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# Real-time UAV Localization and Tracking in Multi-Weather Conditions using Multispectral Image Analysis

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# INTRODUCTION



Unmanned Aerial Vehicles (UAV), also known as drones, have become increasingly popular due to their low cost, ease of operation, and ability to capture high-quality images.

- However, UAV have been known to interfere with the operations of airports and other critical infrastructure, putting lives and property at risk.

- UAV were used as weapons in the Russo Ukrainian War to strike the ground.

# INTRODUCTION



Methods:

- Radar-based Method: Measuring their position, velocity, acceleration, and direction.
- Shortage: Affected by interference from other sources of radio waves and may be expensive and complex to install and maintain.

- Acoustic-based Method:  Using microphones to detect the sound of the UAV.
- Shortage: Has a limited range and may not be able to distinguish between different UAV of the same model.

# INTRODUCTION

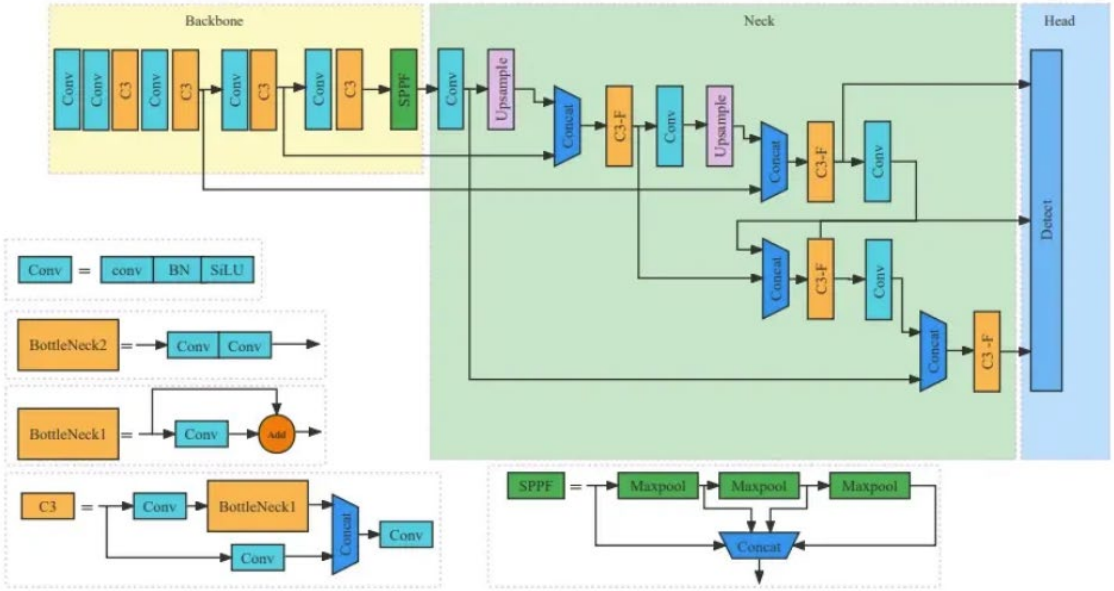


