Automatic Smoke/Forest Fire Detecting System based on Visual IoT

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National Electronics and Computer Technology Center (NECTEC)

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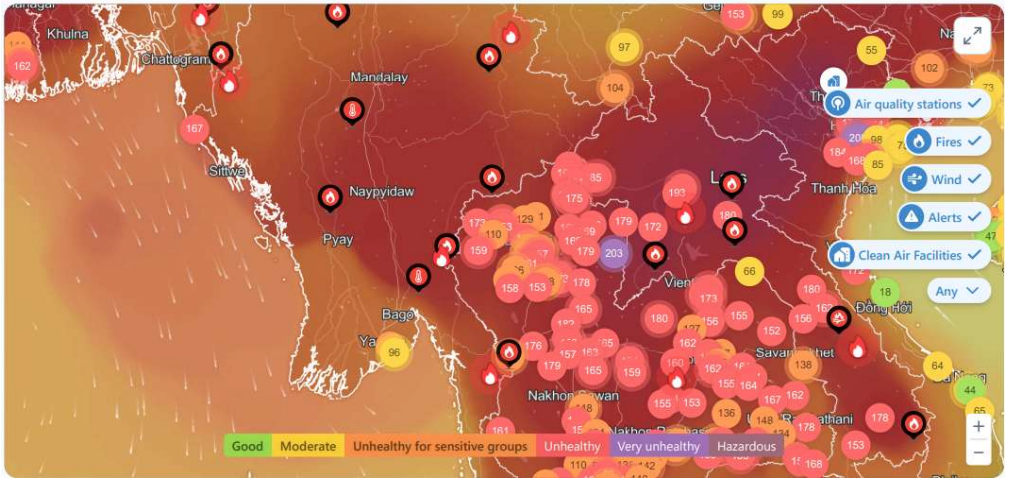
[ASEAN IVO : ASEAN ICT Virtual Organization]

The ASEAN IVO (http://www.nict.go.jp/en/asean_ivo/indes.html) project[1] titled [Visual IoT Network for Environment Protection and Disaster Prevention], was involved in the production of the contents of this work and financially supported by NICT (http://www.nict.go.jp/en/index.html).

[NICT : National Institute of Information and Communications Technology]

Air quality in Chiang Mai

Air quality index (AQI*) and PM2.5 air pollution in Chiang Mai • 16:01, Mar 25



Live most polluted city ranking

Real-time Chiang Mai most polluted city ranking

#	Cities	AQI* US
1	Chang Klan	177
2	Ban Waen	169
3	Talat Khwan	160
4	Nam Phrae	159
5	San Kamphaeng	159
6	Doi Tao	158
7	Mae Rim	158
8	Mae On	155
9	Doi Saket	153
10	Fa Ham	151

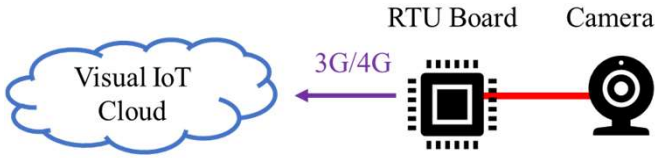
Background :

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:

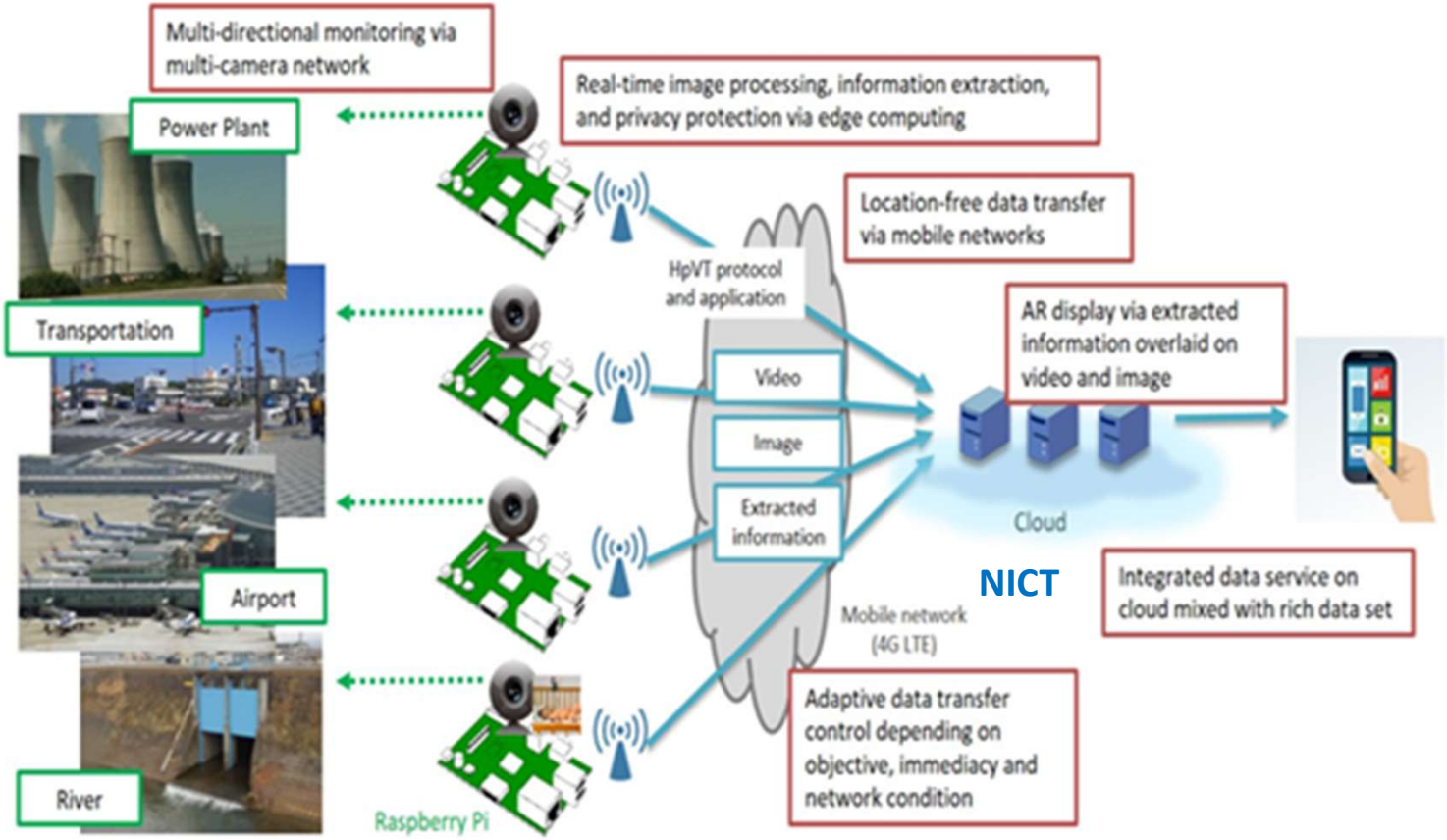
- System of visual IoT cameras with transmission modules
- Algorithms for forest fire detection
- Data visualization

