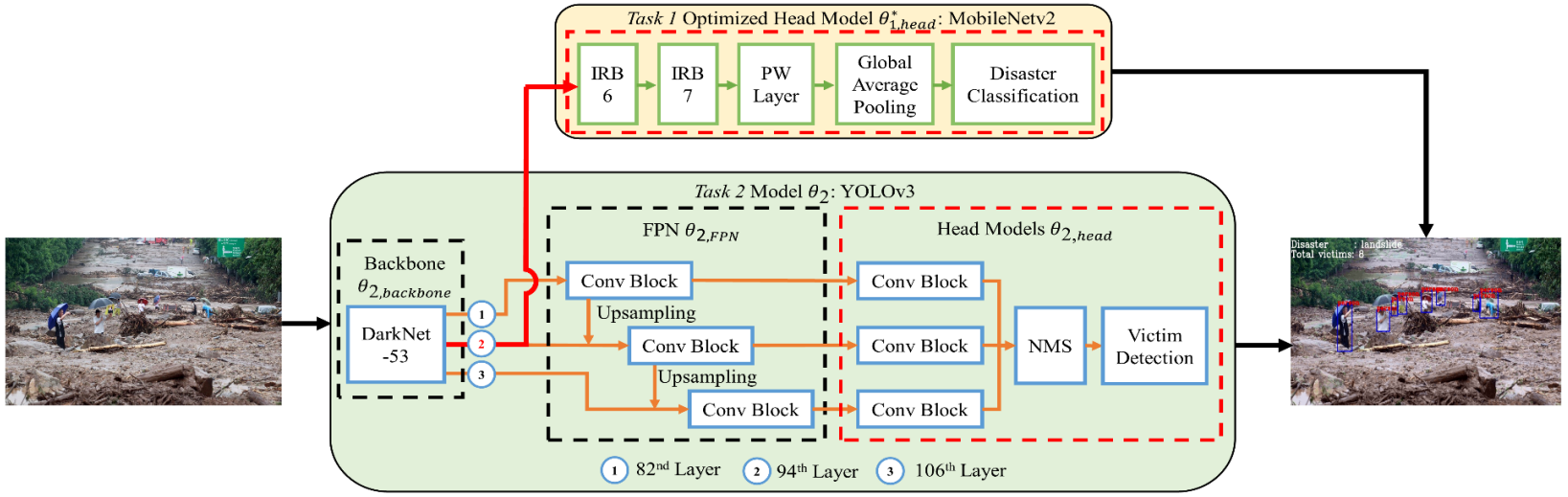
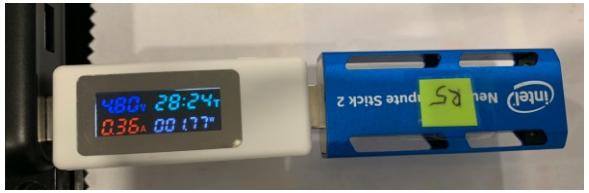


TABLE 11. Model inference speed (FPS) before and after model optimization via OpenVINO toolkit.

