Visual IoT System for Smoke/Fire Detection in Chiang Mai (Thailand)

16 March 2024

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Outline of presentation

- Basic information of the project
- Dataset construction
- Smoke/Fire detection
- Hardware design and Installation

Basic Information of the project

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Project Title :

Visual IoT Network for Environment Protection and Disaster Prevention

Project Members :

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

NECTEC a member of NSTDA NICT MAPUA UNIVERSITY SIIT 25th ANNIVERSARY

Acknowledgement:

This presentation is the output of the ASEAN IVO (http://www.nict.go.jp/en/asean_ivo/index.html) project, and financially supported by NICT (http://www.nict.go.jp/en/index.html).

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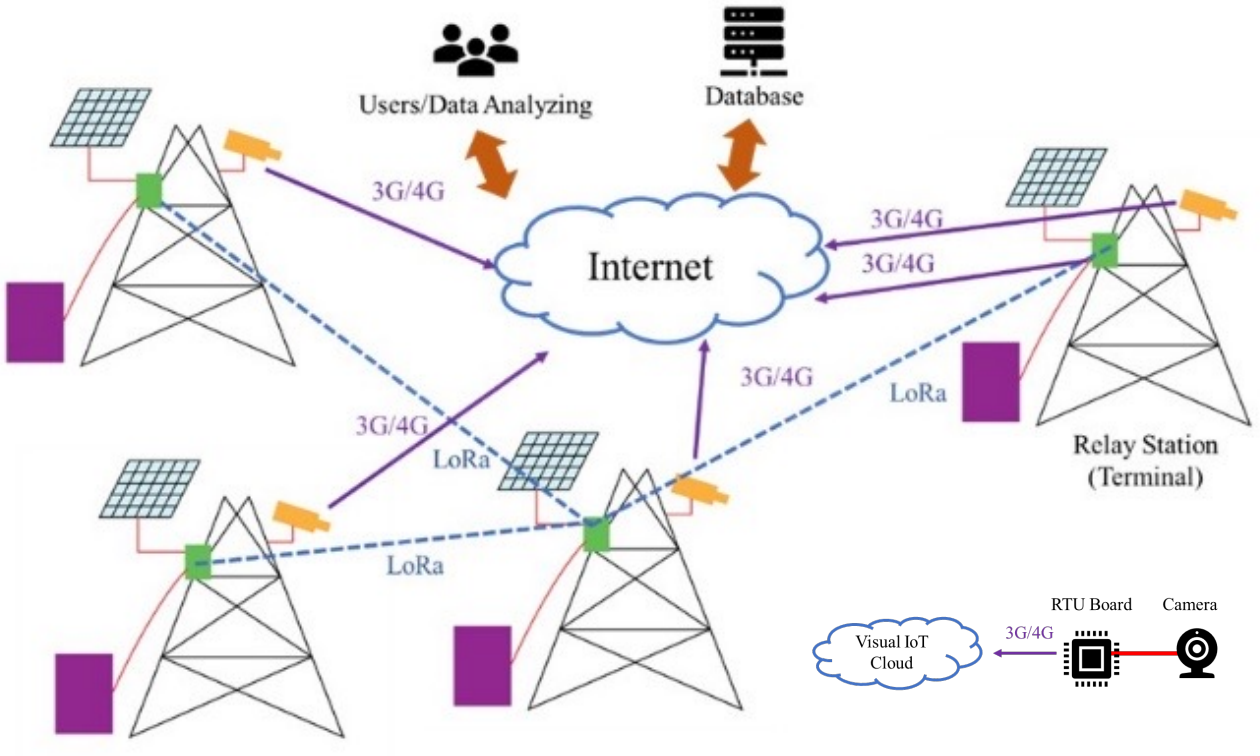
Background :

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 conjunction with other sensors such as satellite image 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

