Visual IoT Network for Environment Protection and Disaster Prevention

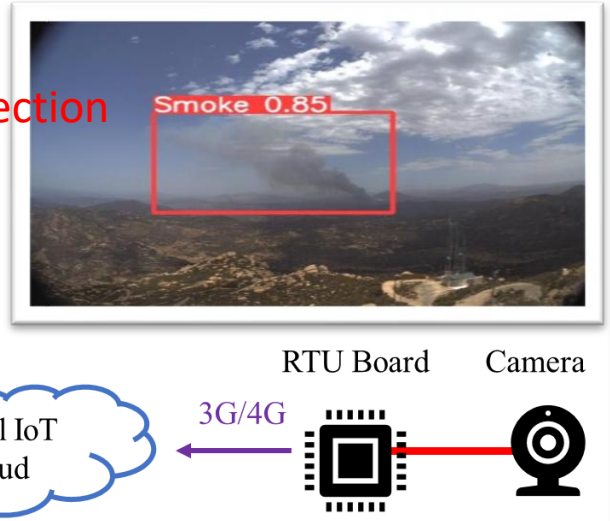
Background :

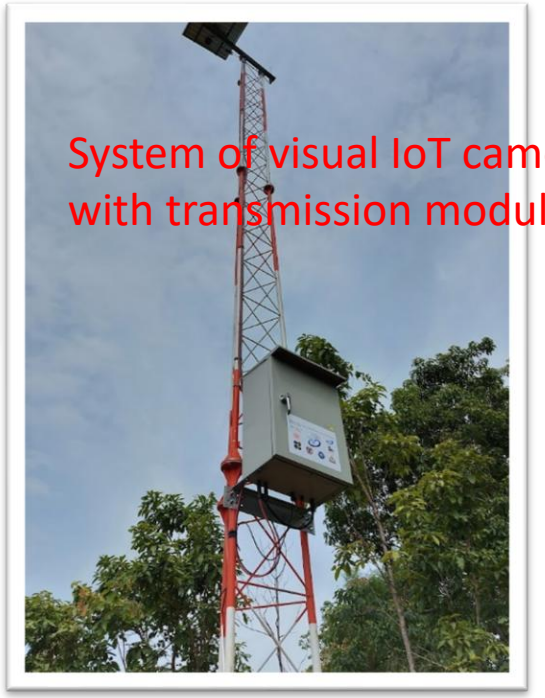
One of the leading causes of air pollution problems (e.g., PM2.5) is a forest fire. It is found that about 92% of burned area in Chiang Mai are in the conservation forest and national park. Furthermore, with the problem of high steep mountainous terrain in conservation and national parks and insufficient patrol staff, it is very difficult to do the effective monitoring and firefighting task with a quick response. Using Visual IoT in the forest fire monitoring system will increase the ability to accurately assess and provide information about the situation of the scene quickly. In this project, Visual IoT will be used in order to assess the situation of forest fire.

Targets:

- System of visual IoT cameras with transmission modules
- Algorithms for forest fire detection
- Data visualization

Algorithms for forest fire detection





Speaker:

Jessada KARNJANA
National Electronics and Computer Technology Center, Thailand

Visual IoT Network for Environment Protection and Disaster Prevention

Project Members :

National Institute of Information and Communications Technology (NICT)
Mapua University
University of Computer Studies, Yangon (UCSY)
National University of Laos (NUOL)
National Electronics and Computer Technology Center (NECTEC)
Sirindhorn International Institute of Technology (SIIT)
King Mongkut's Institute of Technology Ladkrabang (KMITL)

Project Duration : June 2022 – May 2025 (2 years + 1 year extension)

Project Budget: 40,000 USD/year (Total 80,000 USD)

Project Activities

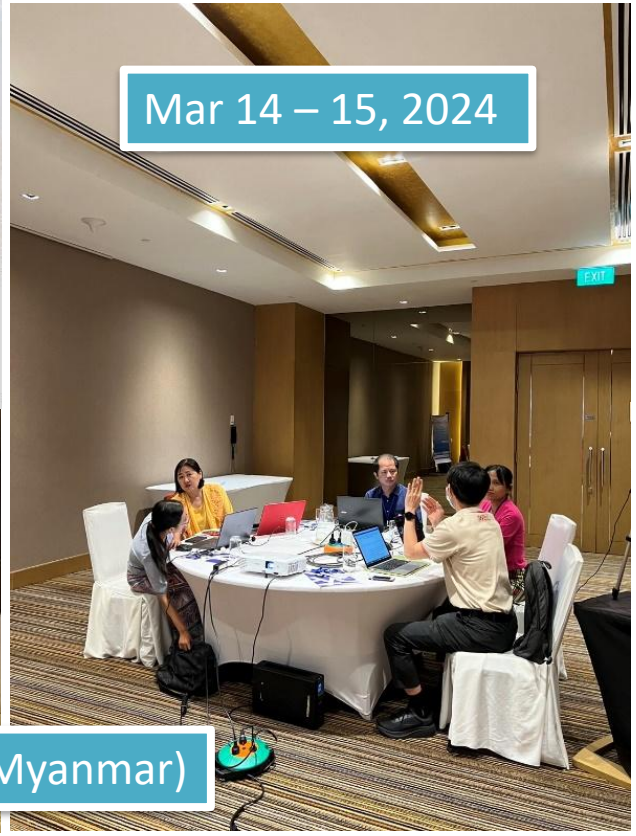
Feb 28 – Mar 1, 2024

Chaing Mai (Thailand)

- To perform final checking of 5 units of Visual IoT system
- To have meeting with each sub-district and inform the method to monitor taken images

Yangon (Myanmar)

To organize a meeting for UCSY and NUOL team supported by NECTEC team and NICT team in order to configure the Visual IoT system including microcontroller (RasPi-4) board, IP camera and communication channel. The configuration of the system to upload and download the taken images to NICT server has been also investigated.



