



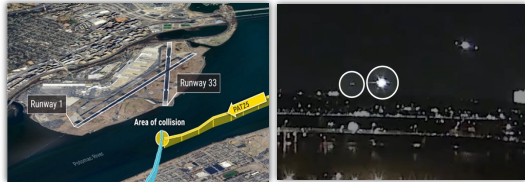
ClairVoyan DAA System: Intelligent Vision-Based Detect-and-Avoid Framework for UAVs



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Problem^[1]

Recent mid-air collision incidents, including a January 2025 collision near Washington D.C., highlight the limitations of existing “See and Avoid” approaches and the urgent need for reliable Detect and Avoid systems.



Current System Limitations:

Target System:



- Payload >5kg & high power load
- Detects cooperative aircraft only
- Single-frame detection
- Ultra-low SWaP constraints
- Distance detection >2.5 km
- Multiple-frame arrogation

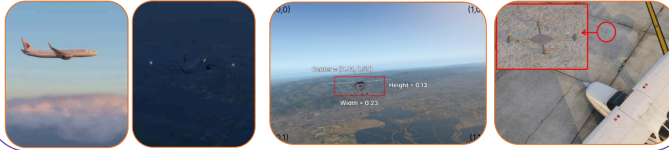
RTCA DO-387 Requirements^[2]

Detection Distance	Small = 2,698 m, Medium = 3,084 m, Large = 3,598 m
Field of View	±110° horizontal, ±15° vertical
Tracking Capacity	Recognize and track at least 10 objects
False Positive Rejection	Reject ground and atmospheric objects
State Estimation	Estimate distance, angle, and azimuth
Speed Classification	Fast (130–170 kts), Mid (100–130 kts), Slow (<100 kts)
Object Classification	Helicopter / Drone / Airplane

System Pipeline

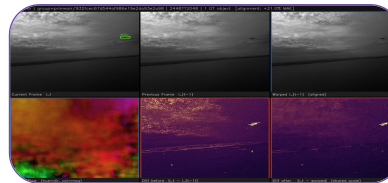
Frame Input: X-Plane Synthetic Data Generation

Diverse weather, lighting and intruder geometries with ground-truth for training and implementation of new intruder classes



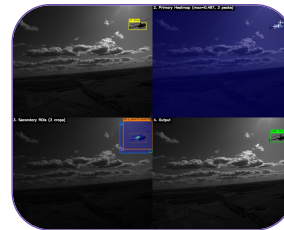
Frame Alignment: Ego-Motion Compensation

- ResNet-34 dense optical flow
- Align previous and current frames
- Stabilizes pixels so true intruder motion stands out



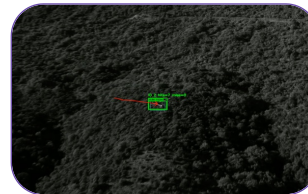
Detection: Cascaded HRNet Detector

- HRNet-32 primary detector on full frame for region proposals
- HRNet-48 on proposal crops
- Outputs bounding box, score, range, and inter-frame displacement
- Training YOLO26 as an HRNet-32 alternative

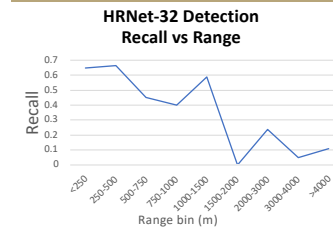


Tracking: Kalman + Greedy Association

- Offset-based matching with track-confidence gating
- DAA State: angular rate and tCPA
- False positive classifier



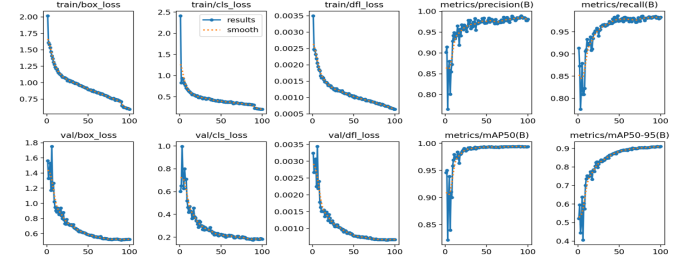
Results



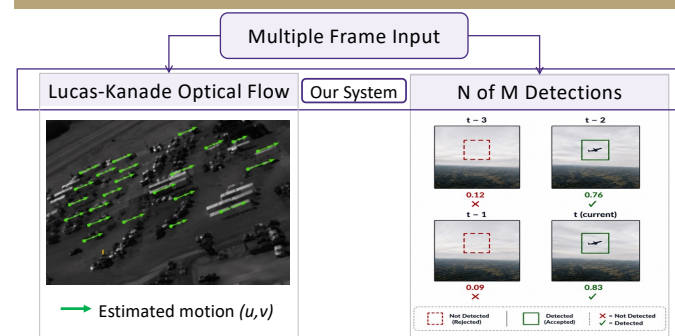
Tracking Accuracy:

- Multiple Object: **0.077**
- Higher Order: **0.121**
- ID Switches: **40**
- Average Track Length: **5.6 frames**
- **2869** Ground Truth
- **267** True Positives
- **5** False Positives
- **2602** False Negatives

YOLO26 Training Metrics:



Core Contributions



References

- [1] P. Kioulopoglou and I. Makris, “Exploring Aviation Accidents and Related Costs,” *Glob. Bus. Econ. Anthol.*, 2024.
 [2] RTCA DO-387, *MOPS for Airborne Collision Avoidance Systems for UAS*.

