Project FireFly: UAV-IoT Systems for Early Forest Fire Detection and Environmental Monitoring in Northern Thailand

Dr Henrik Hesse, Dr Dinesh Bhatia, Dr Kampol Woradit

Institutions: University of Glasgow Singapore (UGS), RMIT Vietnam, Chiang Mai University (CMU)

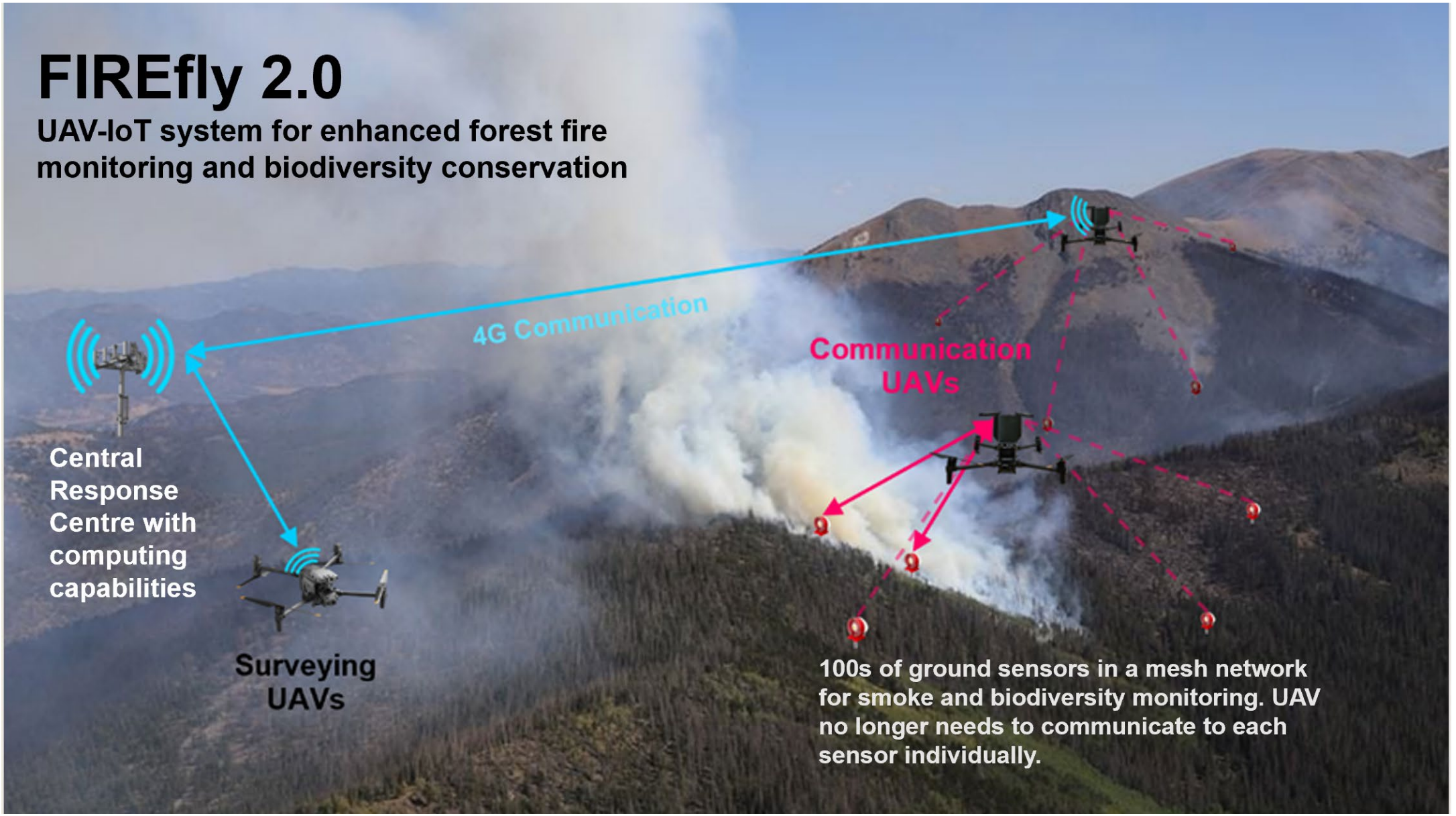
Background : Haze in Southeast Asia especially in Northern Thailand