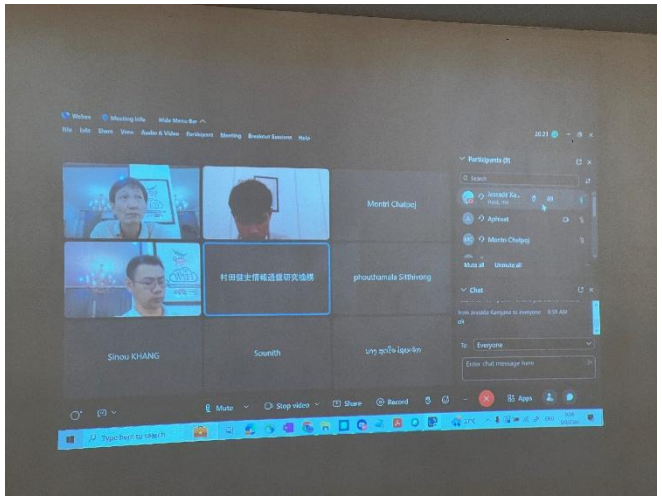
Mar 14 – 15, 2024

Vientiane (Lao PDR)

Aug 6 – 8, 2024

On-line meeting with Mapua Malayan Colleges Mindanao (new member) about system installation at Mt. Apo

Project Activities

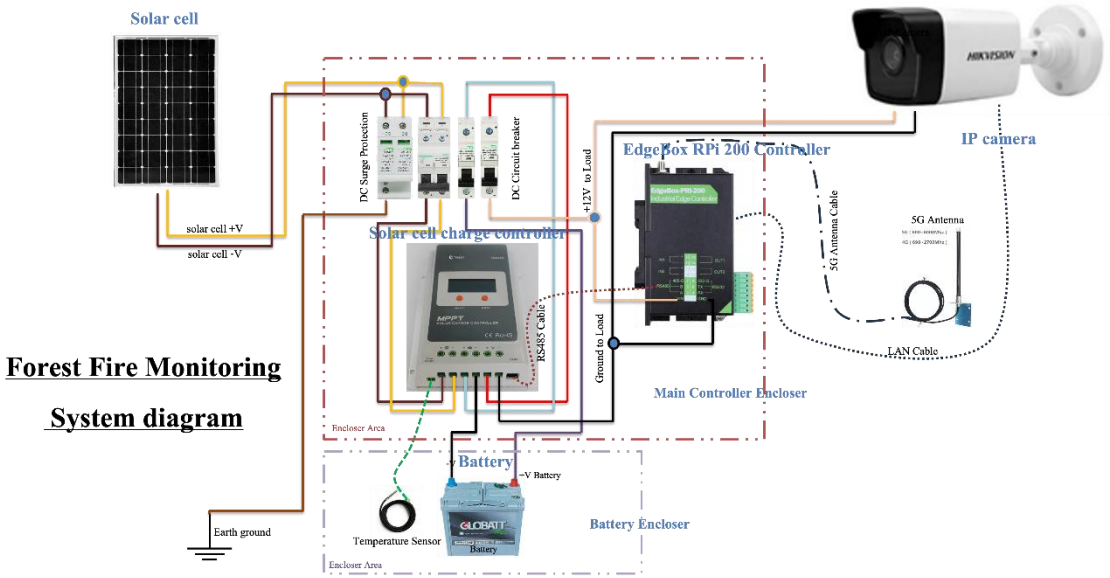


Workshop/Training @NUOL
4-8 September 2023

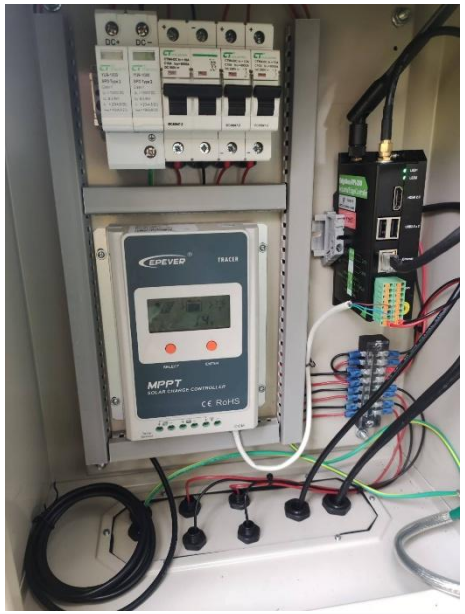
Workshop/Training @UCSY
21 – 25 August 2023

25 – 27 February 2025
Symposium and Meeting in Chaing Mai

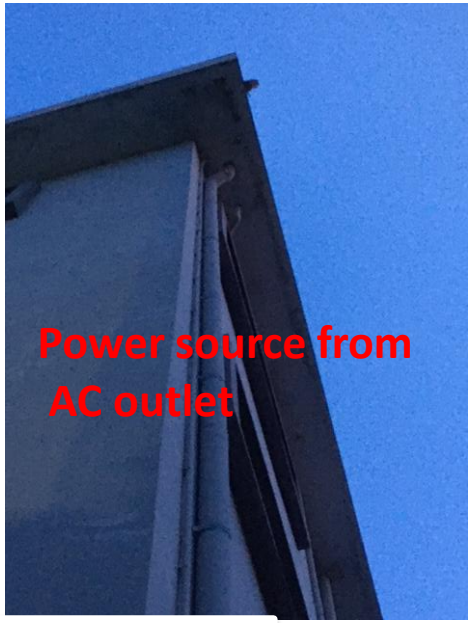
R&D results: Target #1 – System of Visual IoT camera with transmission modules



System diagram (Modified by NECTEC)

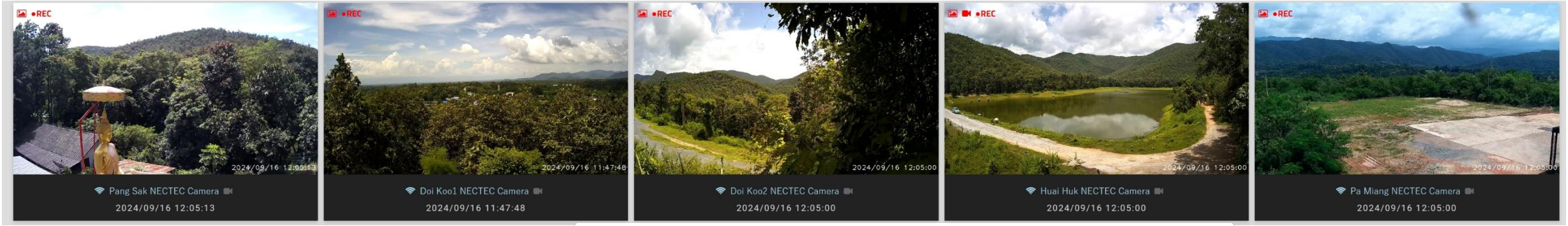


Visual IoT & transmit modules



Locations of installation

- **The Visual IoT system have been installed in Chiang Mai, Thailand (5 units) and Nay Pyi Taw, Myanmar (3 units). Another 2 units have been purchased and will be installed at Sang Tong district, Vientiane, Lao PDR by this October.**