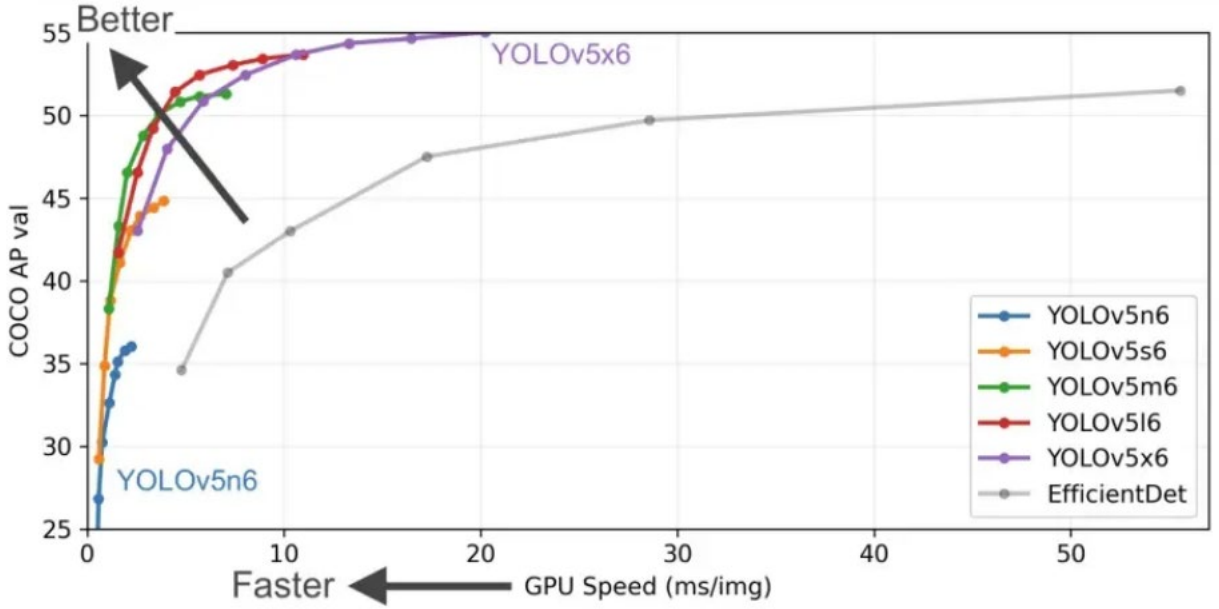
Visual tracking methods: highly accurate and cost-effective.
Visual tracking has the outstanding advantage of highly accurate detection, especially for UAV details. However, it may not perform well in low-visibility conditions, such as fog or darkness.

In this paper,

- we present a novel approach for robust UAV localization and tracking using Multispectral Image Analysis (RGB and Thermal infrared images).
- We have created a dataset of multispectral UAV images captured at a resolution of 1920x1080.
- We combine the You Only Look Once version 5 (YOLOv5) object detection algorithm with the Kernel Correlation Filter Tracking Algorithm (KCF) to develop an approach that is capable of real-time tracking with high accuracy, cost-effectiveness, and the ability to retrack lost targets.

## YOLOv5 Object Detection algorithm



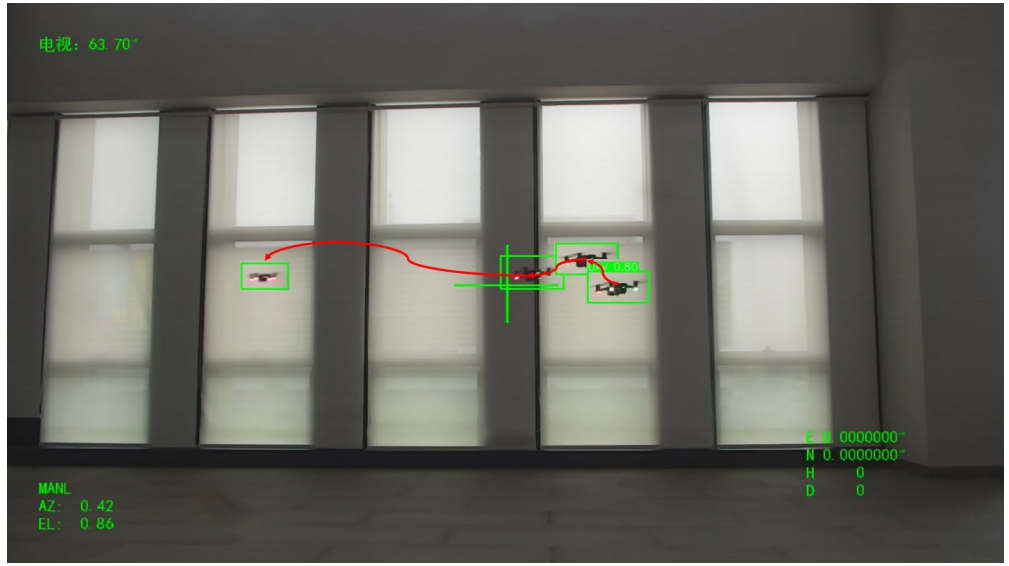

The YOLOv5 algorithm is a popular one-stage object detection algorithm that offers advantages over previous versions, such as smaller mean weights, shorter training time, and faster detection speed.

Only gain 10 FPS at a CPU device.

