Robust Drone Detection in Adverse Weather Using YOLOv11 with Synthetic Rain Augmentation

Proceeding of the IEEE International Conference on Smart Instrumentation, Measurement and Applications, ICSIMA • Conference Paper • 2025 • DOI: 10.1109/ICSIMA66552.2025.11233323

Gunawan, Teddy Surya [a] ; Mazlan, Muhammad Harith Aiman [a] ; Kartiwi, Mira [b] ; Yusoff, Nelidya Md [c]

[a] International Islamic University Malaysia, Electrical and Computer Engineering Department, Kuala Lumpur, 53100, Malaysia

Abstract

This paper investigates the performance of YOLOv11 models for drone detection under adverse weather simulated via synthetic rain at five intensity levels. Five YOLOv11 variants, n, s, m, l, and x, were fine-tuned using rain-augmented datasets. Results show a consistent degradation in accuracy with increasing rain intensity. Among the models, YOLOv11m achieved the best trade-off, maintaining mAP@0.5 above 0.92 and F1-scores above 0.88 under clear to moderate rain. Fine-tuning significantly improved recall and fitness scores compared to baseline performance. A representative confusion matrix yielded 310 true positives, 59 false negatives, and 37 false positives, illustrating the inherent precision-recall trade-off under visual degradation. Compared to earlier YOLO versions, YOLOv11 demonstrated improved resilience to synthetic rain effects such as occlusion and blur. However, performance dropped sharply under heavy rain conditions. These findings support the application of rain-augmented fine-tuning for robust drone detection. Future work includes sensor fusion and real-world weather validation.

Author keywords

Adverse Weather Conditions; Drone Detection; Object Detection; Synthetic Rain Augmentation; YOLOv11

Indexed keywords

Engineering controlled terms

Aircraft detection; Distributed computer systems; Drones; Human computer interaction; Object detection; Object recognition; Rain; Tuning

Engineering uncontrolled terms

Adverse weather; Adverse weather condition; Condition; Drone detection; Fine tuning; Objects detection; Performance; Synthetic rain augmentation; Trade off; YOLOv11

Engineering main heading

Economic and social effects