Algorithms for forest fire detection



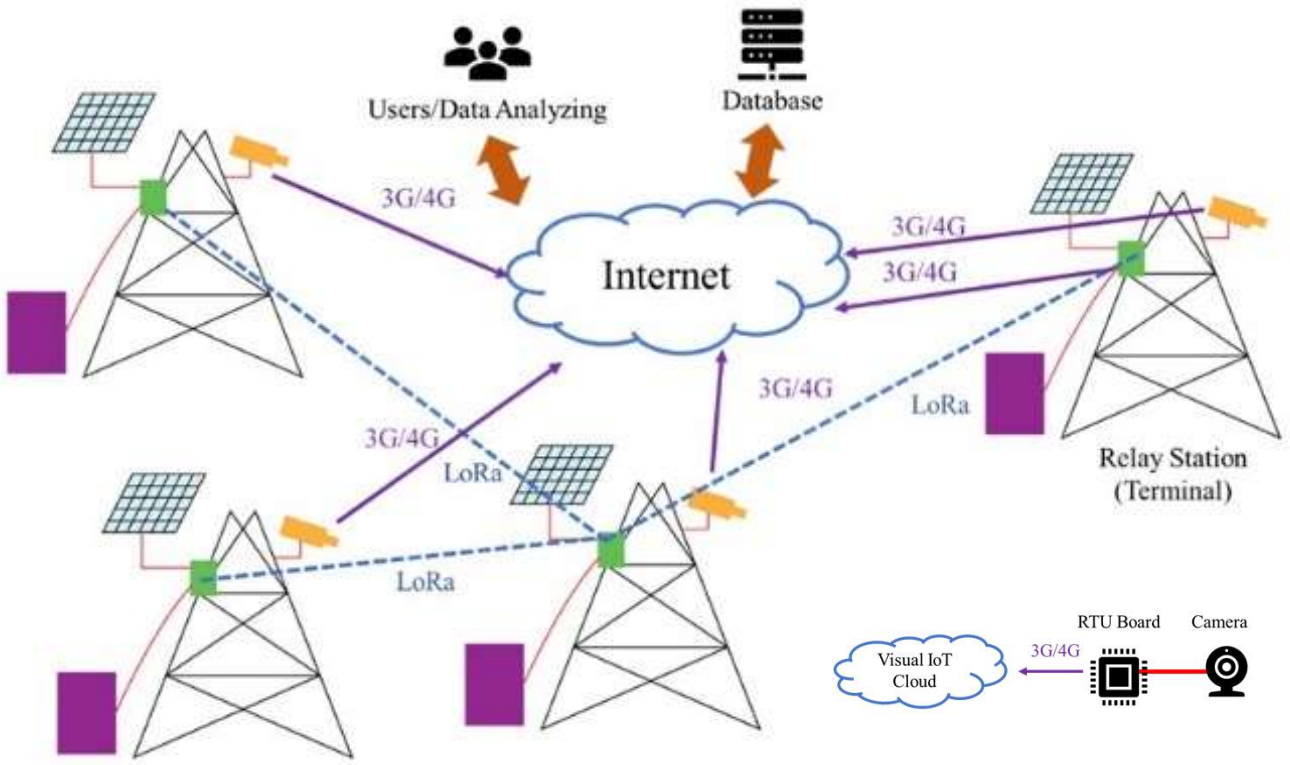
System of visual IoT cameras with transmission modules

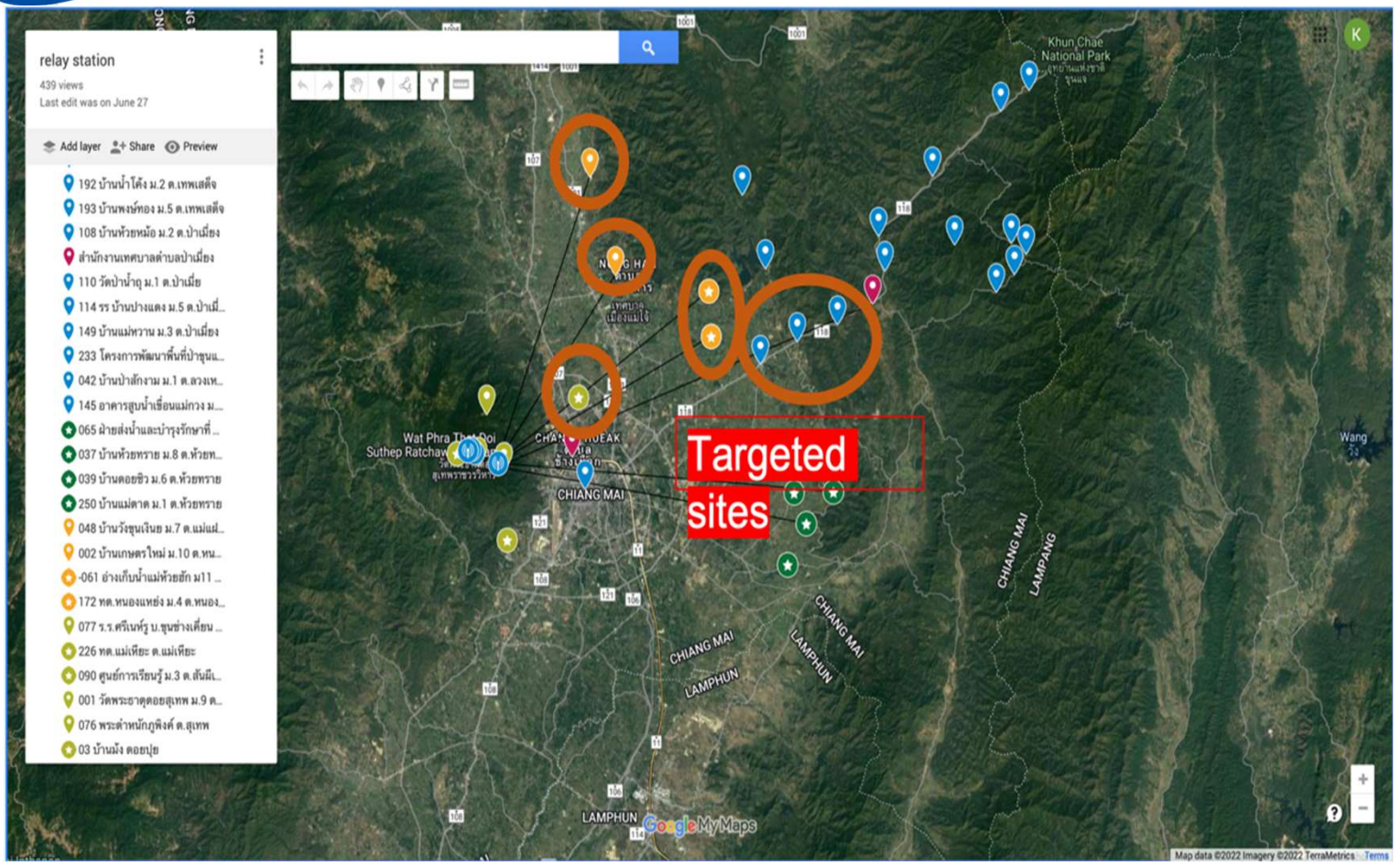
Concept of Visual IoT :