System Overview



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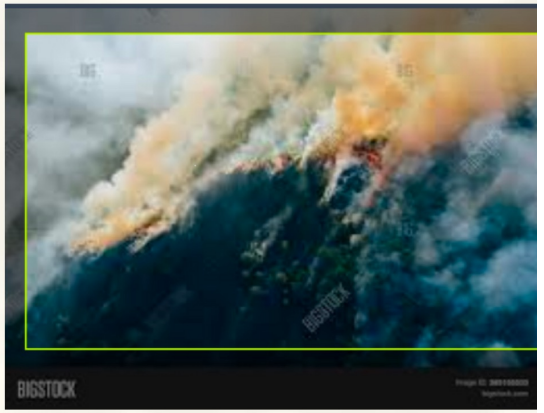
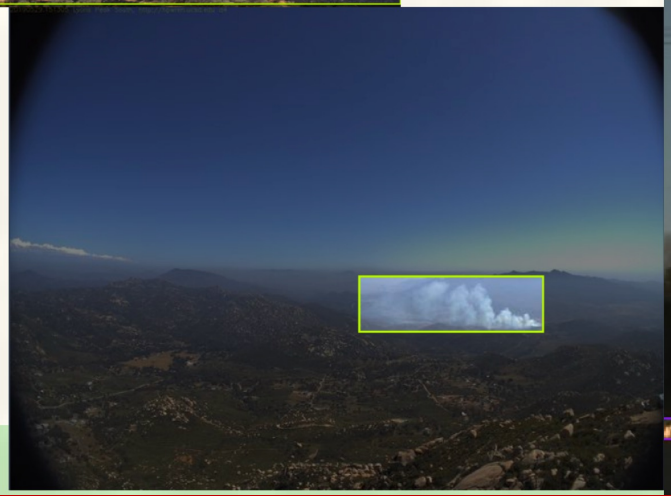
Example Of Available Datasets





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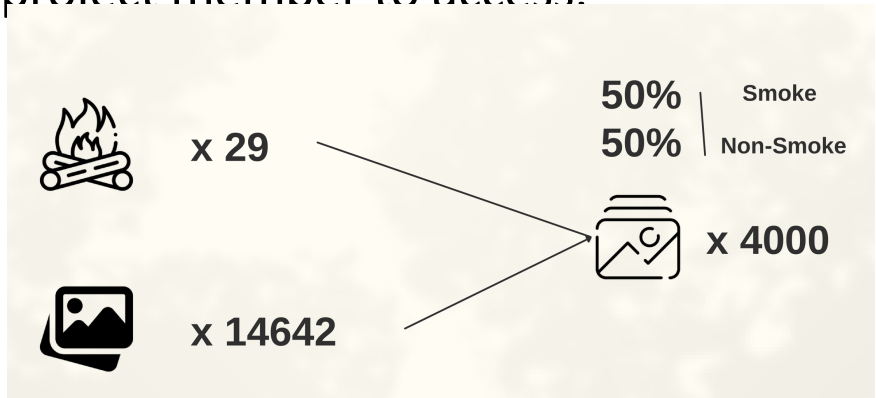
Dataset construction

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

The dataset is open for project member to access.

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 experiment			14,642



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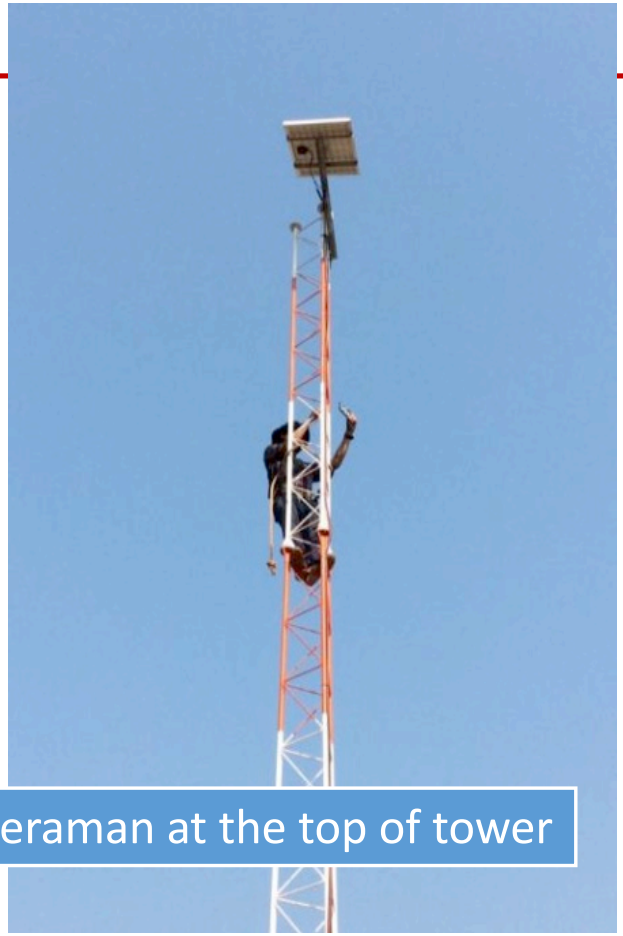
The procedural activities are summarized as follows.