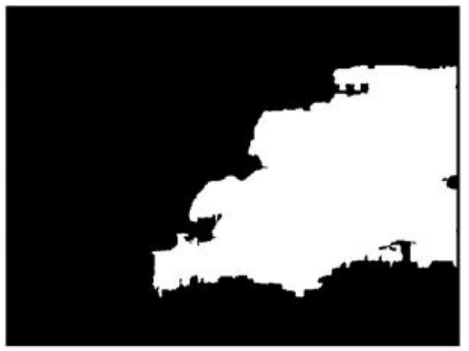
Example of taken images (in Chaing Mai, Thailand)

R&D results: Target #2 – Algorithm for forest fire detection

https://github.com/Biometrix-4/FireSpot-CNX

FireSpot: 4,000 images (Smoke: 2,817, Non-smoke: 1,179)

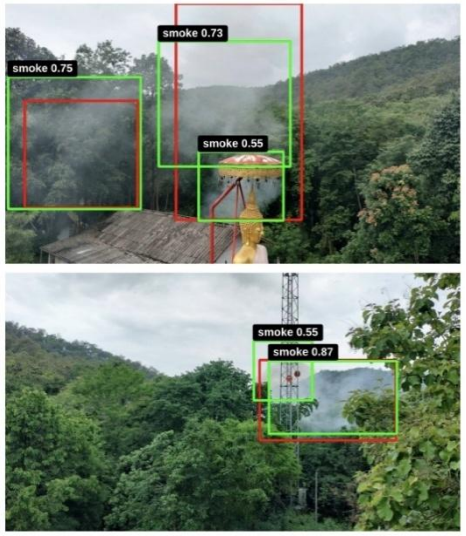
Two datasets: **bounding boxes** and **segmentation masks**

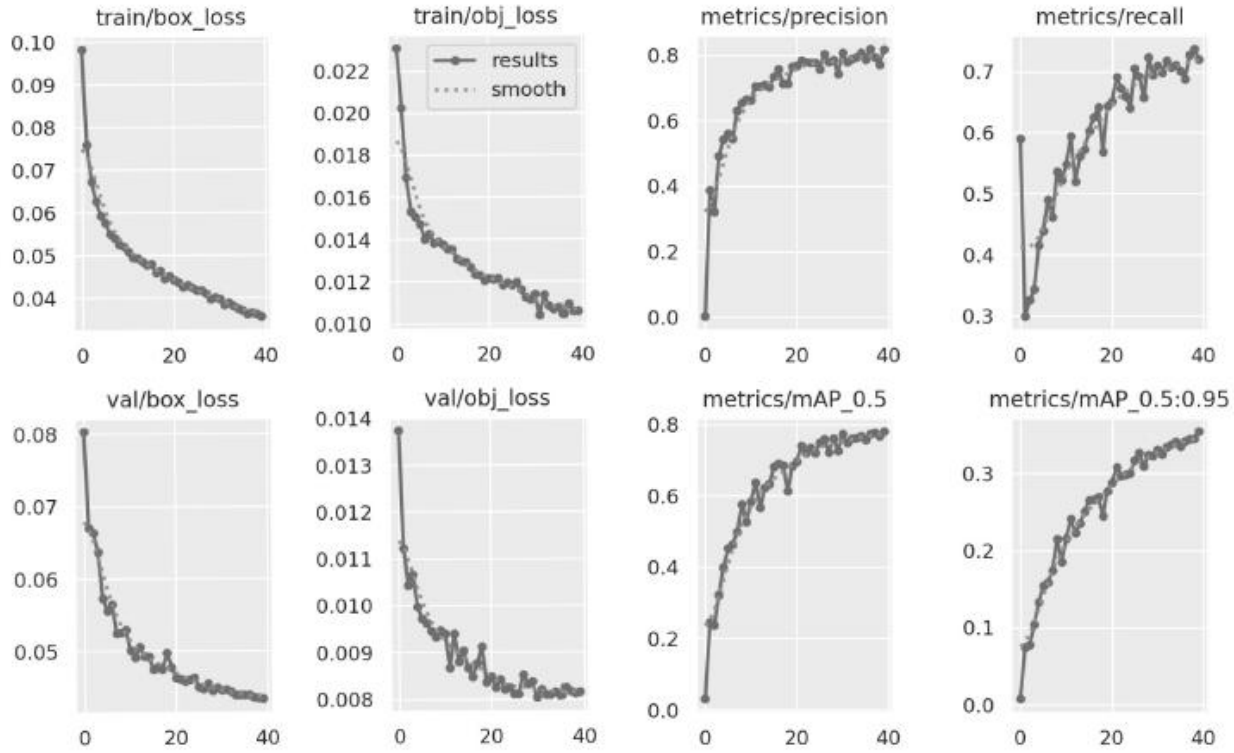


R&D results: Target #2 – Algorithm for forest fire detection

1. FireSpot: A Database for Smoke Detection in Early-stage Wildfires

- Model: YOLOv5
- Training: 60%, Validation: 20%, Test: 20%
- **Conclusion**: The performance evaluation demonstrated promising results, with an accuracy of 93.88%.
- Published in **iSAI-NLP-AIoT 2023**: The 18th International Joint Symposium on AI and NLP, Bangkok, Thailand