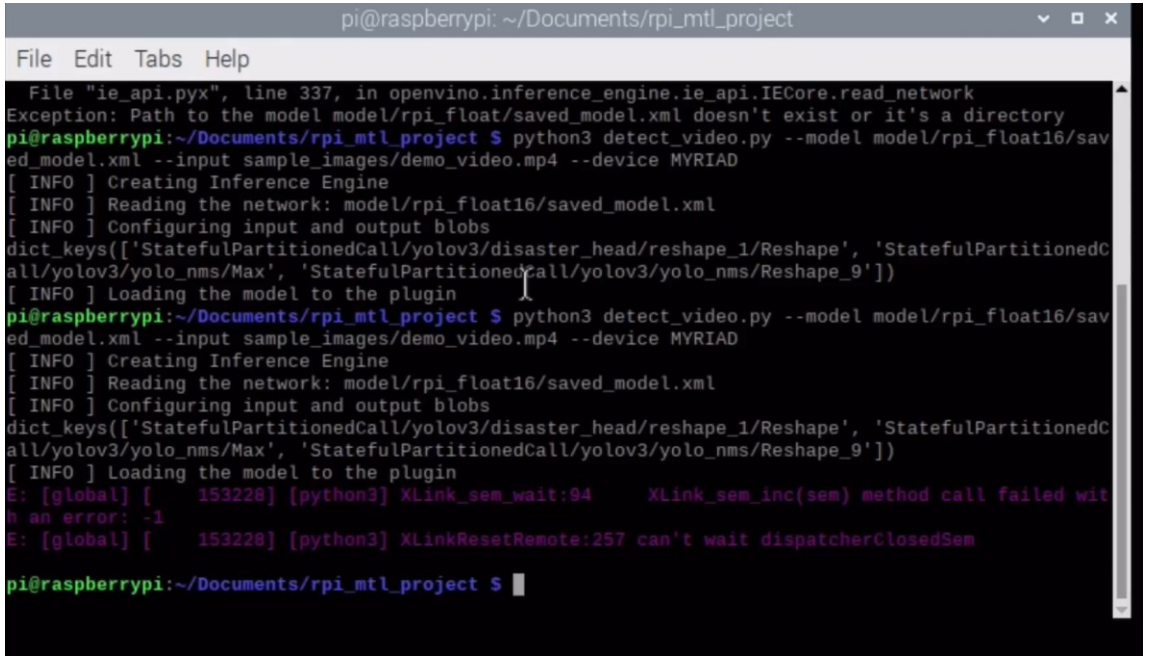
Hardware	Framework	Data Format	FPS
GPU	TensorFlow GPU	FP32	20.31
CPU1	TensorFlow CPU	FP32	6.55
CPU1	OpenVINO IR Format	FP16	9.37
NCS2 on CPU1	OpenVINO IR Format without NMS	FP16	2.50
NCS2 on RP4	OpenVINO IR Format without NMS	FP16	1.80
NCS2 on RP4 (Conventional Approach)	OpenVINO IR Format without NMS	FP16	1.52
CPU1	OpenVINO IR Format	INT8	16.46

(a)

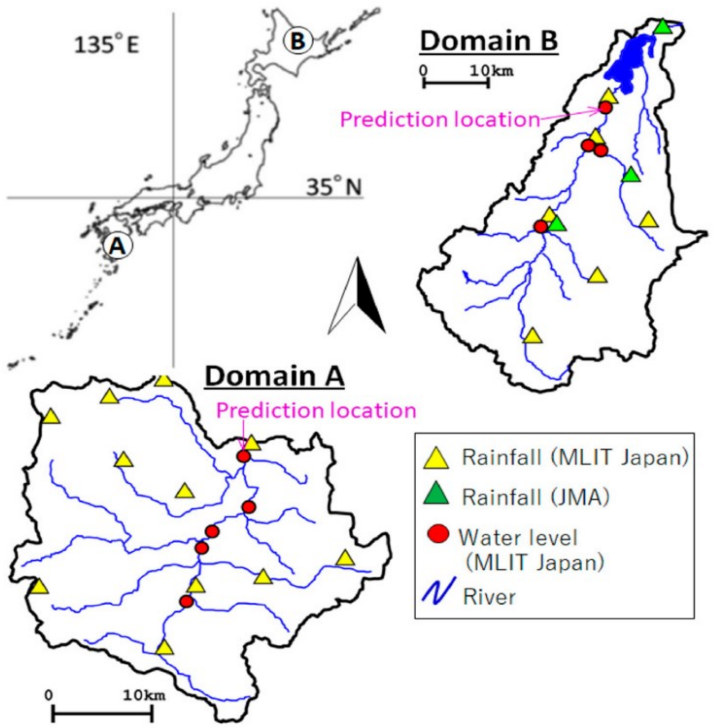


(b)

Power Measurement. (a) Idle time. (b) Execution time.