- Local government officers responsible for setting fire were ready at a planned and designated position (fire spot)
- They made smoke for half an hour for one fire spot.
- Four cameramen, including one at the top of tower, were ready to take photos (snapshot and video) from before the appearance of smoke until it died out.
- Once the fire was set, the camerapersons took photos from different viewpoints simultaneously.
- Then, the local government staff moved to the following designated spot and repeated the procedure.

Meeting with local government officer

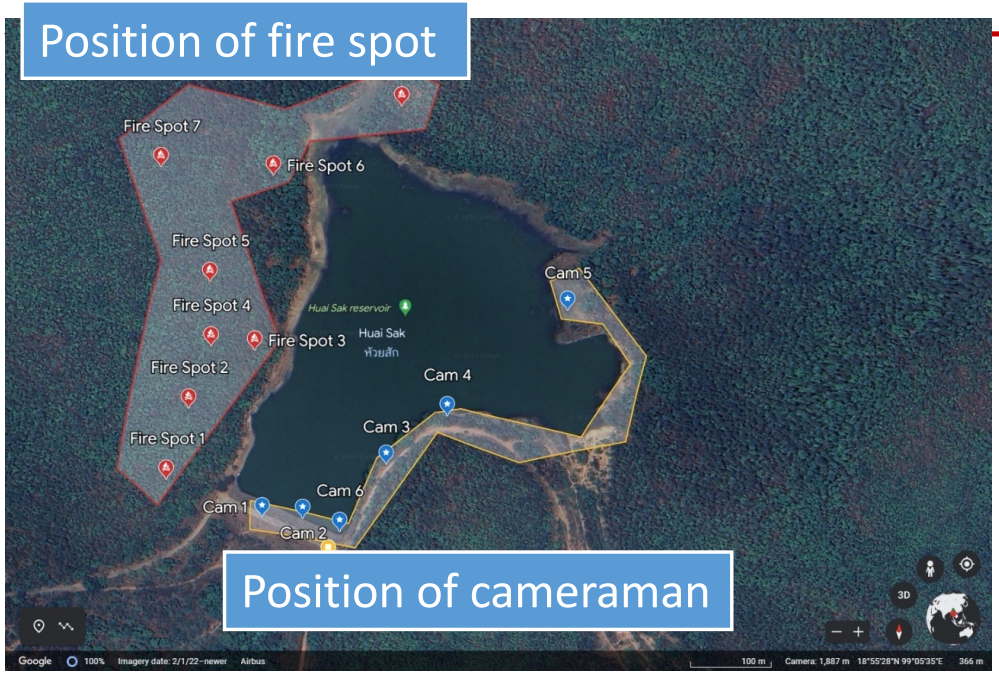
Local government staffs

Fire / smoke setting and extinguishment



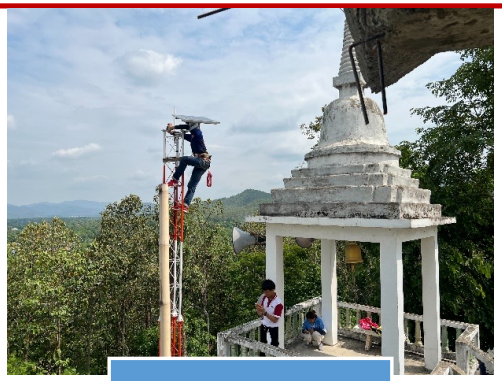
Cameraman at the top of tower

Example of taken image



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

Setting fire



Operational staffs

Cameraman

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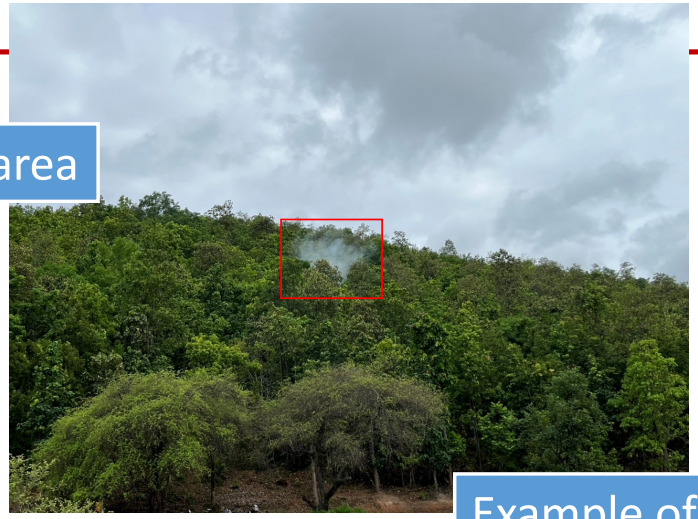
Hua Huk area