- Chiang Mai region suffers from haze during dry season
- Caused by wildfires in mountain region
- Health and social effects on population

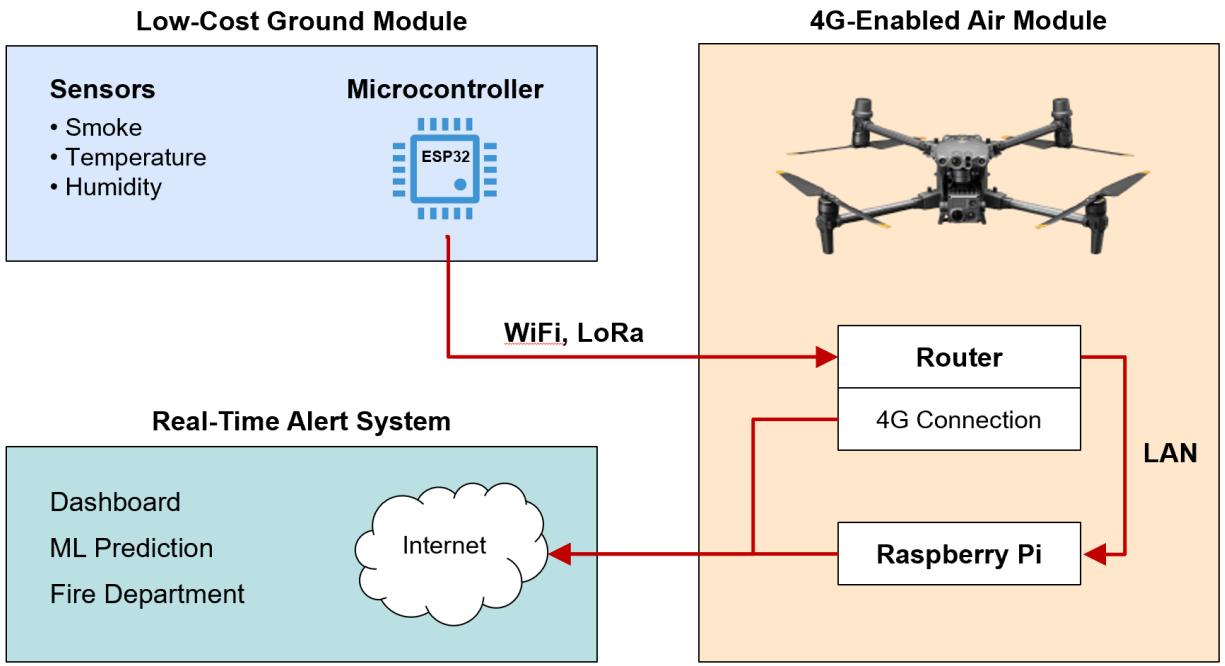
Targets: **Requires early detection to prevent Extreme Wildfire Events**

- Deploy a large network of IoT sensors and UAVs for enhanced data collection, communication, and early fire detection.
- Analyse real world data using ML algorithms for enhanced fire prediction.
- Develop an online dashboard for real-time analysis, alerts, and community engagement.
- Establish a network of UAV communication systems to support multiple remote applications.
- Integrate tree health monitoring and wildlife surveillance using IoT based camera traps.
- Quantify the carbon sequestration potential of reforested areas through tree health monitoring.