System Overview:

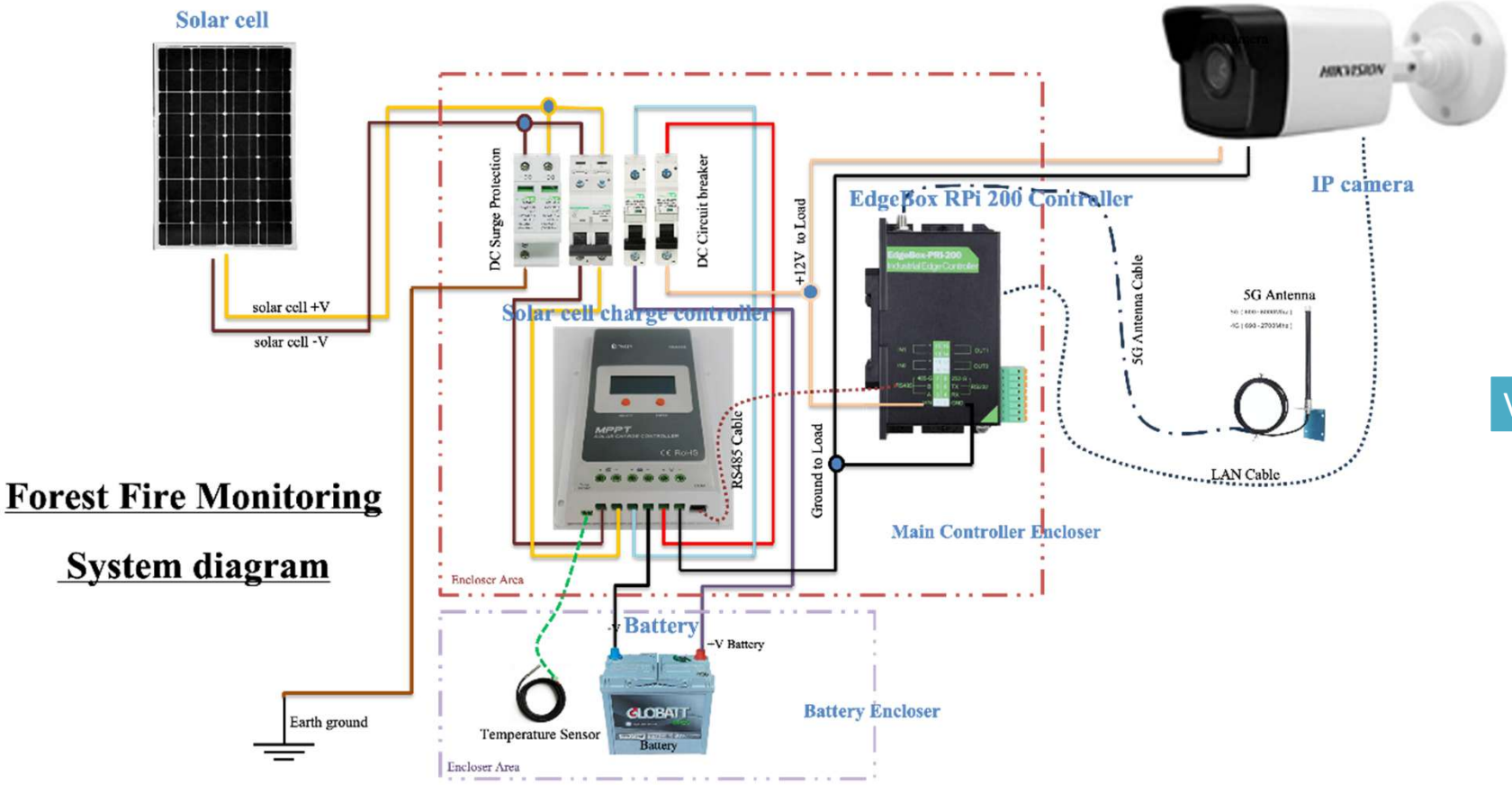
NICT (Japan)