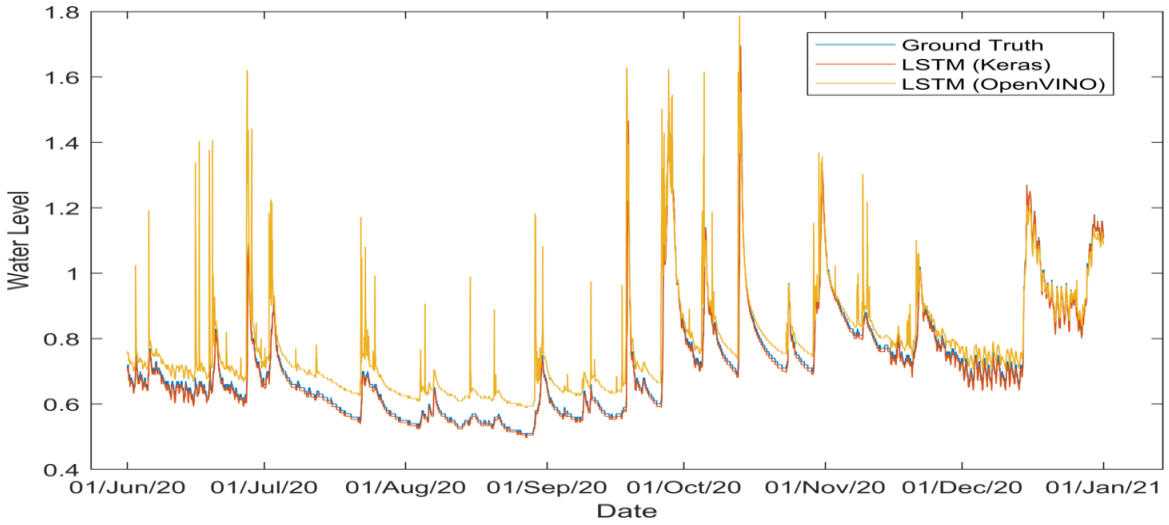
R&D results (**GOAL 1&2**): Flood Forecasting using Edge AI and NerveNet LoRa Mesh



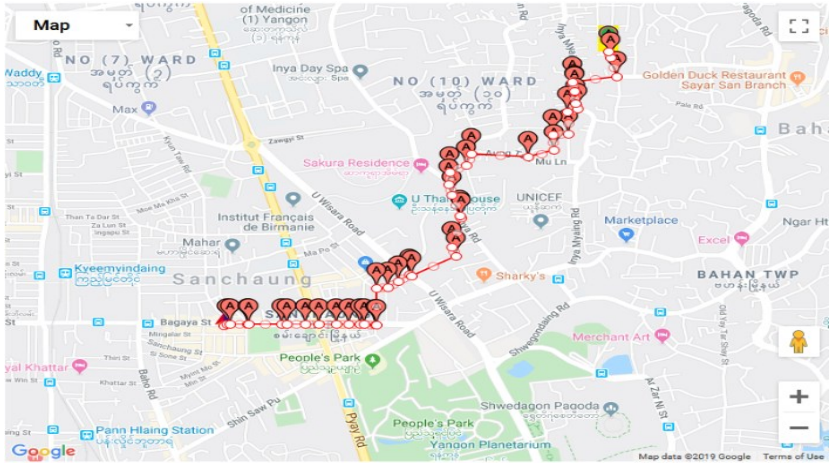
Abashiri River watershed [8], located northeast of Hokkaido, Japan.

TABLE I. TRAINING AND TESTING PERIOD FOR THE DATASET

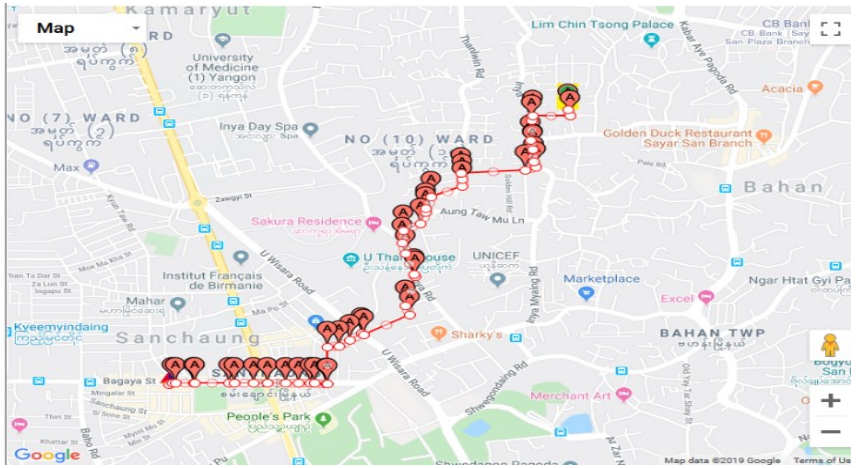
Dataset	Training	Test
Hongou (Jan 2019 to Dec 2020)	Jan 2019 to May 2020	Jun 2020 to Dec 2020