# RELATED WORK

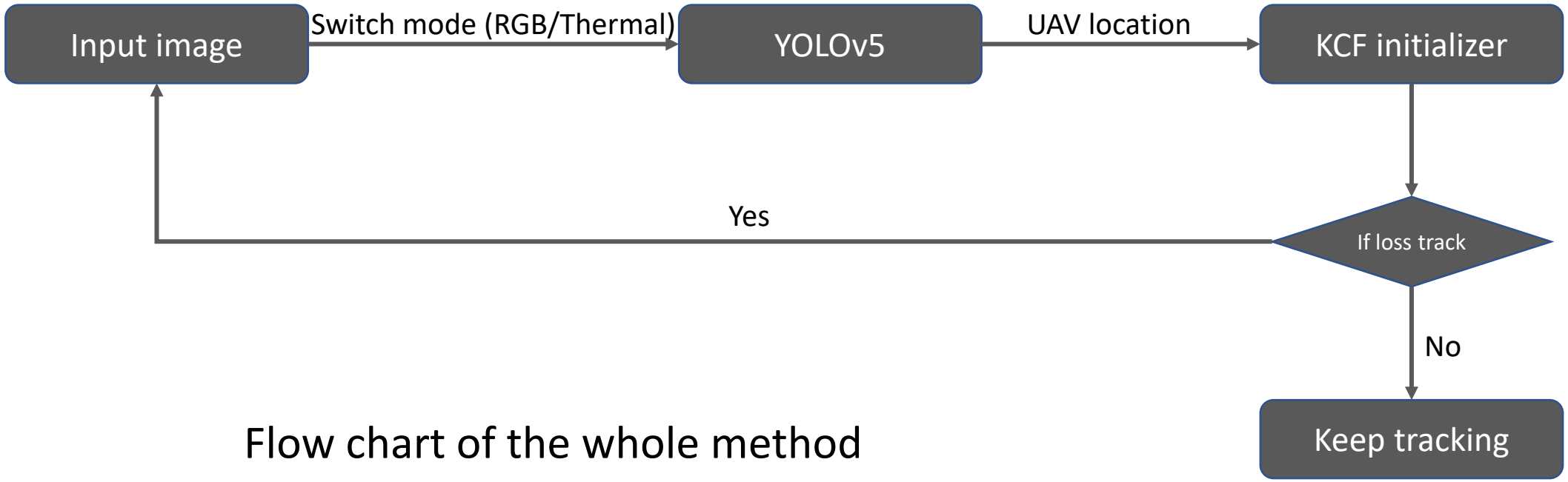
## KCF tracking algorithm

- The most classic and fast real-time tracking algorithm.
- Weak in scenarios where the target is moving swiftly, hidden, or undergoing significant transformations.
- Unable to re-track once the object is lost.