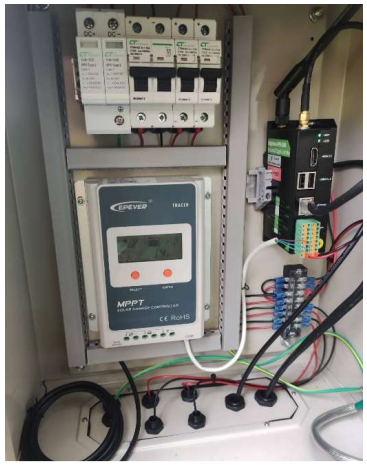


Locations of Visual IoT System installation in Chiang Mai

Hardware design and implementation



Overall system diagram



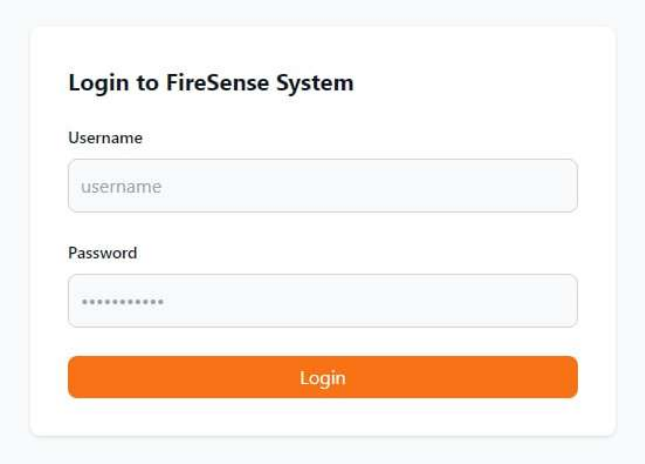
Visual IoT & transmit modules

Locations of installation

Example of taken images (in Chaing Mai, Thailand)

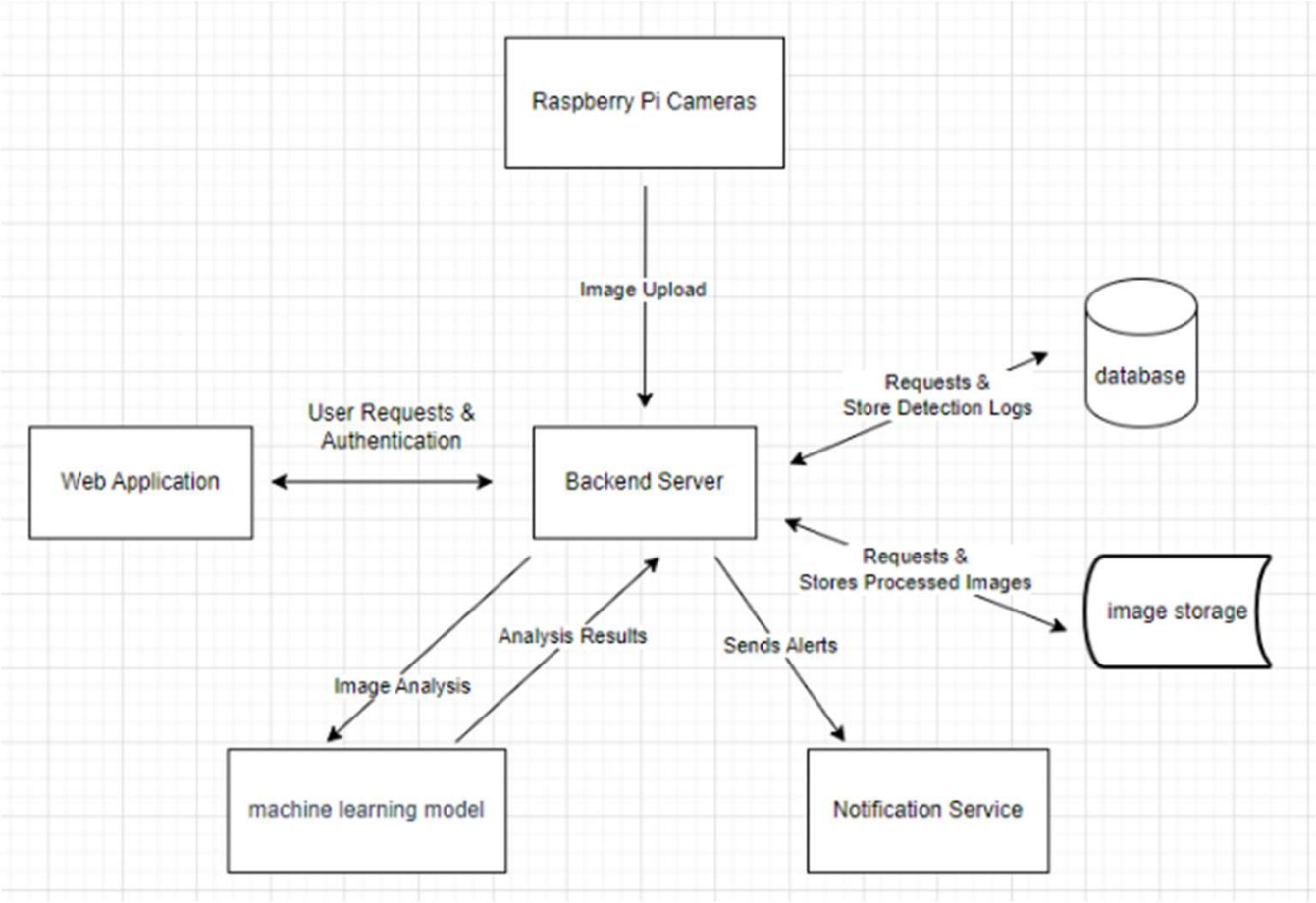
Pang Sak **Doi Koo 1** **Doi Koo 2** **Huai Huk** **Pa Miang**