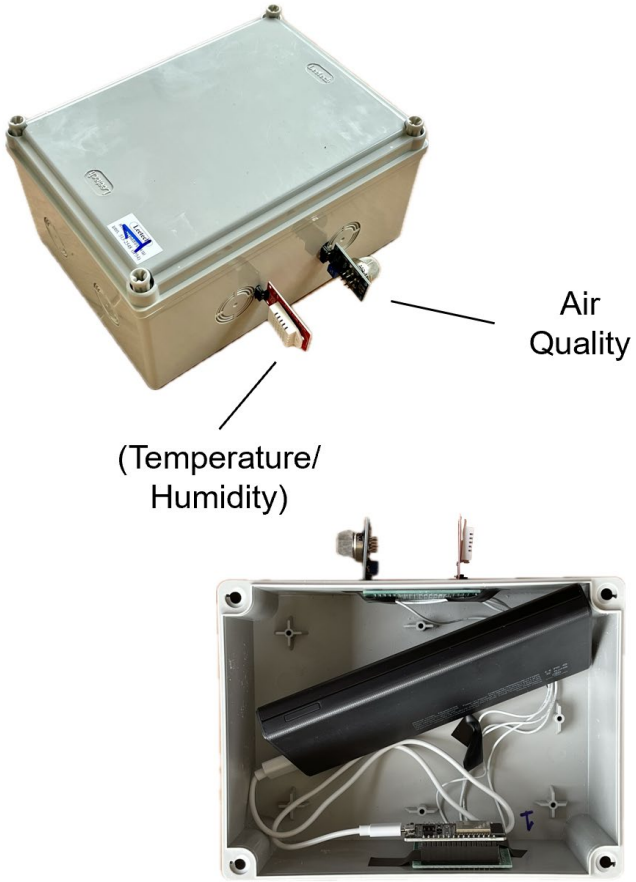
Proposed Method: Overall Concept



Proposed Method: Communication Strategy



Puttapirat et al. UAV Development for Distributed Sensing of Forest Fires, 2024.



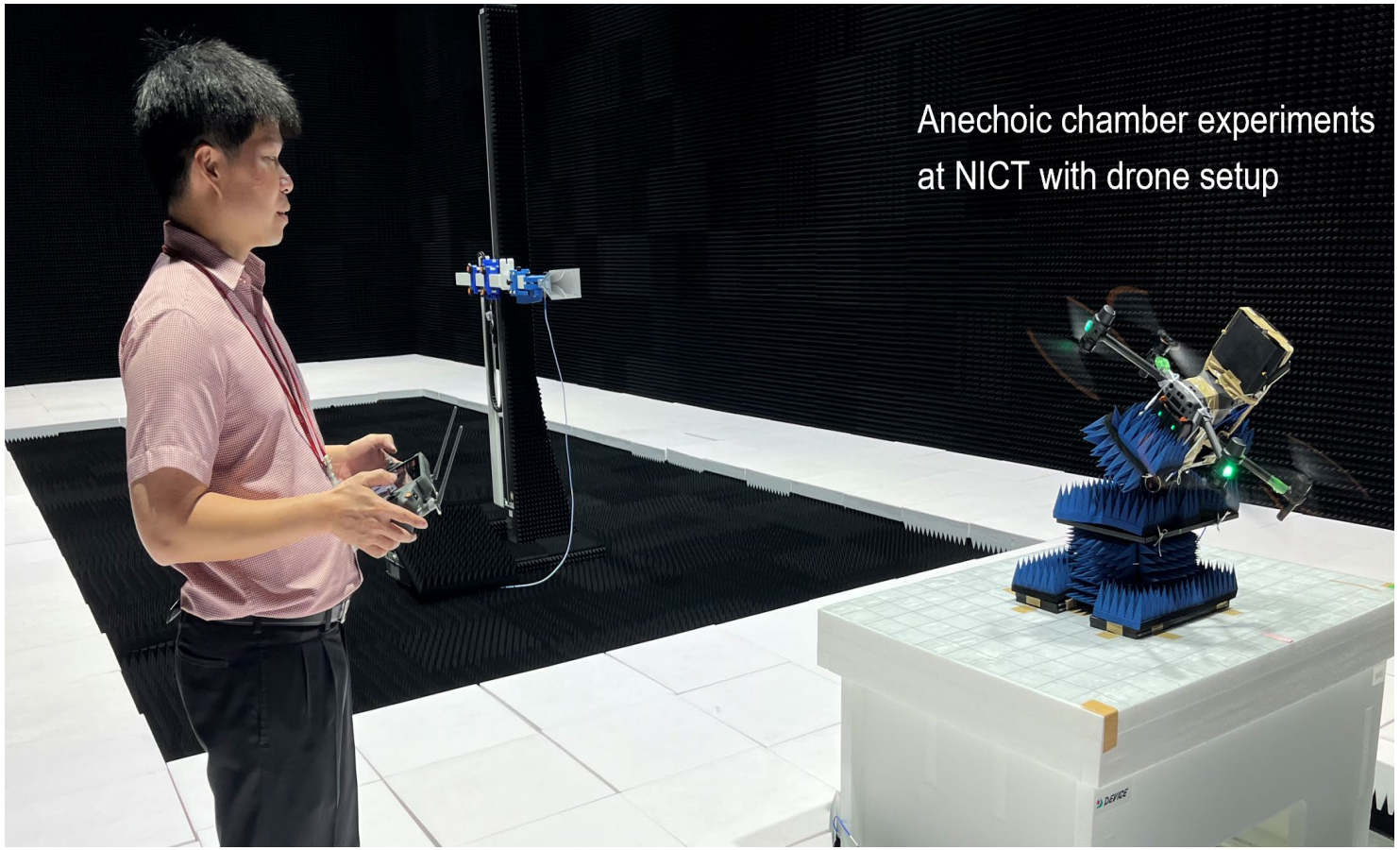
Low cost sensor modules connected to the ESP 32.