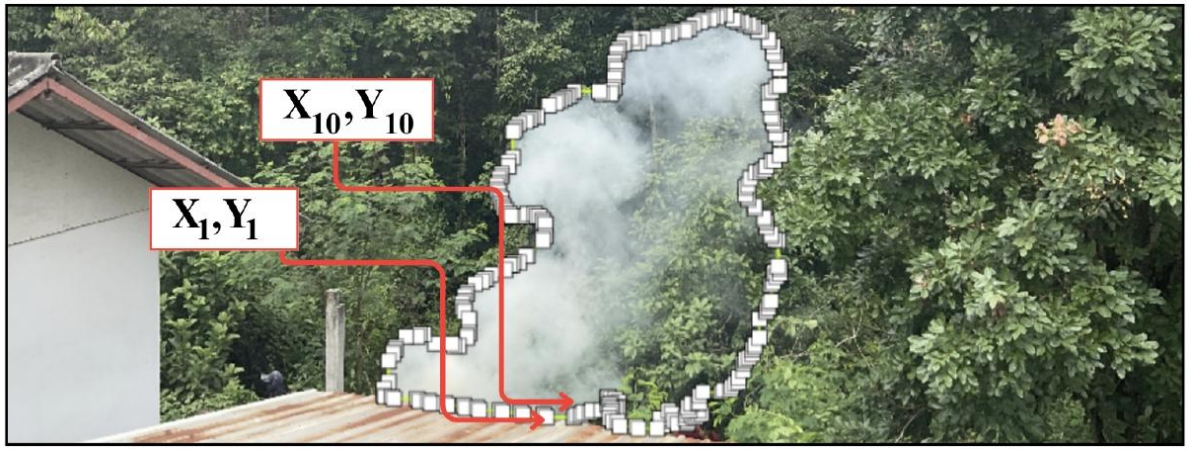


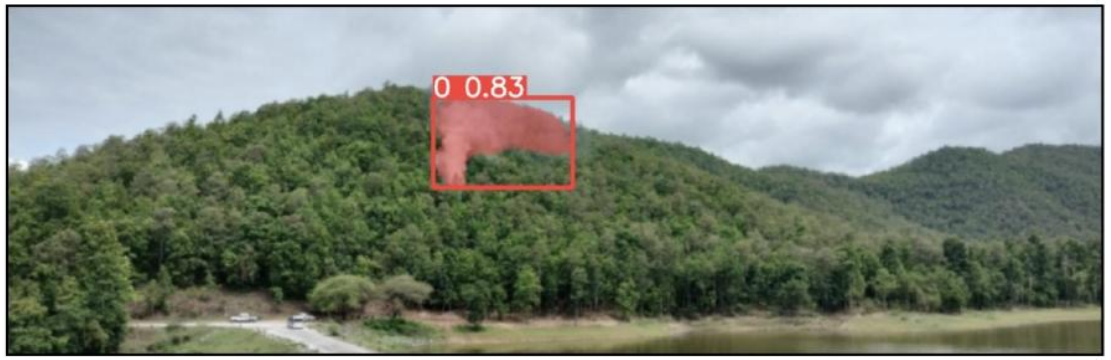
Round	Precision	Recall	$mAP_{0.5}$	$mAP_{0.5:0.95}$	F1-score
1	**0.8171**	0.7198	**0.7809**	**0.3547**	**0.9688**
2	0.7749	**0.7228**	0.7693	0.3435	0.9605
3	0.8055	0.7207	0.7772	0.3332	0.9700
4	0.7631	0.6948	0.7364	0.3359	0.9616

R&D results: Target #2 – Algorithm for forest fire detection

2. FireSpot-Seg: A Segmentation Database for Smoke Detection in Early-stage Wildfires

- Model: YOLOv8s-Seg
- **Conclusion**: achieving 94.4% accuracy in bounding box detection and 92.8% in segmentation at a 0.3 IoU threshold
- Presented in **KST 2025**: 17th International Conference on Knowledge and Smart Technology, Bangkok, Thailand





Seg

IoU Threshold	Accuracy	Precision	Recall	F1-score
0.3	**92.80%**	**97.77%**	**87.60%**	**92.41%**
0.4	90.40%	97.64%	82.80%	89.61%
0.5	88.40%	97.52%	78.80%	87.17%
0.6	84.40%	97.25%	70.80%	81.94%
0.7	78.00%	96.67%	58.00%	72.50%

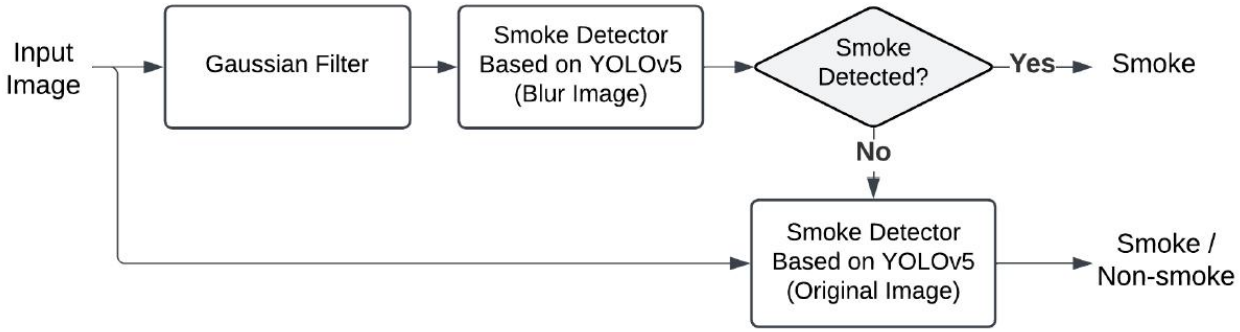
Box

IoU Threshold	Accuracy	Precision	Recall	F1-score
0.3	**94.40%**	**97.84%**	**90.80%**	**94.19%**
0.4	92.00%	97.73%	86.00%	91.49%
0.5	90.00%	97.62%	82.00%	89.13%
0.6	87.00%	97.44%	76.00%	85.39%
0.7	83.80%	97.21%	69.60%	81.12%

R&D results: Target #2 – Algorithm for forest fire detection

3. Real-time Wildfire-prone Area Monitoring and Early Warning System Based on Two-stage YOLO-based Smoke Detection Model

- Two-stage YOLO-based smoke detection model
- **Conclusion**: The system achieved a balanced accuracy of 98.62%, significantly surpassing baseline models with an improvement of 4.02%.
- Presented in **IUKM 2025**: The International Conference on Integrated Uncertainty in Knowledge Modelling and Decision Making, Ho Chi Minh City, Vietnam