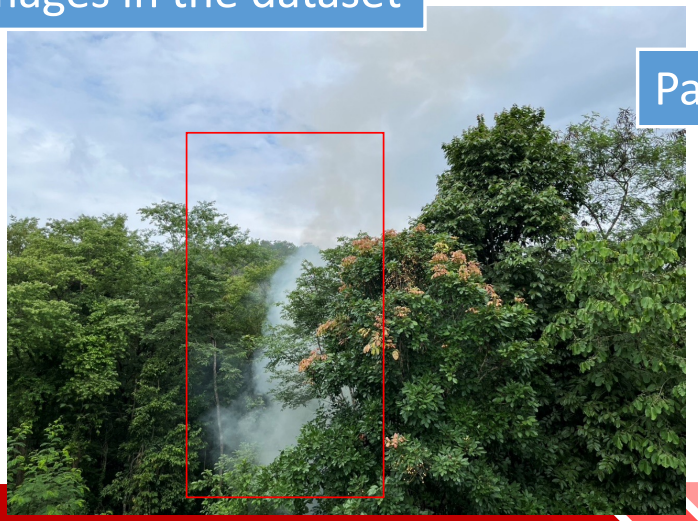


Pa Miang area

Example of images in the dataset

Doi Koo #1 area

Pang Sak area



Our dataset

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Smoke/Fire detection

YOLOv5

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

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

TP = number of true positives

FP = number of false positives

FN = number of false negatives

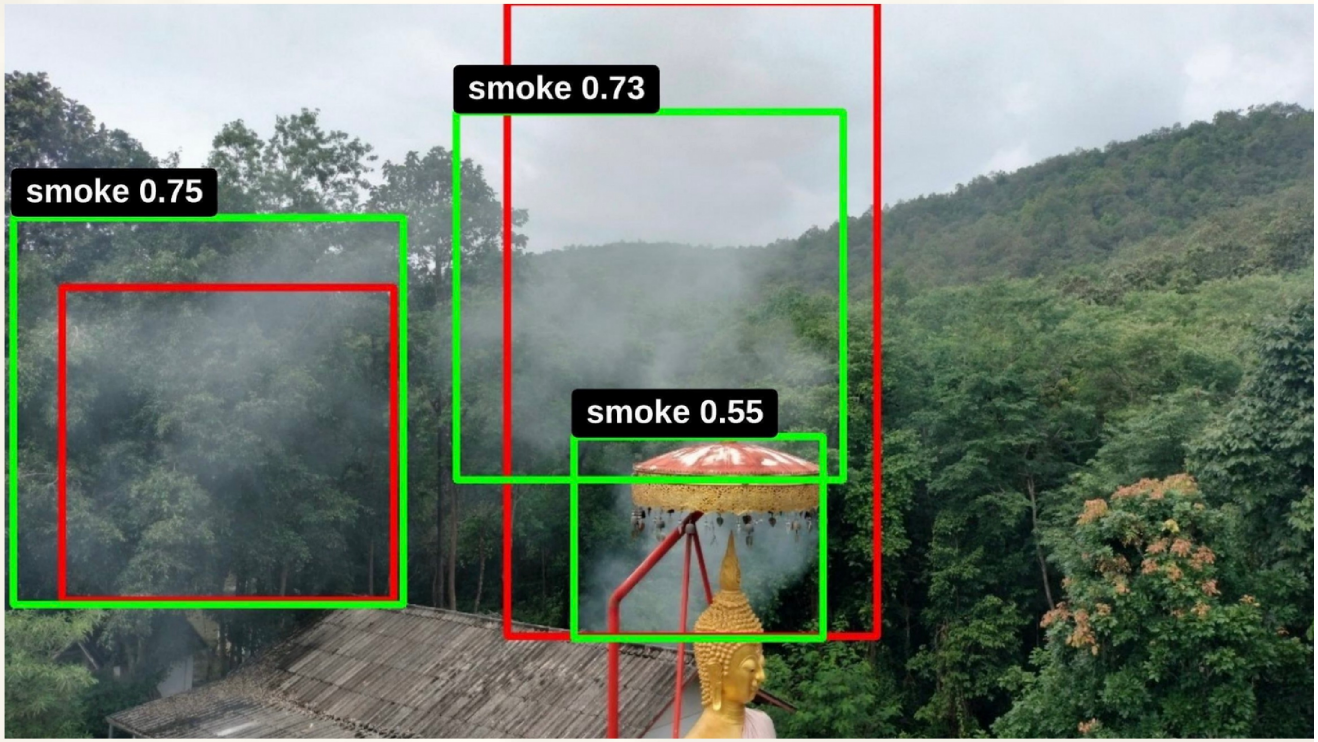
The evaluation metrics

