UAV Intrusion Detection using Deep Learning Approaches

N V V N J Sri Lakshmi[1], Shrabani Ghosh[2], Santos Kumar Das[3], *Senior Member, IEEE*

***Abstract*—Every day, there is an upsurge in the number of terrorist attacks carried out by drones. As a result, drone detection has become mandatory. Real-time detection of drones is a very challenging task due to their small size, lightning conditions, and relative viewing angles. In this article, a new UAV dataset is presented to perform drone detection tasks using two deep learning techniques, YOLOv5 and YOLOv8, along with the existing Det-Fly dataset. Implementing the YOLOv5 technique, the mean average precision (mAP) for drone detection on both the Det-Fly and UAV datasets is 97.2% and 94.1%, respectively. Similarly, the corresponding values for the YOLOv8 algorithm are 99.5% and 95.0%, respectively.**

***Index Terms*—Deep Learning, UAV Detection.**

I. Introduction

Unmanned Aerial Vehicles (UAVs), or drones, have become significantly more important in our daily lives. The rapid advancement of UAV technology offers numerous benefits in both civilian and military applications. As drone terrorism and other malicious activities are increasing, it is very essential to detect an intruder drone before it leads to any disaster. Drone detection, often known as anti-drone technology, is the process of detecting unauthorised drones in any given restricted area. However, unauthorised drone detection is a challenging task, as it is very tough to continuously monitor them in low-light and complex environments.

II. Methods

YOLOv5 employs CSPDarknet53, a customised deep neural network architecture, as its backbone and the Path Aggregation Network (PANet) as its neck structure. Multiple convolutional layers in its detection head process the feature maps generated by the backbone and neck. The latest version of the YOLO series, YOLOv8, contains a few network modifications from the YOLOv5 architecture. i) The C2f module is employed instead of the C3 module. ii) The first 6×6 Conv in the backbone is modified to 3×3 Conv. iii) The first 1×1 Conv in the bottleneck is replaced with a 3×3 Conv. iv) Two convolutions, Conv No. 10 and Conv No. 14, were removed from the YOLOv5 configuration. The UAV dataset contains 12 video sequences of a drone that were captured at distances ranging from 10 to 20 metres and at an altitude of 5 to 50 metres during both daytime and nighttime lighting conditions. It consists of nine daytime sequences and three nighttime sequences. A total of 943 images were extracted from 12 recorded videos. Each extracted image from 9 videos has a dimension of 1080×1920 pixels, and each image from the remaining 3 videos has a dimension of 1080×2400 pixels.

Research supported by DRDO, INDIA.
1,3 are with the Dept. of ECE, NIT Rourkela, Odisha, INDIA. 2 is with the DRDO, Chandipur. phone: +91-661-2462466; e-mail: dassk@nitrkl.ac.in).

III. Results

Two state-of-the-art deep learning algorithms, YOLOv5 and YOLOv8, are evaluated on both the Det-Fly dataset and our UAV dataset. For implementation, from both datasets, 70% of the images are used for training, 20% for validation, and 10% for testing. Before the training process, a data pre-processing step is performed where all the images are resized to 640×640. Fig. 1 shows the detection results of the YOLOv5 and YOLOv8 algorithms on the UAV dataset and the performance analysis are listed in Table I.

TABLE I
Performance analysis of YOLOv5 and YOLOv8

Algorithm	Det-Fly dataset			UAV dataset		
	Precision	*Recall*	*mAP*	*Precision*	*Recall*	*mAP*
YOLOv5	98.20%	95.00%	97.20%	95.30%	93.80%	94.10%
YOLOv8	99.80%	98.70%	99.50%	95.80%	94.00%	95.00%

Fig. 1. Testing results of YOLOv5 and YOLOv8 on the UAV dataset.

IV. Conclusion

In this article, two deep learning algorithms, YOLOv5 and YOLOv8, are evaluated on both Det-fly and our UAV dataset. The mAP values for UAV detection using the YOLOv5 algorithm on both the Det-Fly and UAV datasets are 97.2% and 94.1%, respectively. Similarly, for the YOLOv8 algorithm, they are 99.5% and 95.0%, respectively. According to the results, it is observed that the dataset should be further improved by including various flying objects with distinct sizes as well as different background conditions.

References

[1] D. Thuan, "Evolution of YOLO algorithm and YOLOv5: The state-of-the-art object detection algorithm," 2021.

[2] R. Blog. (2023) What is YOLOv8? the ultimate guide. https://blog.roboflow.com/whats-new-in-yolov8/. Accessed on: Jan 11, 2023.

[3] Y. Zheng, Z. Chen, D. Lv, Z. Li, Z. Lan, and S. Zhao, "Air-to-air visual detection of micro-UAVs: An experimental evaluation of deep learning," IEEE Robotics and automation letters, vol. 6, no. 2, pp. 1020–1027, 2021.