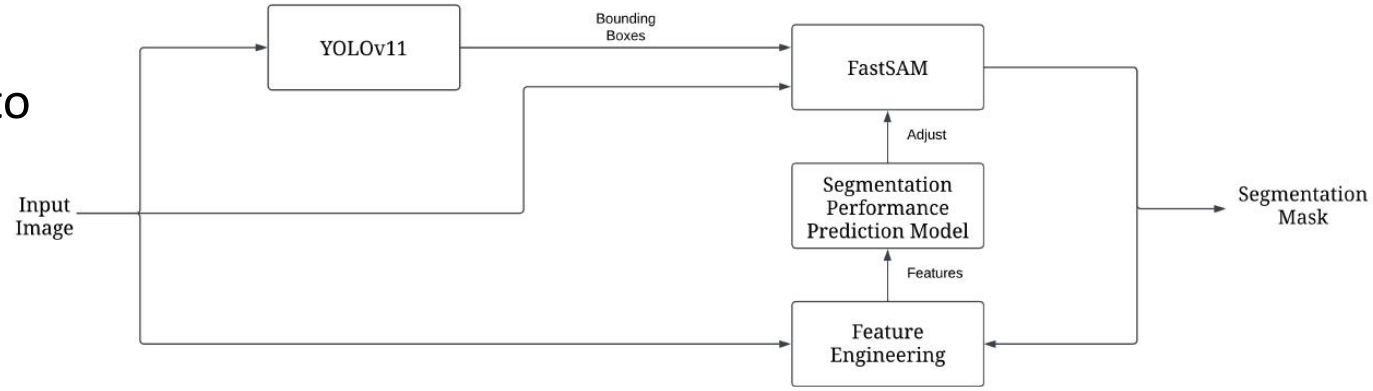
Example of an input image (left) and its corresponding Gaussian-blur image (right). Note that the previous model incorrectly classified the original input image as the image containing smoke.

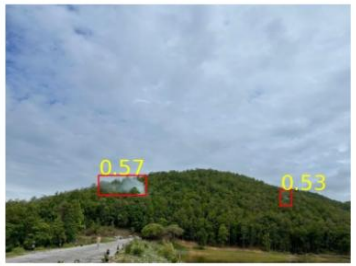
Model	Accuracy	Precision	Recall	F1-Score	Balanced Accuracy
YOLOv5-based model with original input image	0.9819	0.9934	0.9804	0.9868	0.9830
YOLOv5-based model with Gaussian blur input image	0.9820	1.0000	0.9739	0.9868	0.9869
Baseline model [13]	0.9505	0.9733	0.9542	0.9637	0.9481
Proposed method	0.9865	0.9934	0.9869	0.9902	0.9862

R&D results: Target #2 – Algorithm for forest fire detection

4. Smoke Segmentation Improvement Based on Fast Segment Anything Model with YOLOv11 for a Wildfire Monitoring System

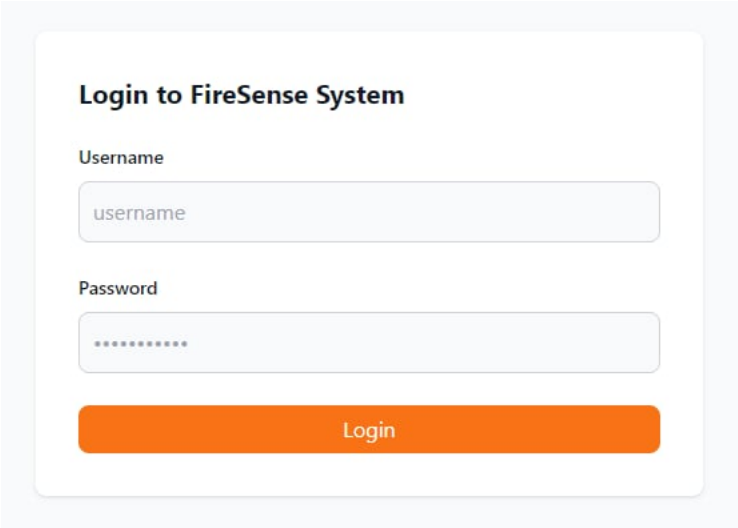
- We extend prior work by proposing a mode to predict the errors and performance of segmentation masks without access to the ground truth, with the aim of facilitating iterative self-improvement of segmentation models.
- **Conclusion**: The findings open the way to future work where the results of the error prediction model can be used as feedback to improve the prompts and hyperparameters of the segmentation model.
- Presented in **IoTDBS 2025**: 10th International Conference on IoT, Big Data and Security, Porto, Portugal





