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LDDm-Det: Distilling-YOLOv8: An Efficient Lightweight Real-time UAV Detection Model for Edge Devices

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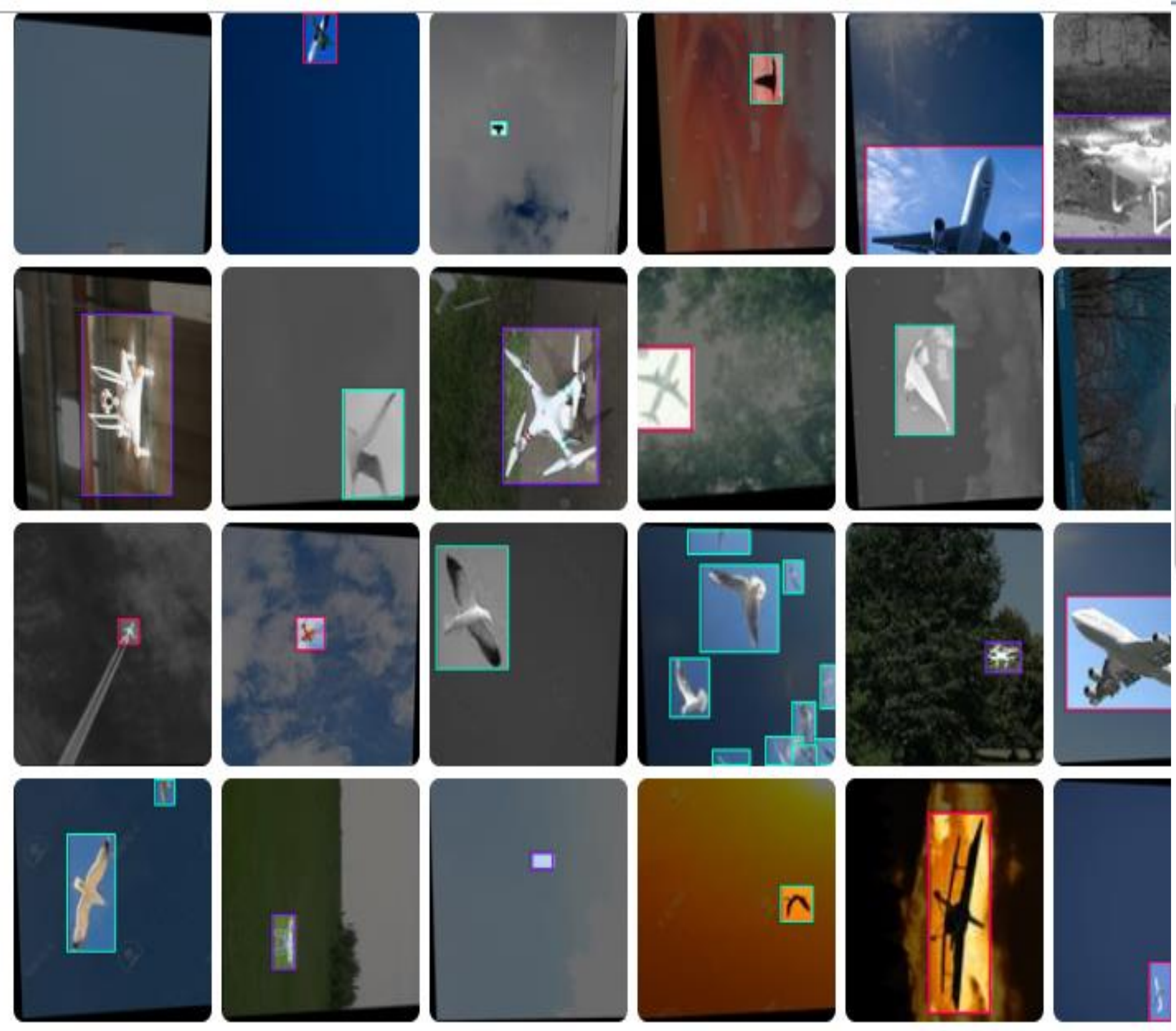
INTRODUCTION & AIM

- Unmanned aerial vehicles (UAVs) are increasingly used across sectors such as security, agriculture, journalism, commerce, and entertainment due to their versatility and efficiency.
- However, their misuse for criminal activities and autonomous warfare has raised significant security concerns, prompting governments to prioritize reliable drone detection systems, especially in sensitive zones like airports.
- Detection approaches include manual monitoring and automated methods, with deep learning particularly CNNs and YOLO showing superior real-time performance.
- Despite this, YOLO models are computationally heavy and unsuitable for deployment on edge devices with limited resources. To address this gap, this study introduces **LDDm-Det**, a lightweight YOLOv8-based detection model optimized for efficient, real-time drone detection on edge platforms.