Battery with integration of solar panel

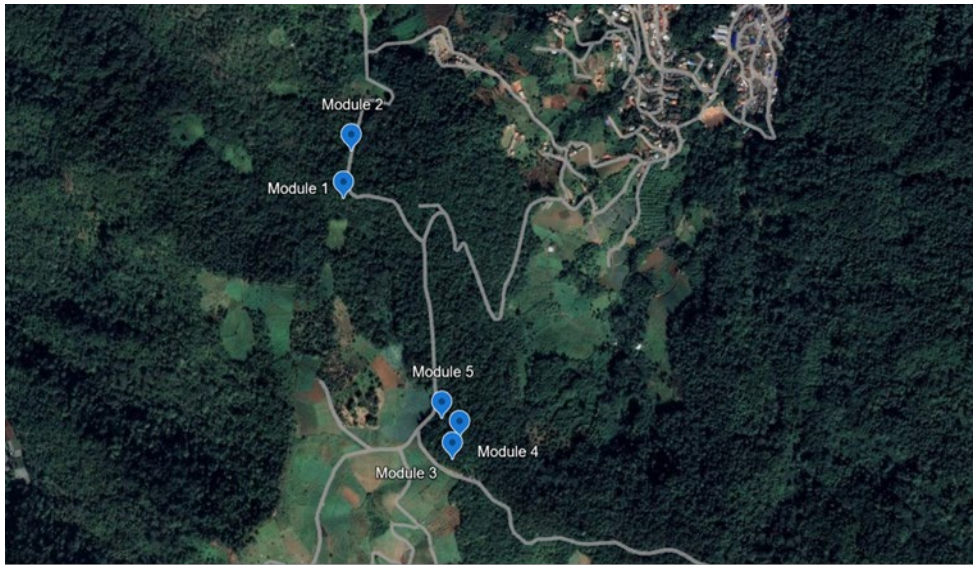
Goal: Perpetual operation of smoke Sensors for early detection of forest fires