Metrics of 4-fold cross validation

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	0.97
4	0.7631	0.6948	0.7364	0.3359	0.9616

Custom Evaluation

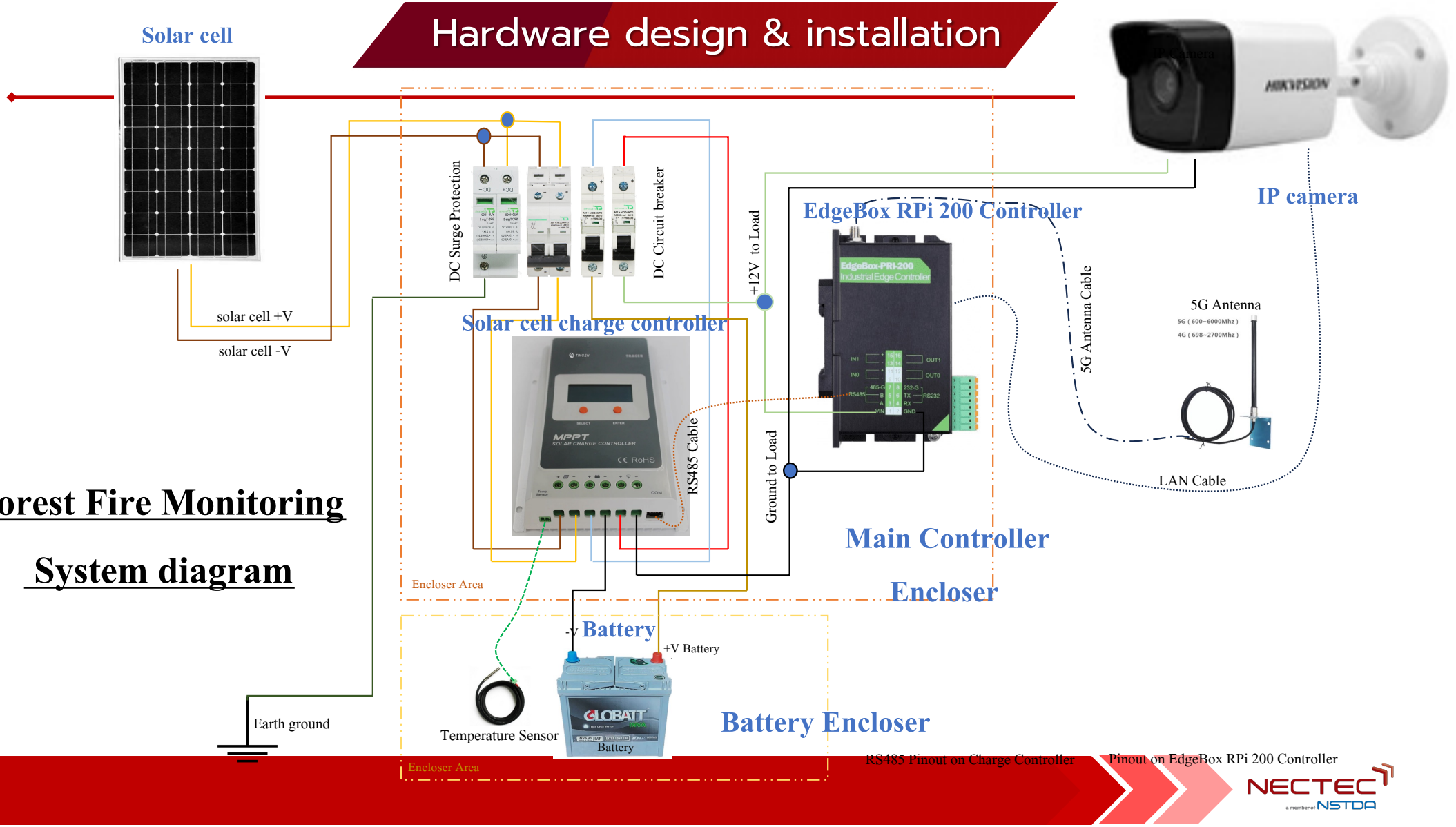
- image with smoke is counted as a TP if the model detects at least one smoke area with an IoU value larger than a predefined threshold; otherwise, it is considered a FN.
- image without smoke is counted as a TN if the model detects no smoke objects; otherwise, it is considered a FP.