# Proposed Method



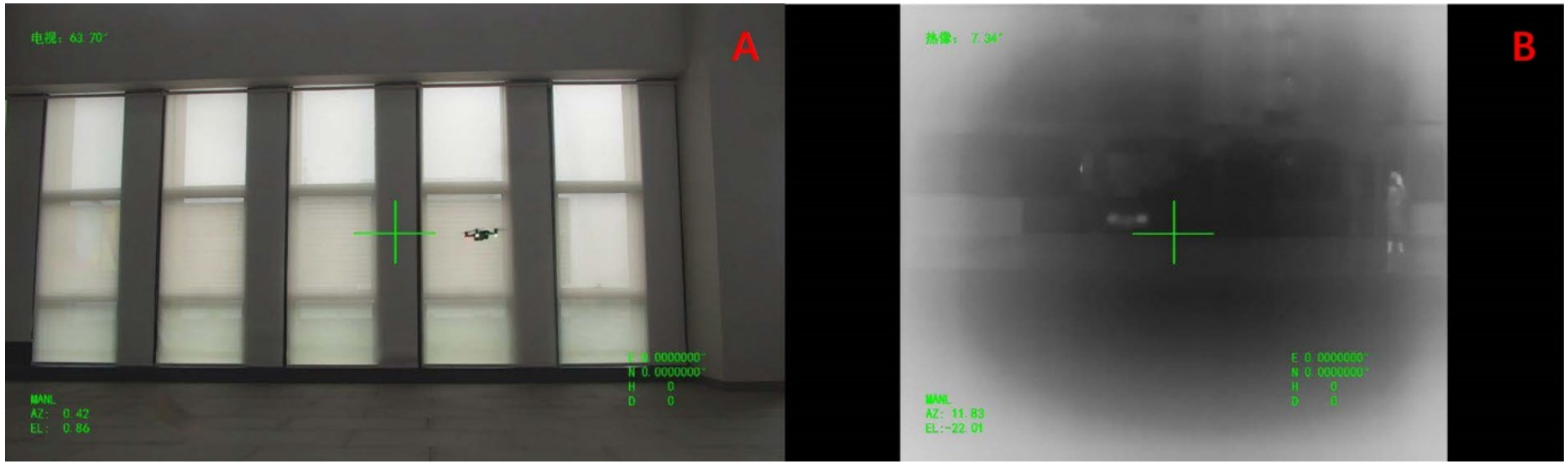



Flow chart of the whole method

# EXPERIMENTS



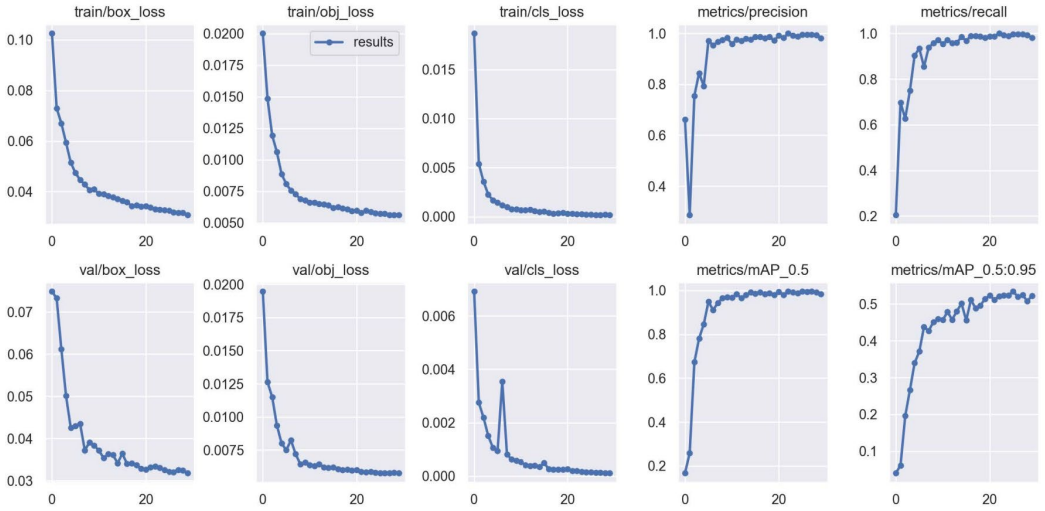
YOLOv5 Model Training

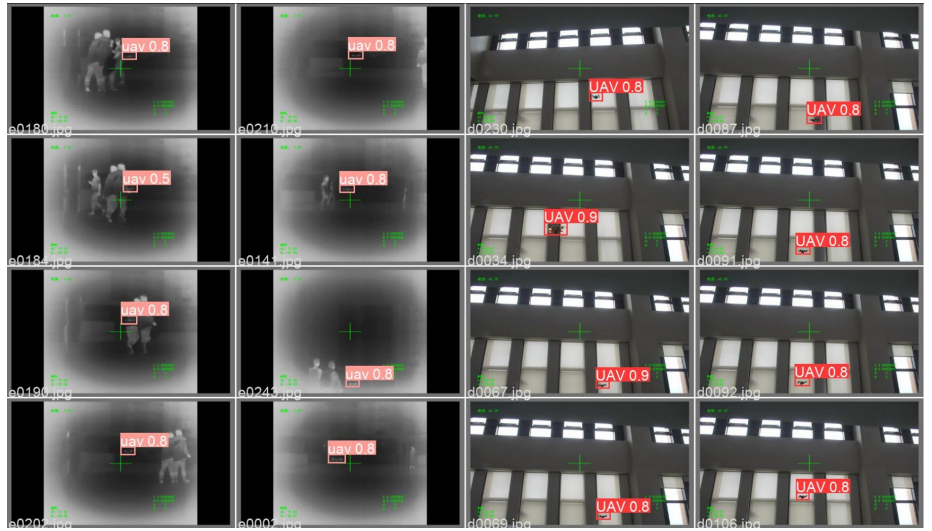



We have compiled a dataset comprising RGB/thermal infrared images to facilitate the localization and tracking of UAV that may be exploited for surveillance purposes. The dataset includes a total of 3000 images, which are comprised of both RGB and thermal infrared imagery. Furthermore, we have utilized the LabelMe tool to manually annotate the dataset.