Proposed Method: Communication Strategy

Proposed Method: Experimental Setup



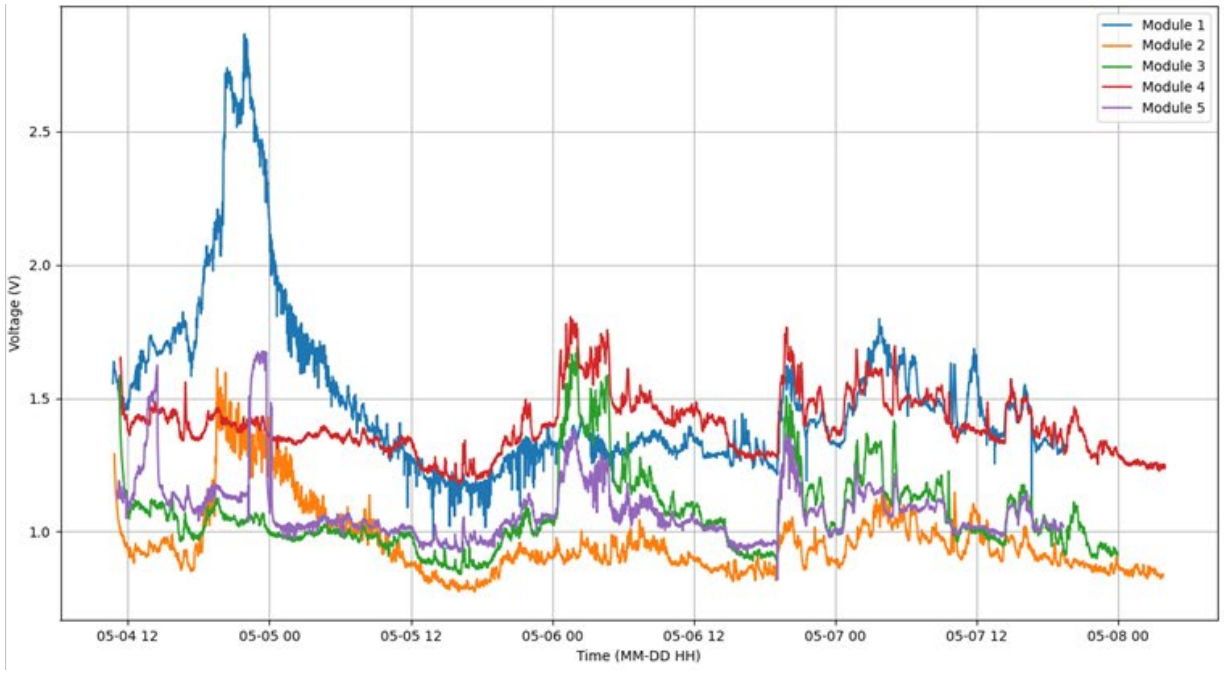
UAV setup tested in Anechoic Chamber to check for signal interference to ensure reliable connectivity to ground sensors.



Ground sensors deployed at multiple locations in Chiang Mai.

Validation with actual fire events :(

Impact: Capture of Real Forest Fires



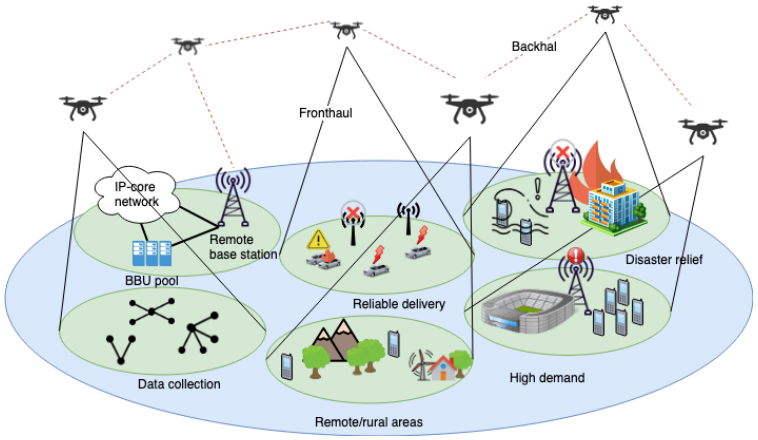
Forest Fire Event: Fires near Ban Mae Sai Village on 3-5 May 2024 captured by Module 1