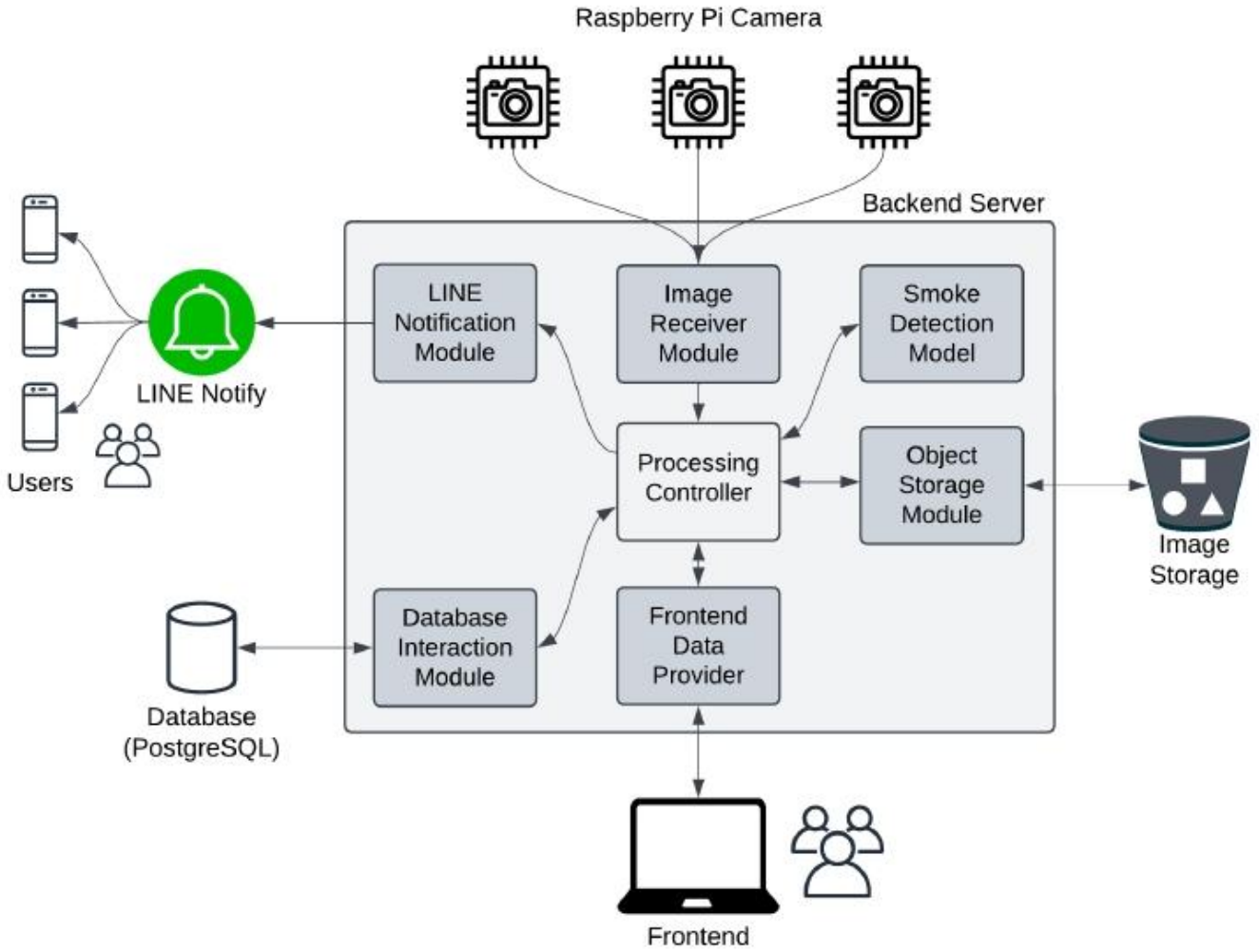
Model	Target	MSE	R^2
ResNet50	FNP	0.0565	-0.0654
	TPP	0.0462	0.0659
	FPP	0.0002	-1.1521
ResNet18	FNP	0.0519	0.0622
	TPP	0.0430	0.1278
	FPP	0.0003	-4.1705
EfficientNet-B2	FNP	0.0502	0.0475
	TPP	0.0439	0.0996
	FPP	0.0007	-11.0456

R&D results: Target #3 – Data visualization

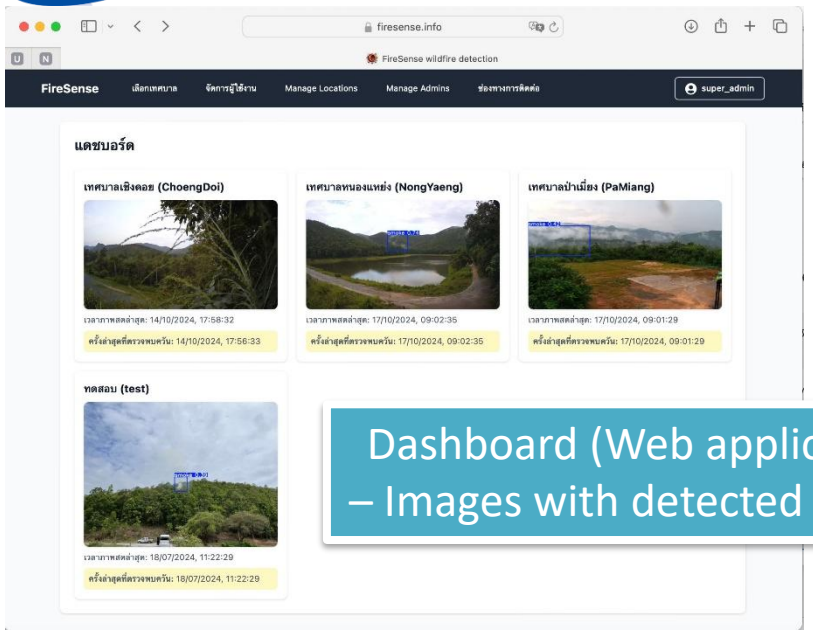


The dashboard could be browsed from the web site (https://firesense.info)

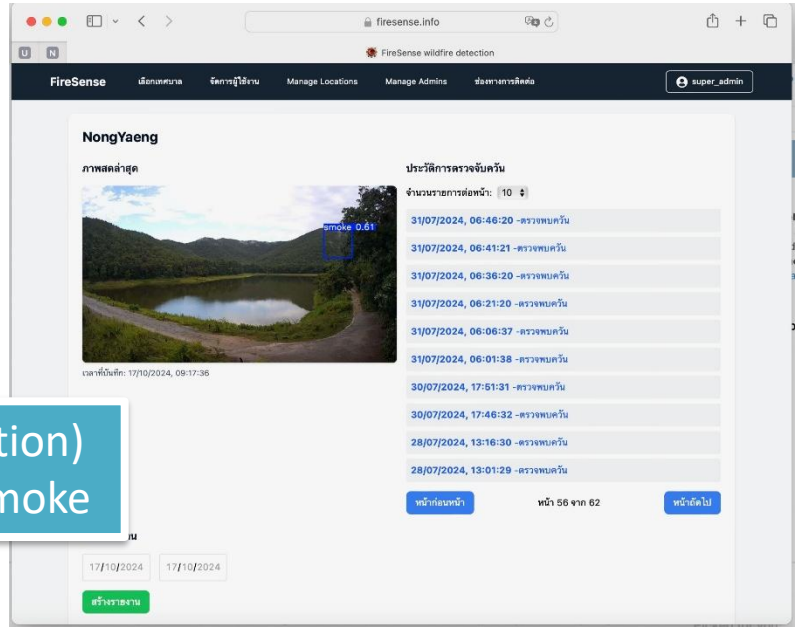
- Super admin (NECTEC team)
- Admin (Representatives of sub-districts and authorized peoples.
- User