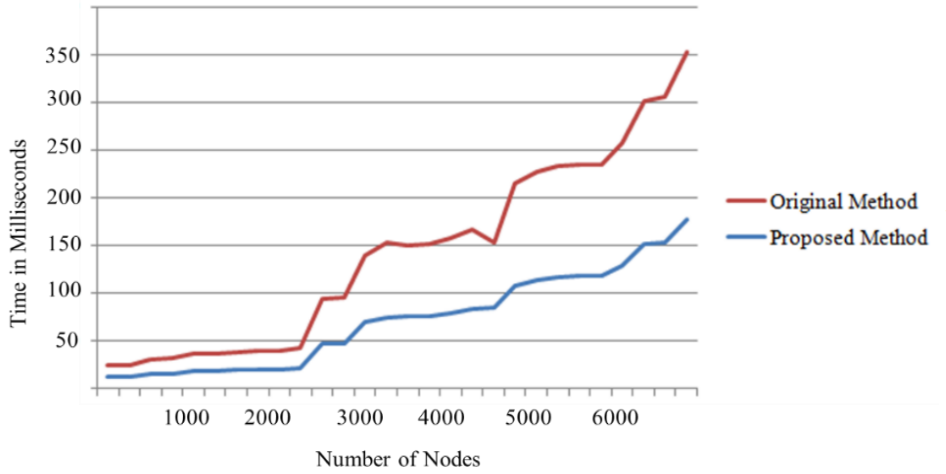
R&D results (**GOAL 3**): Evacuation Route Strategy Optimization



(a)



(b)



(c)

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:
Universiti Tunku Abdul Rahman (UTAR), National Institute of Information and Communications Technology (NICT), MIMOS Berhad (MIMOS), University of Computer Studies, Yangon (UCSY), Pathumwan Institute of Technology (PIT)

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[1], K-zin Phyo[1], Mau-Luen Tham[2], Yasunori Owada[3], Nordin Bin Ramli[4], Suvit Poomrittigul[5]	[1]UCSY, [2]UTAR, [3]NICT, [4]MIMOS, [5]PIT	2021 IEEE 10th Global Conference on Consumer Electronics (GCCE)	12-15/10/2021	Kyoto, Japan
2.	Joint Disaster Classification and Victim Detection using Multi-Task Learning	Mau-Luen Tham[1], Yi Jie Wong[1], Kwan Ban Hoe[1], Yasunori Owada[2], Myint Myint Sein[3], Yoong Choon Chang[1]	[1]UTAR, [2]NICT, [3]UCSY	2021 IEEE 12th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)	01-04/12/2021	New York, USA
3.	Efficient Device-Edge Inference for Disaster Classification	Nathaniel Tan Sze Yang[1], Mau-Luen Tham[1], Sing Yee Chua[1], Ying Loong Lee[1], Yasunori Owada[2], Suvit Poomrittigul[3]	[1]UTAR, [2]NICT, [3]PIT	2022 Thirteenth International Conference on Ubiquitous and Future Networks (ICUFN)	05-08/07/2022	Barcelona, Spain

Scientific Contribution:

Presentations at International Conferences:
Universiti Tunku Abdul Rahman (UTAR), National Institute of Information and Communications Technology (NICT), MIMOS Berhad (MIMOS), University of Computer Studies, Yangon (UCSY), Pathumwan Institute of Technology (PIT)

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
4.	Artificial Intelligence of Things (AIoT) for Disaster Monitoring using Wireless Mesh Network	Mau-Luen Tham[1], Yi Jie Wong[1], Kwan Ban Hoe[1], Xin Hao Ng[1], Yasunori Owada[2]	[1]UTAR, [2]NICT	2023 The 6th International Conference on Software Engineering and Information Management (ICSIM)	31/01/2023-02/02/2023	Palmerston North, New Zealand
5.	Flood Forecasting using Edge AI and LoRa Mesh Network	Mau-Luen Tham[1], Xin Hao Ng[1], Rong Chuan Leong[1], Yasunori Owada[2]	[1]UTAR, [2]NICT	12th International Conference on Industrial Technology and Management (ICITM)	16-18/02/2023	Cambridge, United Kingdom
6.	Performance Study of Disaster-Resilient Mesh Networking using NerveNet Wi-Fi and LoRa	Mau-Luen Tham[1], Chee Hong Lean[1], Wei Sean Lim[1], Rong Chuan Leong[1], Yasunori Owada[2], Myint Myint Sein[3]	[1]UTAR, [2]NICT, [3]UCSY	2023 6th Conference on Cloud and Internet of Things (CIoT)	20-23/03/2023	Lisbon, Portugal

Scientific Contribution:

Published Journal Papers:

No:	Paper title:	Author names (*indicate Corresponding Author)	Affiliation	Journal name:	The publisher of the Journal	The volume number and Pages
1.	An Optimized Multi-Task Learning Model for Disaster Classification and Victim Detection in Federated Learning Environments	Yi Jie Wong[1] ,Mau-Luen Tham[1*], Kwan Ban Hoe[1], Ezra Morris Abraham[1], Yasunori Owada[2]	[1]UTAR, [2]NICT	IEEE Access (Q2 & IF 3.847)	Institute of Electrical and Electronics Engineers	vol. 10, pp. 115930 – 115944 doi: 10.1109/ACCESS.2022.3218655
2.	FedDdrl: Federated Double Deep Reinforcement Learning for Heterogeneous IoT with Adaptive Early Client Termination and Local Epoch Adjustment	Yi Jie Wong[1] ,Mau-Luen Tham[1*], Kwan Ban Hoe[1], Yasunori Owada[2]	[1]UTAR, [2]NICT	Sensors (Q2 & IF 3.847)	MDPI	vol. 23, no. 5 doi: 10.3390/s23052494
3.	Mobility-Aware Resource Allocation in IoRT network for Post-Disaster Communications with Parameterized Reinforcement Learning	Homayun Kabir[1] ,Mau-Luen Tham[1*], Yoong Choon Chang[1], Chee-Onn Chow[2], Yasunori Owada[3]	[1]UTAR, [2]UM, [3]NICT	Sensors (Q2 & IF 3.847)	MDPI	vol. *23*, no. 14 doi: 10.3390/s23146448

Societal Impact: Knowledge Transfer Programme (Contribution Paper)

ASIA-PACIFIC TELECOMMUNITY
The 35th APT Standardization Program Forum (ASTAP-35)
17-20 April 2023, Bangkok, Thailand

Document No:
ASTAP-35/INP-xx
13 April 2023

Malaysia

PROPOSED INCLUSION OF NEW USE CASE TO APT REPORT ON LOCAL-AREA RESILIENT INFORMATION SHARING AND COMMUNICATION SYSTEMS

In the Expert Group on Disaster Risk Management and Relief System (EG DRMR) of ASTAP Working Group Network and System (WG NS), an ATP report, entitled "APT Report on local-area resilient information sharing and communication systems," has been discussing since ASTAP-33, June 2021. In this report, editorial efforts are being made by NICT. In the latest draft shown below, some systems including "NerveNet" have been described.

ASTAP-34/TMP-22
Draft of APT Report on local-area resilient information sharing and communication systems
https://www.apt.int/sites/default/files/2022/04/ASTAP-34-TMP-22_LocalAreaResilientSystem_EG_DRMRS-20220421.docx

Universiti Tunku Abdul Rahman (UTAR), Malaysia has collaborated with NICT in using NerveNet for disaster monitoring. Thus, Malaysia would like to include a new use case of NerveNet to Section 5.1.3.4 of the APT report.

Proposed text:

5.1.3.4. Disaster Monitoring using Artificial Intelligence (AI) and NerveNet

When disaster events happen, an efficient rescue operation requires the detected disaster type and number of victims. A straightforward approach would be deploying two single-task AI models that perform the disaster classification and victim detection separately, as shown in Figure 5-6(a). Such approach is ill-suited for IoT applications due to high memory footprint and computing power. A better solution would be using a multi-task learning (MTL) model, as displayed in Figure 5-6(b). The advantages of using the MTL model are listed in Figure 5-6(c).

KEMENTERIAN KOMUNIKASI DAN DIGITAL

Suruhanjaya Komunikasi dan Multimedia Malaysia
Malaysian Communications and Multimedia Commission

Contact: Mau Luen Tham Email: thamml@utar.edu.my
Universiti Tunku Abdul Rahman, Malaysia

Conclusions:

Goal 1:

- A multi-task learning (MTL) model that performs joint disaster classification and victim detection has been developed.
- The model can be run in Raspberry Pi 4 with low power consumption.