Software design and implementation

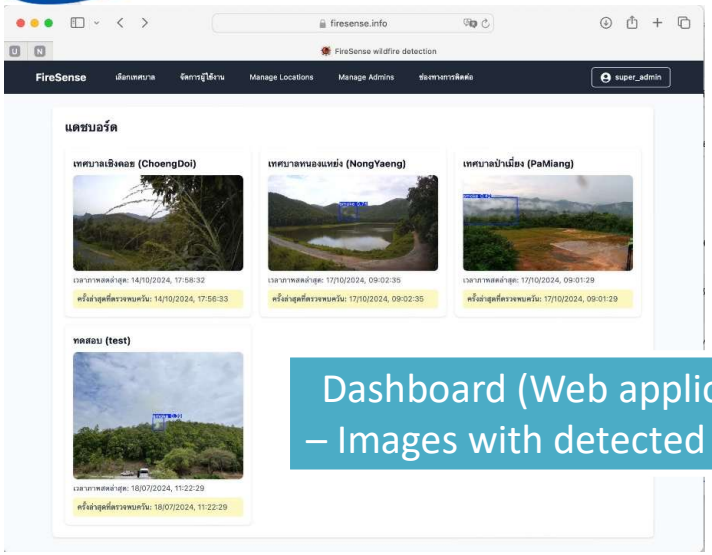


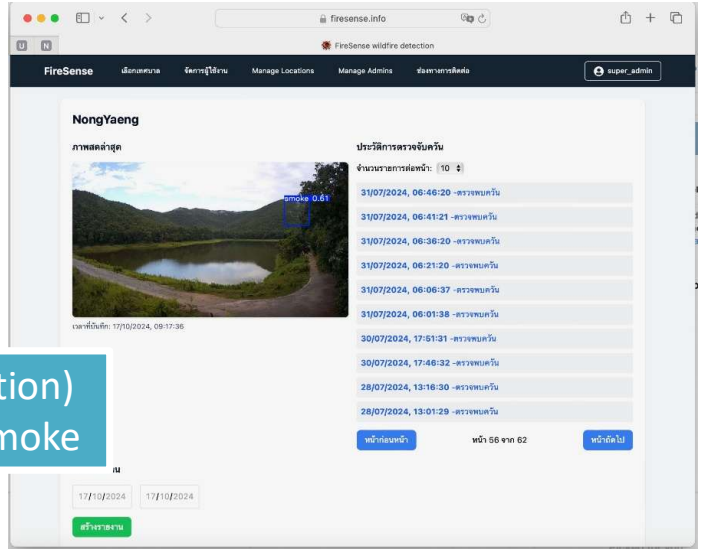
The dashboard could be browsed from the web site (https://firesense.info)