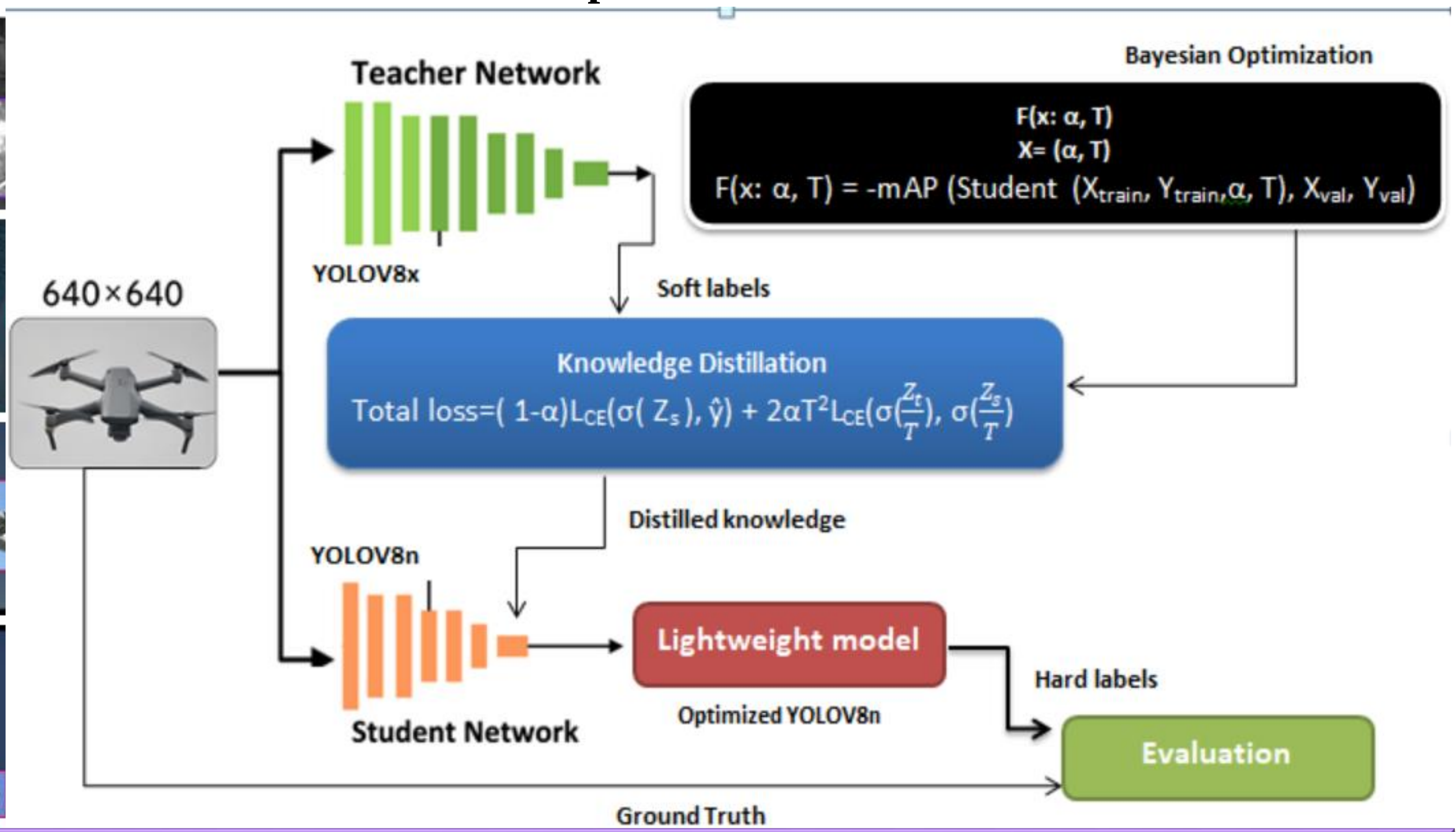
METHOD

- The LDDm-Det framework is developed using the YOLOv8 architecture and enhanced through Knowledge Distillation (KD).
- A high-capacity YOLOv8x teacher model transfers its rich spatial and semantic features to a compact YOLOv8n student model. The teacher contains 68M parameters at 258 GFLOPs, while the student uses only 3M parameters and 8.9 GFLOPs.
- Distillation enables the lightweight student to mimic the accuracy of the teacher with far lower computational cost. This makes the model efficient and suitable for real-time drone detection on edge devices.