# EXPERIMENTS





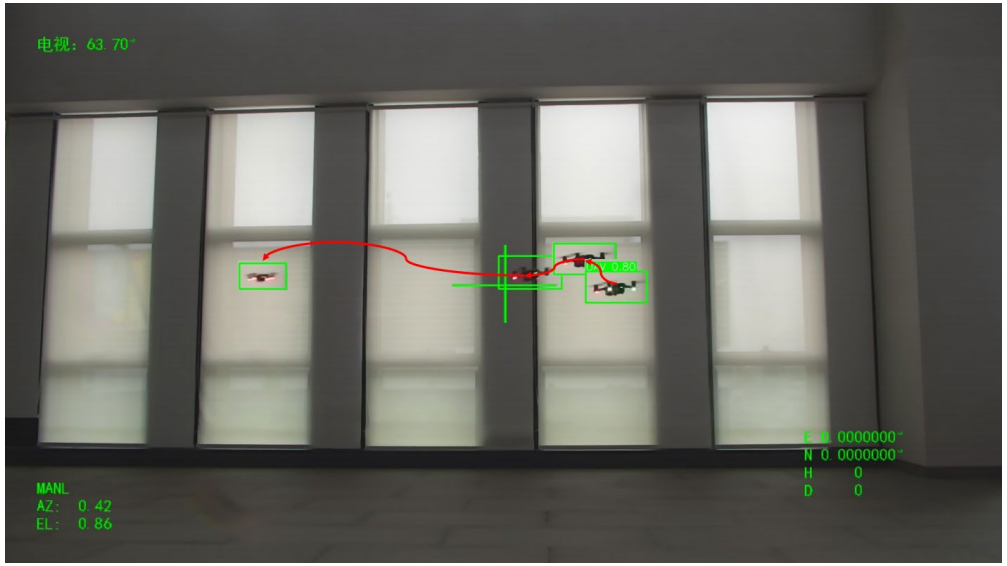

| Spectral | CLS Loss | OBJ Loss | BOX Loss | mAP |
|---|---|---|---|---|
| RGB | 0.0004 | 0.0195 | 0.02587 | 0.9873 |
| Infrared | 0.0005 | 0.0197 | 0.02500 | 0.9657 |

Our YOLOv5 model achieved a mean average precision (mAP) of 0.9765 on the validation set, indicating that it is suitable for detecting objects in video streams.

# EXPERIMENTS



KCF Algorithm Implementation



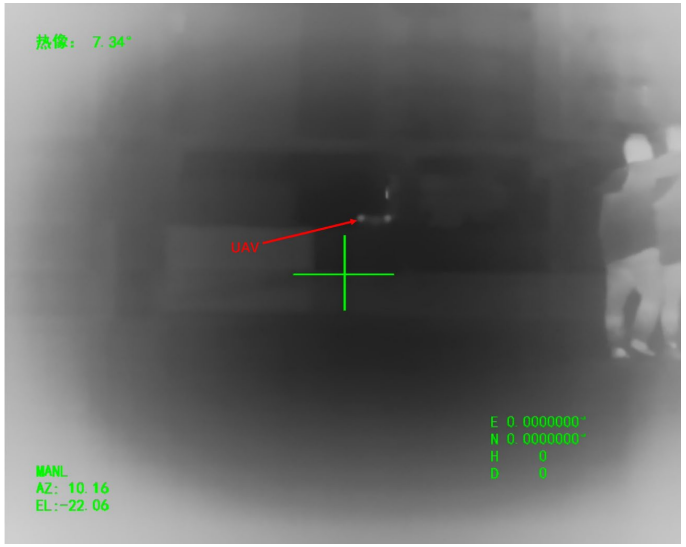

| Method | Frame Per Second (FPS) |
|---|---|
| YOLOv5 | 12.5FPS |
| Proposed | 31FPS |

- The first bounding box with ’UAV’ label is detected by YOLOv5 algorithm, and the following bounding boxes is tracked by KCF tracking algorithm as proposed above.
- In the experiment, the detection speed using only YOLOv5 was 12.5 FPS, while the detection speed using the method proposed in this article was 31 FPS.

# CONCLUSIONS



- Our study have the potential to enhance public safety and security by preventing UAV misuse.
- We highly encourage researchers to explore target detection algorithms that are specifically tailored for infrared images.
- We advocate for researchers to explore and compare different tracking methods in order to further enhance the accuracy and efficiency of UAV tracking and control.



# Thanks for your listening.

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