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

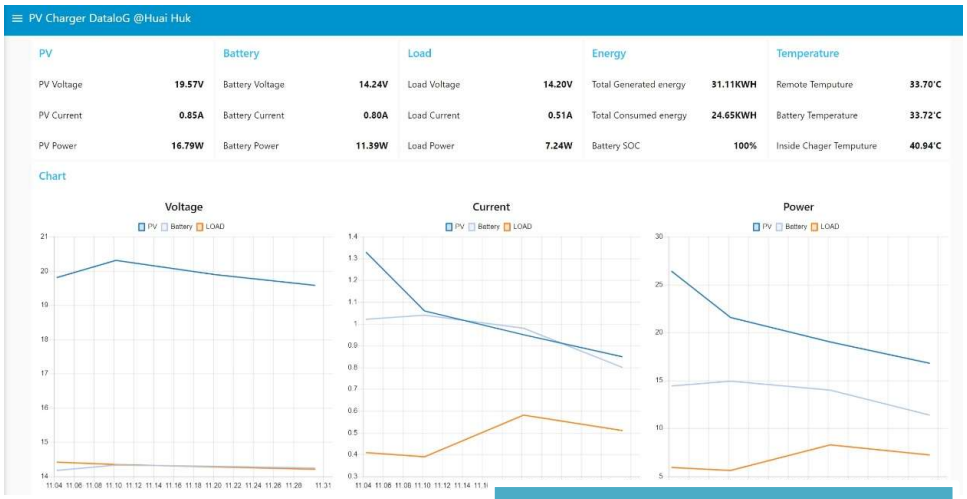


Data visualization



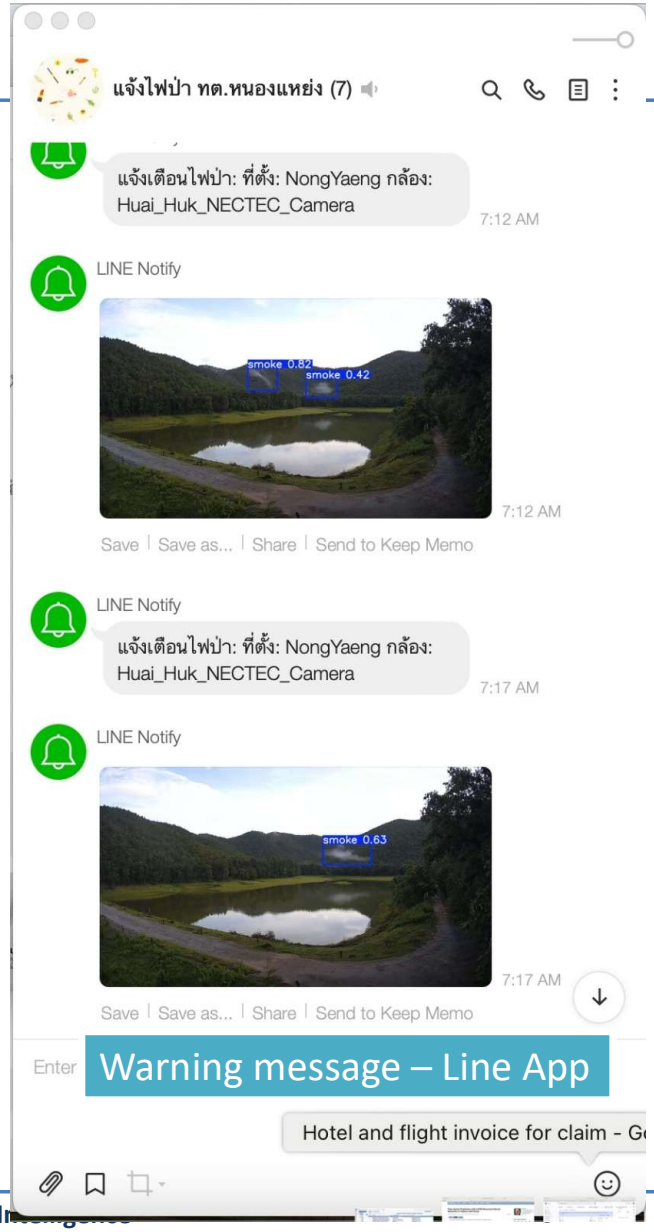


Dashboard (Web application) – Images with detected smoke



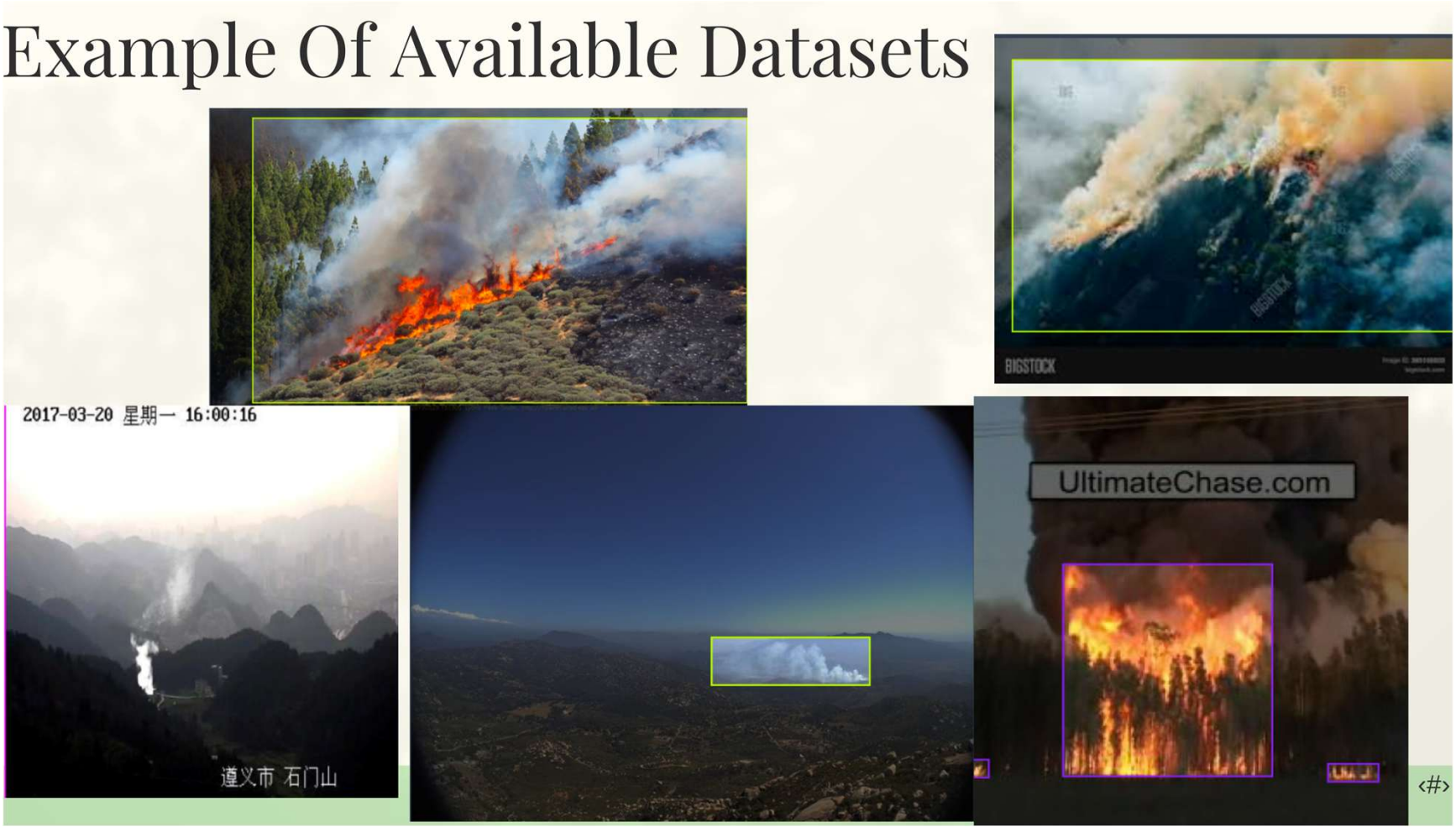
Dashboard – Solar panel

- The location of camera in each sub-district could be selected.
- 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.