Sample image data sets

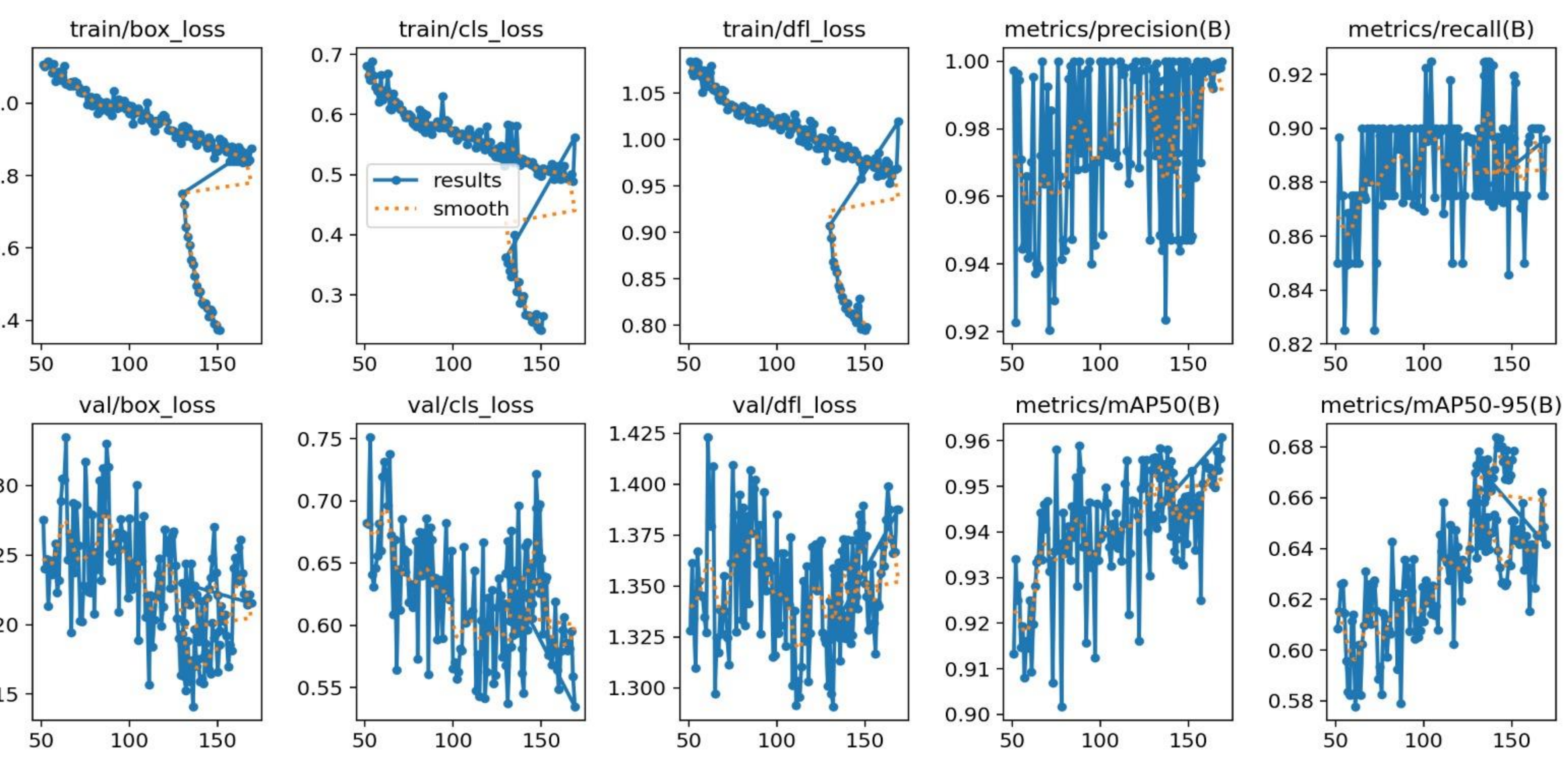


Proposed LDDm-DET Architecture



RESULTS & DISCUSSION

- The proposed LDDm-Det employs YOLOv8 as a compact feature extractor and incorporates a lightweight, anchor-free detection head alongside a shallow feature pyramid for multi-scale object localization.
- Knowledge distillation transfers rich spatial and semantic features from a larger teacher detector, while Bayesian optimization tunes key hyperparameters such as distillation temperature, loss weighting, and feature fusion depth.



- Experiments on public drone detection datasets show that LDDm-Det achieves competitive mean Average Precision (mAP =0.96) while retaining a smaller model size of only a few megabytes, enabling real-time detection on edge devices and localization on resource-constrained devices.

Comparison of the Proposed LDDm-Det Model with Bigger Models

Models	mAP (%)	FLOPs	Model size	No.params
(Zhai et al., 2023)	95.1	221	5.63MB	4.467m
(Peng, He, & Zhang, 2025)	92.5	188	9.2MB	19.02m
(Liu et al., 2020)	90.88	23	-	-
Proposed LDDm-Det	96.0	8.9	3.8MB	3m

CONCLUSION

- Traditional detection techniques struggle with accuracy and reliability, especially for small UAVs, leading to increased reliance on deep learning methods.
- YOLO-based detectors offer high accuracy but remain too computationally heavy for deployment on resource-limited edge devices.
- To address this challenge, the proposed LDDm-Det model combines YOLOv8 with knowledge distillation and Bayesian optimization to achieve lightweight, real-time drone detection.
- The system maintains strong accuracy while significantly reducing computational cost, making it suitable for deployment on edge platforms.