Impact: One step towards forest fire detection and prediction

Small step towards early detection of wildfires (and hopefully prevention)

Hybrid UAV-IoT communication extends the capabilities of IoT applications to Internet of Drones*

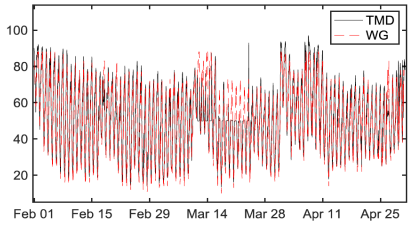
Development of a prediction model and dashboard for real-time alert of fire department #



Input Data

Time series weather data

$T(t), p(t), h(t), r(t), V_W(t), \theta_W(t)$



ML Models

Random Forest

Support Vector Machines

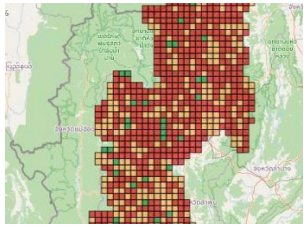
Transformers

Model Ensemble

Model Output

Risk levels of fire

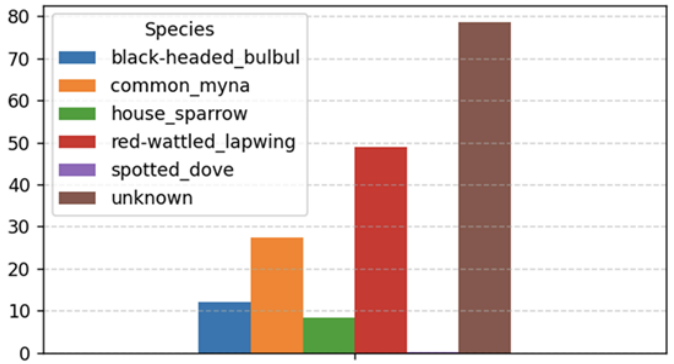
$P_r(T, p, h, r, V_W, \theta_W, x, y)$



*Hesse et al. Workshop: Digital Solutions for Natural Event Management. IEEE World Forum on Internet of Things (WF-IoT), 2023.
#Puttapirat et al. Forest Fire Monitoring and Prediction Using Machine Learning. IEEE Conference on Artificial Intelligence and Machine Learning, 2024

Output/Outcome: A validated concept with new capabilities

- A newly developed mesh network deployed with enhanced capabilities. Super Node and Child Node concept used.
- Multiple nodes deployed in two sites:
  - Pong Yang North (3.9 Acres) and
  - Mon Cham (1.2 Acres) virgin restoration plot added to the project in June 2025 to assess Biodiversity conservation and Forest Restoration
- Common bird species identified
- Seed dropping trials conducted using UAV



Conclusion

- Initial target of FIREfly project was to develop a low-cost reliable sensor network to detect fires.
- Our developed sensor network showed capability to detect real-world forest fire events
- UAV-Ground sensor connectivity was successful in capturing data
- Enhanced our sensor network capabilities for biodiversity conservation applications
- UAV deployed for multiple applications including communication and seed dropping
- Project has led to increase collaboration with local indigenous communities
- Ultimate aim is to expand the project capabilities across the region and develop a robust solution

Thank you for listening. We are looking forward to many more impactful projects together!

Henrik Hesse – University of Glasgow, Singapore

Dinesh Bhatia – RMIT University, Vietnam

Kampol Woradit – Chiang Mai University, Thailand