Performance evaluation of our YOLOv5 – based smoke detection

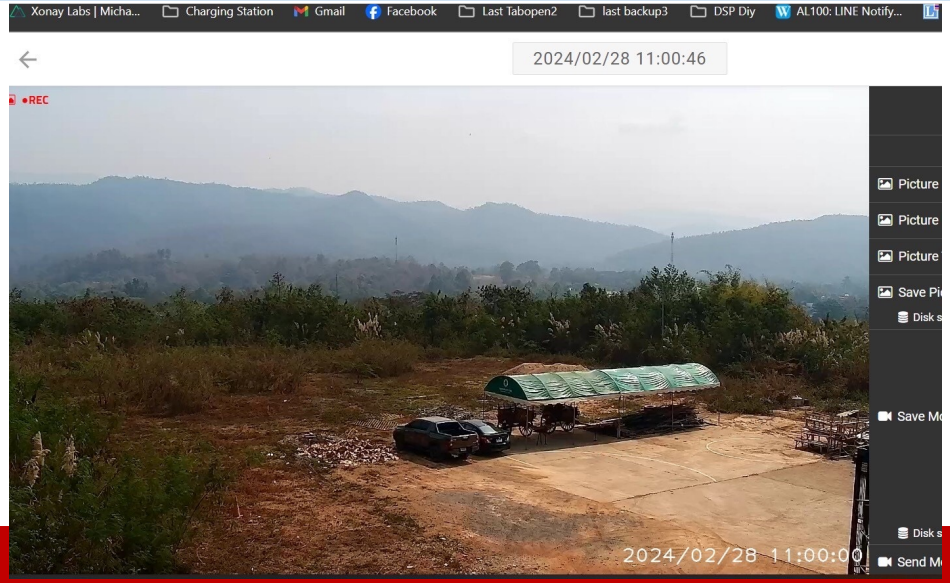
IoU Threshold	Accuracy	Precision	Recall	F1-score	Balanced Accuracy
0.3	**0.9388**	**0.974**	**0.9375**	**0.9554**	**0.9396**
0.4	0.9375	0.974	0.9357	0.9545	0.9387
0.5	0.9375	0.974	0.9357	0.9545	0.9387
0.6	0.9363	0.9739	0.9339	0.9535	0.9378
0.7	0.9338	0.9738	0.9304	0.9516	0.936

Hardware design & installation



Forest Fire Monitoring System diagram

System installation and sample image at Pa Miang area



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System installation and sample image at Huay Hug are

Conclusion

- Visual IoT system has been used for detecting smoke or early stage of forest fire in Chiang Mai (Thailand) and Myanmar
- 4,000 images of the dataset have been constructed
- Prediction of smoke/fire using YOLOv5 return accuracy of 93.88 %
- 5 sets of Visual IoT system have been installed in 3 targeted sub-district in Chiang Mai since Mar 1, 2024

Contact us

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