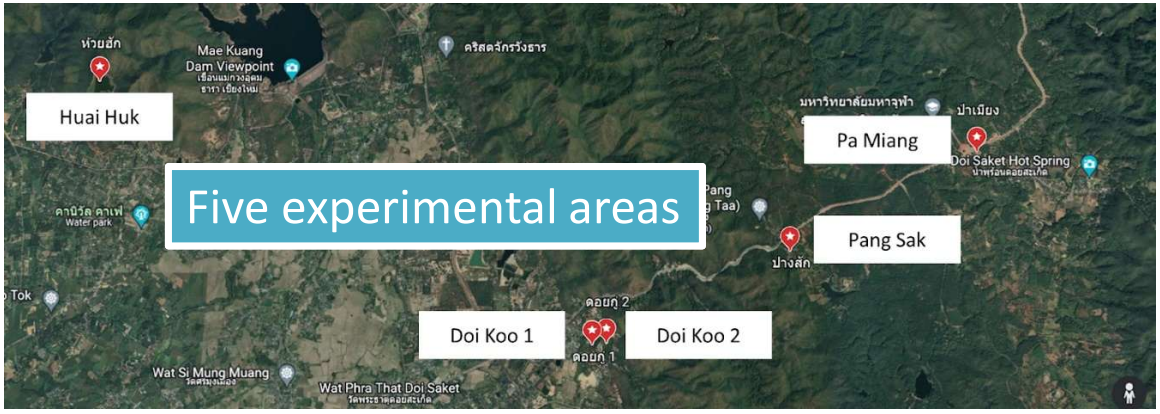
Warning message – Line App

Dataset construction

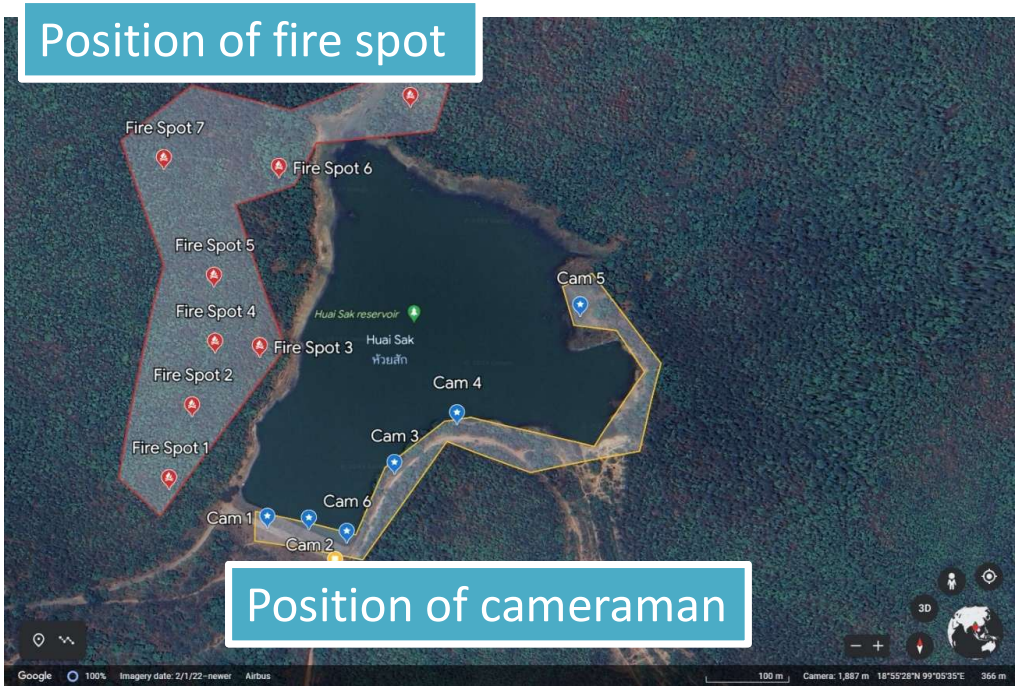


Field experiment for developing an image-based dataset have been conducted in all 3 targeted sub-districts.

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



Setting fire

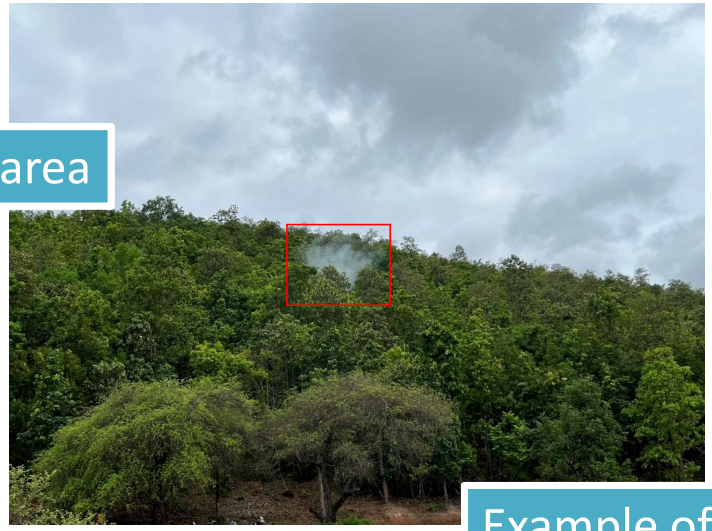


Experiment site at Hua Huk (Nong Yang sub-district)