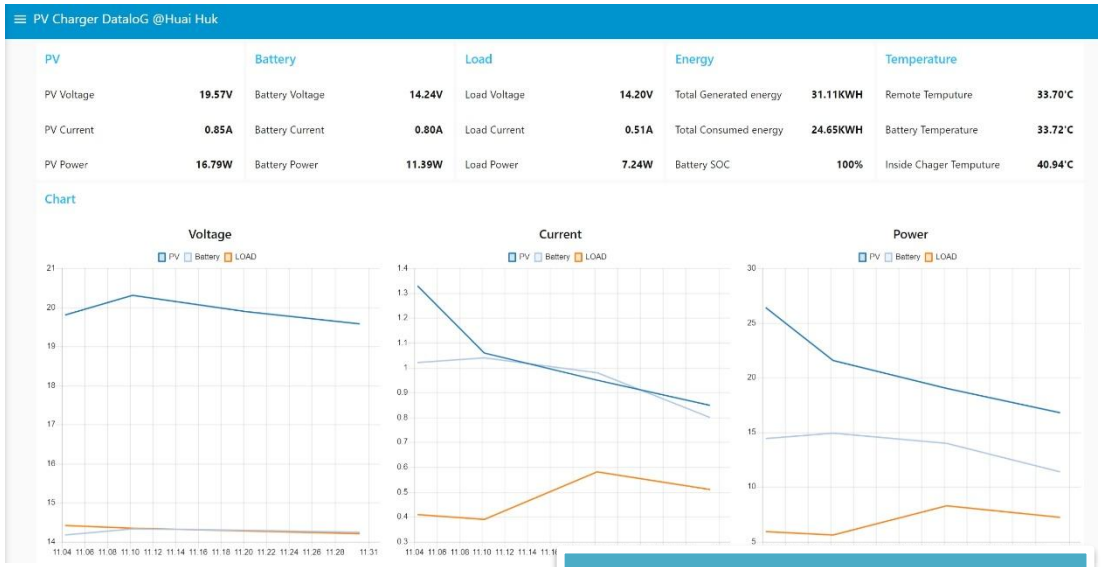


R&D results: Target #3 – Data visualization



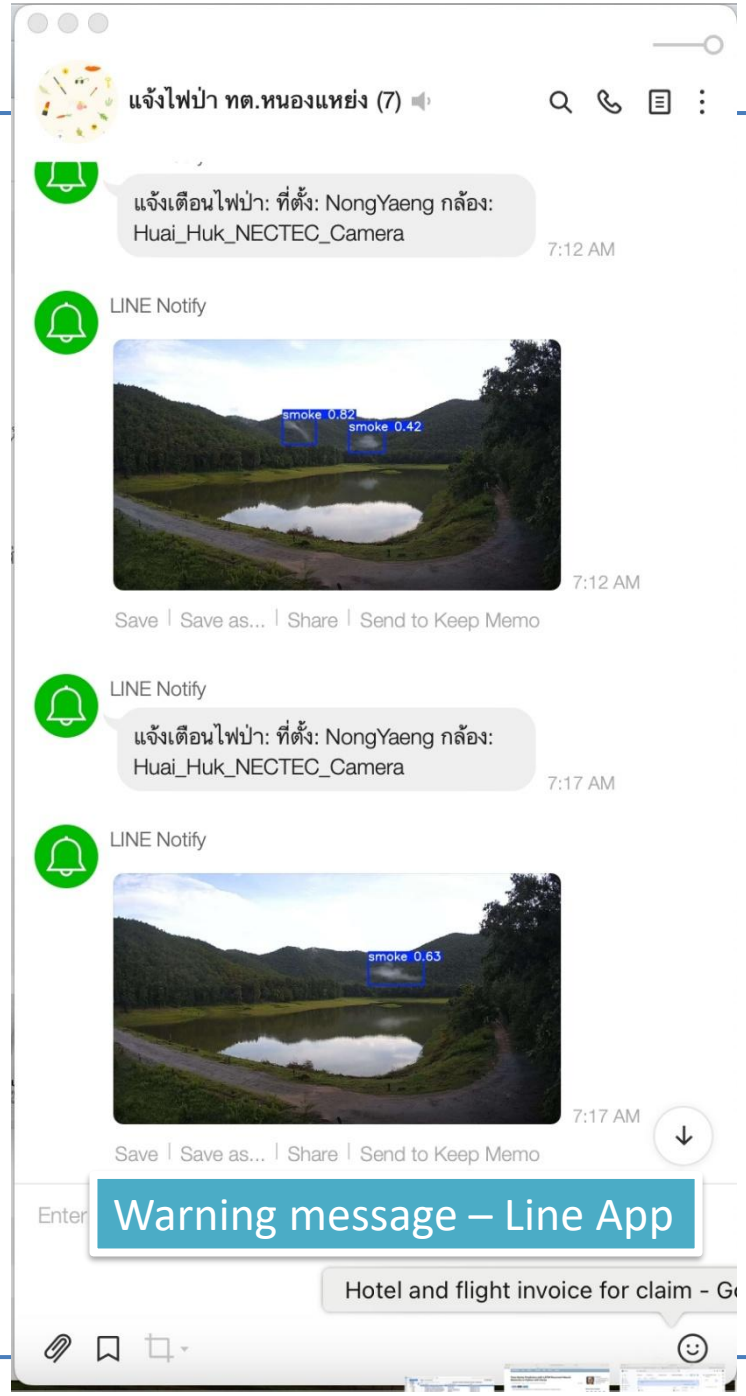
Dashboard (Web application) – Images with detected smoke





Dashboard – Solar panel

- The location of camera in each sub-district could be selected and
- The voltage, current and power of solar panel and battery are also monitored.
- The warning message of smoke detection is sent to local government via Line Application.