Goal 2:

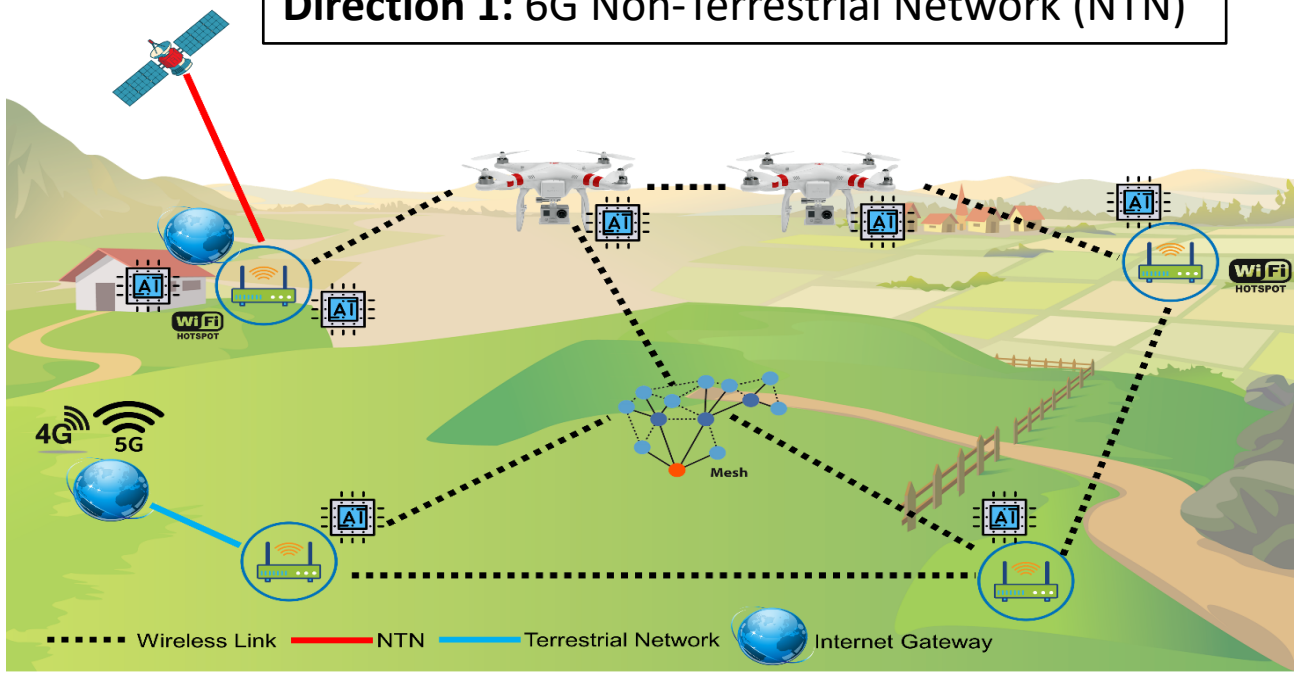
- The NerveNet Wi-Fi has been deployed to enable image synchronization.
- The NerveNet LoRa has been deployed to enable text synchronization.
- To allow nationwide monitoring and control, NerveDASH has been developed to visualize data collected from multiple regional mesh networks.

Goal 3:

- The estimation of effective emergency route strategy has been 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 Directions:

Direction 1: 6G Non-Terrestrial Network (NTN)



Empowering Non-Terrestrial Networks With Artificial Intelligence: A Survey

AMJAD IQBAL[1,2], MAU-LUEN THAM[1], YI JIE WONG[1], (Graduate Student Member, IEEE), ALA'A AL-HABASHNA[2], GABRIEL WAINER[2], (Senior Member, IEEE), YONG XU ZHU[3], (Senior Member, IEEE), AND TASOS DAGIUKLAS[4]

[1]Department of Electrical and Electronic Engineering, Lee Kong Chian Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, Sungai Long Campus, Selangor 43000, Malaysia
[2]Department of Systems and Computer Engineering, Carleton University, Ottawa, ON K1S 5B6, Canada
[3]Department of Electrical and Electronic Engineering, University of Warwick, CV4 8UW Coventry, U.K.
[4]Division of Computer Science and Informatics, School of Engineering, London South Bank University, SE1 0AA London, U.K.

Corresponding author: Mau-Luen Tham (thamml@utar.edu.my)

This work was supported in part by Universiti Tunku Abdul Rahman (UTAR), Malaysia, under UTAR Research Fund (UTARRF) under Grant IPSR/RMC/UTARRF/2021C1/T05; in part by the British Council under UK-ASEAN Institutional Links Early Career Researchers Scheme under Project 913030644; and in part by Natural Sciences and Engineering Research Council of Canada (NSERC) Canada.

Direction 2:
Disaster Detection using Thermal Imaging