Cameraman

Operational staffs

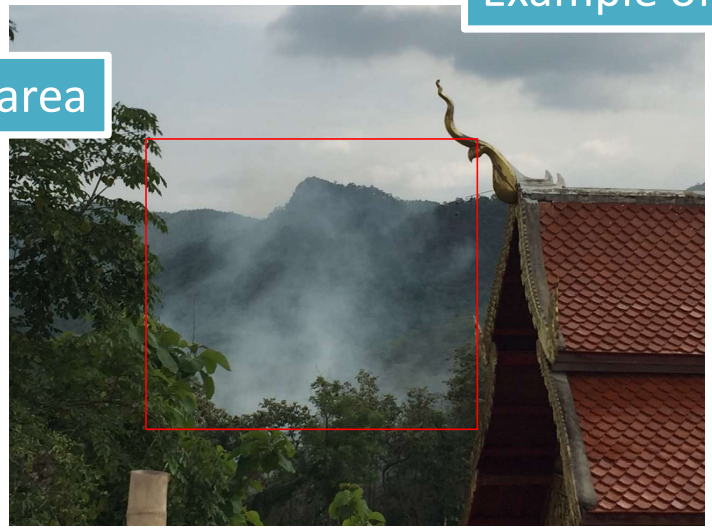
Huai Huk area



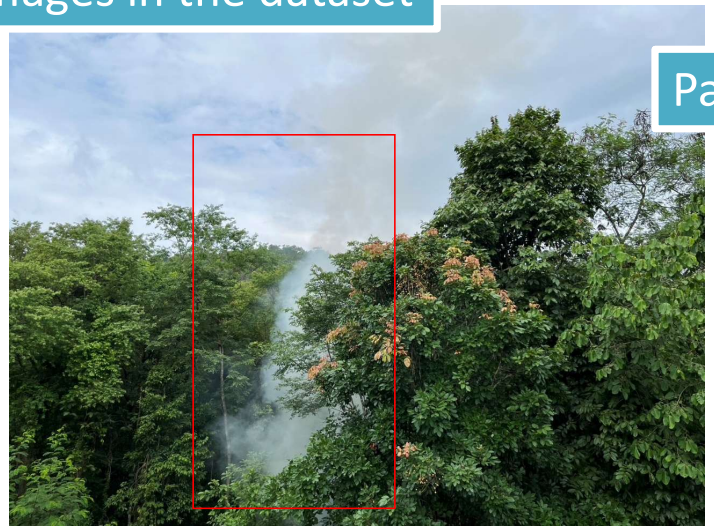
Pa Miang area

Example of images in the dataset

Doi Koo #1 area

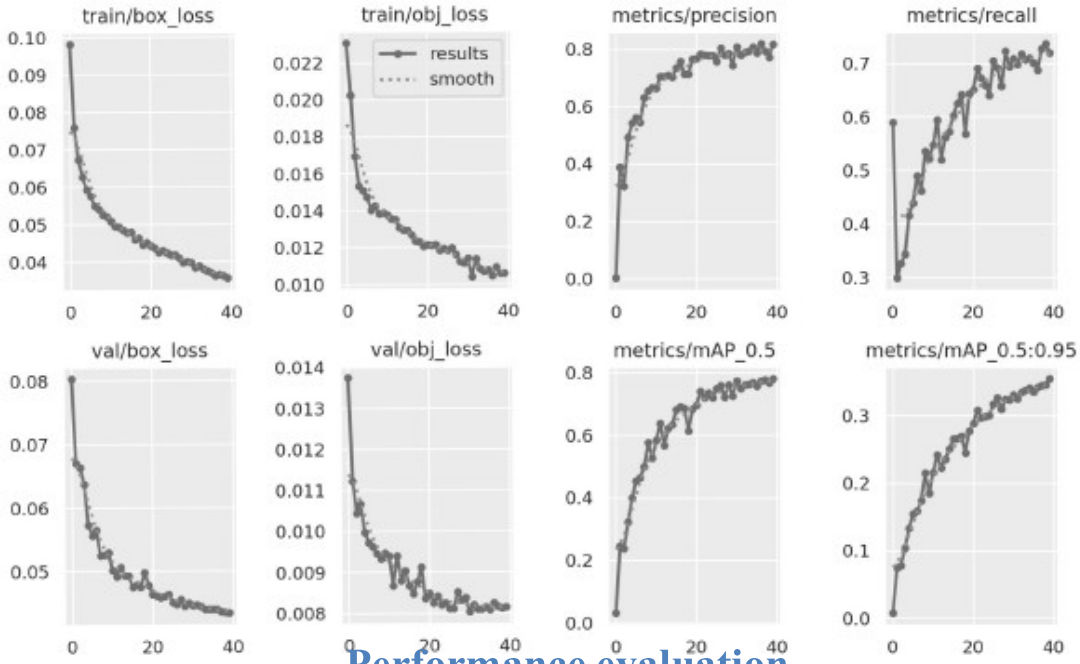


Pang Sak area



Our dataset

Algorithm for smoke detection



Smoke Detection Model

Performance evaluation

IoU Threshold	Accuracy	Precision	Recall	F1-score	Balanced Accuracy
0.3	**0.9388**	**0.974**	**0.9375**	**0.9554**	**0.9396**
0.4	0.9375	0.974	0.9357	0.9545	0.9387
0.5	0.9375	0.974	0.9357	0.9545	0.9387
0.6	0.9363	0.9739	0.9339	0.9535	0.9378
0.7	0.9338	0.9738	0.9304	0.9516	0.936

YOLOv5

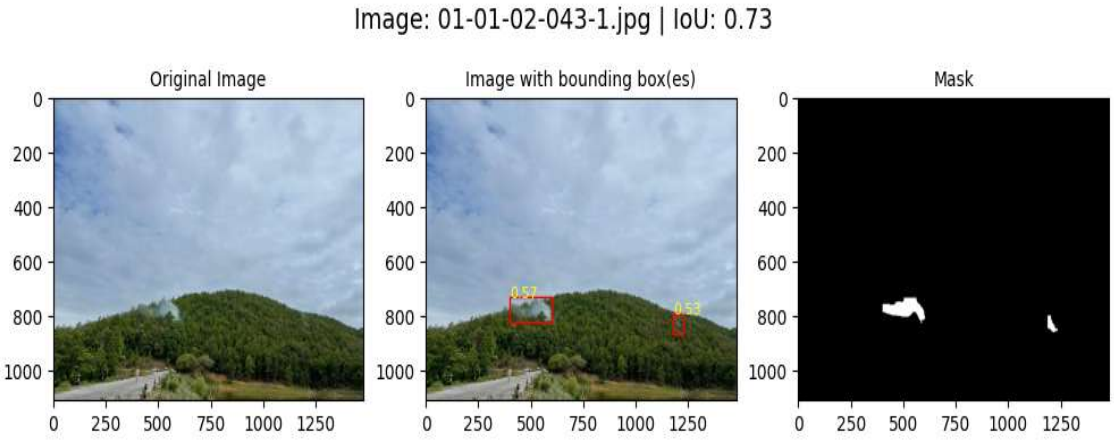
$$F_1 = 2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}} = \frac{\text{TP}}{\text{TP} + \frac{1}{2}(\text{FP} + \text{FN})}$$

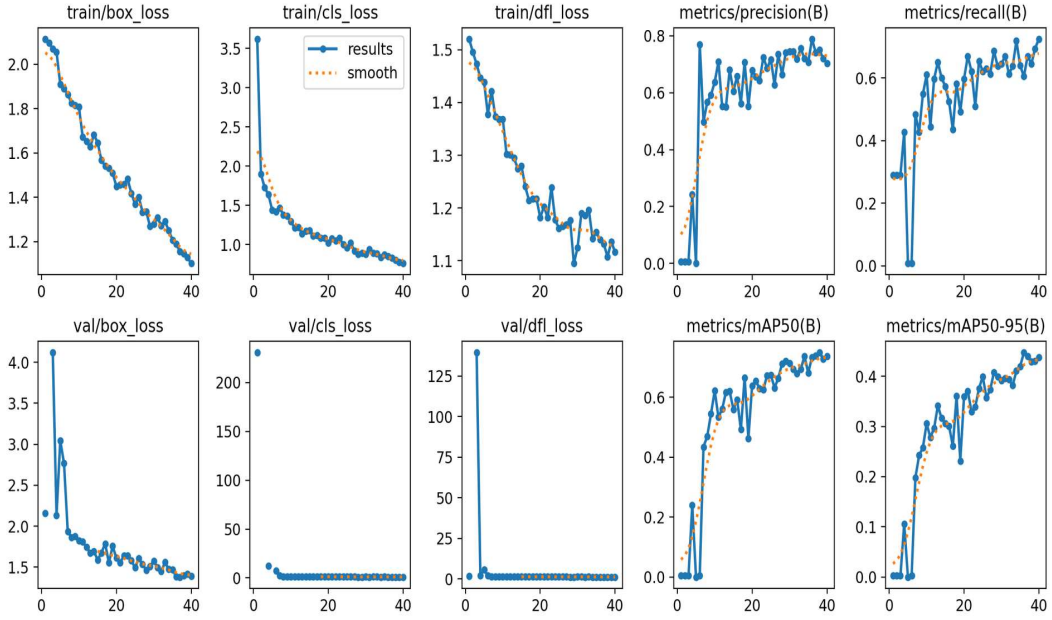
TP = number of true positives
FP = number of false positives
FN = number of false negatives

YOLOV11 Fine-tuning Performance

YOLOv11 + FastSAM + Gradient Boost

- Precision of 0.70 and recall of 0.72 on the validation set
- Mean Average Precision (mAP) of 0.74 at IoU 0.5





Conclusion:

- Visual IoT-based wildfire detection system showcases a comprehensive solution for early-stage wildfire management.
- Robust hardware and software implementation ensures reliability and sustainability in challenging outdoor environments.
- Detection accuracy of 93.88% , precision of 97.40%, and an F1-score of 95.54% could be achieved by YOLO-based object detection models and FastSAM segmentation models.
- The Segmentation step adds further value with a precision of 70% and recall of 72% enabling precise smoke localization and spread estimation.

Contact us

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