Warning message – Line App

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	Forest Fire Detection and Warning System for Disaster Prevention	Ye Naing and Thin Lai Lai Thein	UCSY	International Conference for Computer Applications	Feb 27-28, 2023	Yangon, Myanmar
2	Vision System for Recognition of Water Level, Rain Water, and Flood Detection	J. D. Cadion, C. Lacandora, J. D. Cruz, J. Kanjana and K. Tungpimolrut	Mapua University, NECTEC	IEEE 14th Control & System Graduate Research Colloquium	Aug 5, 2023	Shah Alam, Malaysia
3	FireSpot: A Database for Smoke Detection in Early-stage Wildfires	N. Pornpholkullapat, W. Phankrawee, P. Boondet, T. L. L. Thein, P. Siharath, J. D. Cruz, K. Murata, K. Tungpimolrut and J. Karnjana	NECTEC, SIIT, CMU, UCSY, NUOL, Mapua University, NICT	The 18th International Joint Symposium on Artificial Intelligence and Natural Language Processing	Nov 27-29, 2023	Bangkok, Thailand
4	Visual IoT System for Smore/ Fire Detection in Chiang Mai (Thailand)	K. Tungpimolrut	NECTEC	International Conference for Computer Applications	Mar 16, 2024	Yangon, Myanmar

Scientific Contribution

Presentations at International Conferences:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
5	FireSpot-Seg: A Segmentation Database for Smoke Detection in Early-stage Wildfires	Taksaorn Aksornsin et al.	SIIT, NECTEC	17th International Conference on Knowledge and Smart Technology (KST)	26 February 2025 - 01 March 2025	Bangkok, Thailand
6	Real-time Wildfire-prone Area Monitoring and Early Warning System Based on Two-stage YOLO-based Smoke Detection Model	T Chaikarnjanakit et al.	SIIT, NECTEC	International Symposium on Integrated Uncertainty in Knowledge Modelling and Decision Making	17 - 19 March 2025	Ho Chi Minh, Vietnam
7	Smoke Segmentation Improvement Based on Fast Segment Anything Model with YOLOv11 for a Wildfire Monitoring System	P Bunpleng et al.	SIIT, NECTEC, NICT	International Conference on Internet of Things, Big Data and Security	6-8 April 2025	Porto, Portugal
8	Automatic Smoke/Forest Fire Detecting System based on Visual IoT	Kanokvate Tungpimolrut et al.	NECTEC, KMITL, NICT	11th International Conference on Computing and Artificial Intelligence (ICCAI 2025)	March 28-31, 2025	Kyoto, Japan

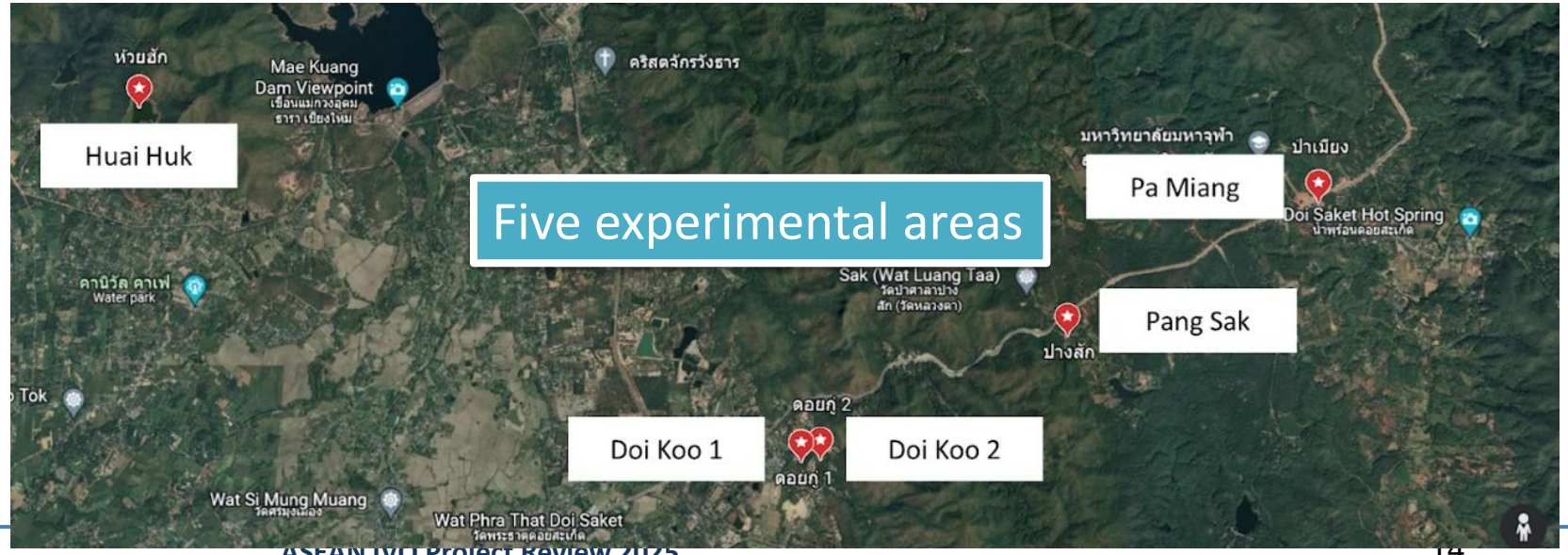
Societal Impact:

Dataset construction

Field experiment for developing an image-based dataset have been conducted in all 3 targeted sub-districts in Chiang Mai, Thailand. The dataset is open for project member to access.

Our dataset

Area	Location	Total number of fire spots	#Photos taken
1. Huai Huk	lat 18.9245582, long 99.094015	8	4,355
2. Pa Maing	lat 18.9145094, long 99.2284893	7	3,977
3. Doi Koo 1	lat 18.8854613, long 99.1708773	5	2,580
4. Doi Koo 2	lat 18.885279, long 99.1706582	4	1,887
5. Pang Sak	lat 18.9026969, long 99.203065	5	1,843
Total number of photos taken in this field experriment			14,642



Conclusion:

- **Workshop/Training Meetings**: 2 workshops, 2 sites
  - Myanmar, Lao PDR
- **Field experiments:** 3 field experiments, in 3 countries
  - Chiang Mai (Thailand) – Nong Yang, Pa Miang and Choeng Doi sub-district (5 cameras/locations in 3 sub-districts)
  - Nay Pyi Taw (Myanmar) – 3 camera/locations
  - Vientiane (Lao PDR) – 2 camera/locations
- **Perform the development of (1) System of Visual IoT camera with transmission modules (2) Algorithms for forest fire detection and (3) Data visualization as planned.**
- **8 international conference papers**