The Seed of Advanced Air Mobility

Building a Single Object Tracking Prototype for Air Platforms

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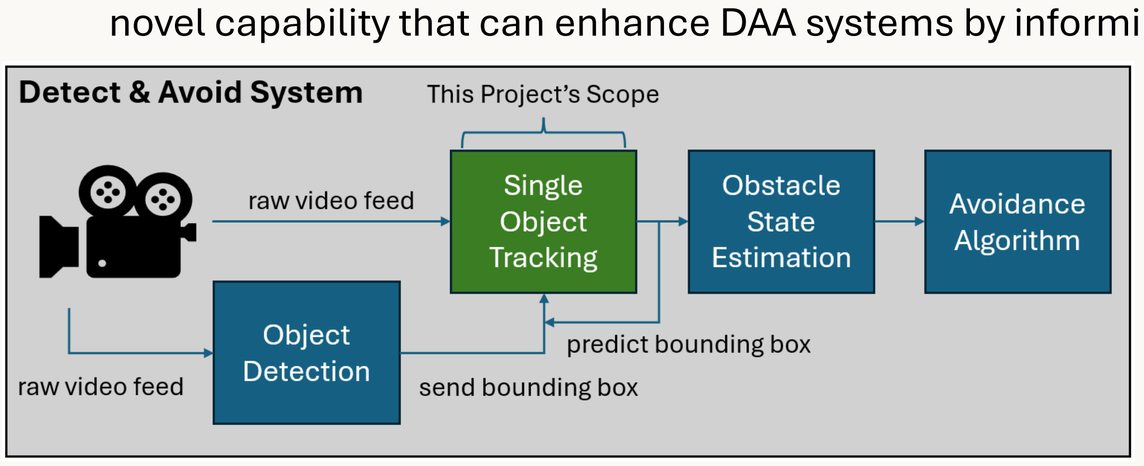
Problem Statement

Background: Advanced Air Mobility is a new era of aviation that uses autonomous aircraft to increase the safety and efficiency of air transportation. Autonomous aircraft require "Detect & Avoid" (DAA) systems to navigate crowded airspace. Visual object tracking is a novel capability that can enhance DAA systems by informing the aircraft of airborne obstacles at a low computational cost.

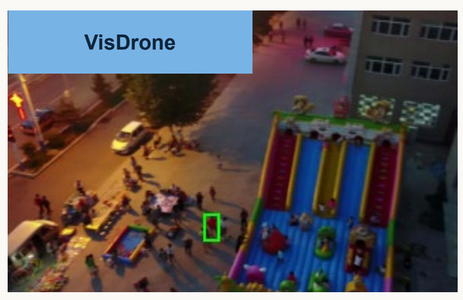


Enhance the utility of a DAA system for autonomous aerial vehicles by evaluating, improving, and deploying a state-of-the-art Single Object Tracking (SOT) deep learning model on a representative edge compute module.

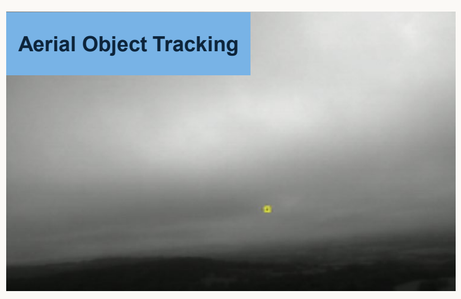
3 Open-Source Datasets

Level of Difficulty & Representativeness of Use Case

Purpose: benchmarking SOT models



Purpose: improving finetuning pipeline



Purpose: training final single object tracking model

Methodology

Model Benchmarking & Selection → **Improve Finetuning Pipeline** → **Hardware Implementation**

Model Benchmarking & Selection

Model	Release	Arc.	Success Rate	Size	Speed (FPS)
Liquid Time Constant	Jun 2020	LNN			
MixFormerV2	May 2023	ViT			
E.T. Track	Jan 2023	ViT			
ORTrack – DEIT	Jun 2025	ViT	66.1	7.9M	226.4
SGLATrack	Mar 2025	ViT	66.9	~9M	224.7
GRM	Mar 2023	ViT	70.2	~95M	45.0
SmallTrack	Aug 2023	ViT	63.7	~35M	72.5
OSTrack	**Mar 2022**	**ViT**	**70.7**	**92M**	**93.1**

Qualitative Criteria
1) Assumed Implementability
2) Stakeholder Familiarity
3) Relevance to Use Case

After literature review, 8 models were selected for qualitative benchmarking. 5 moved on to a more rigorous quantitative benchmarking.

Quantitative Criteria

OSTrack Selected for Finetuning

Improve Finetuning Pipeline

Baseline OSTrack
65.4% AUC

- **Learning Rate (LR) Adjustments**
  1) Target LR
  2) LR Warm-Up
  3) LR Scheduler
- Increased **Data Augmentation** for Out-of-Sample Robustness
- **Freezing Network Layers** so Only Task-Specific Weights are Updated

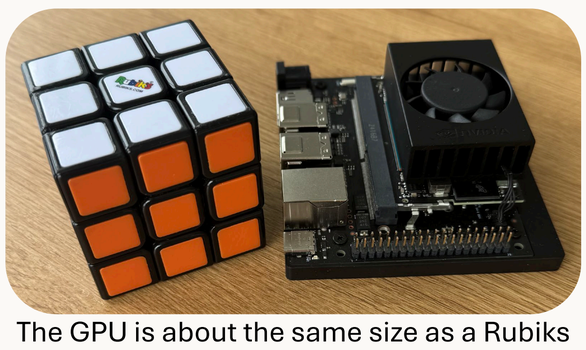
Finetuning Pipeline

Finetuned OSTrack
69.9% AUC

Note: VisDrone test set used for AUC metrics

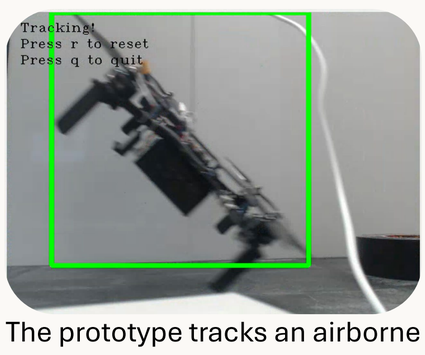
Hardware Implementation

NVIDIA Jetson Orin Nano GPU & Logitech WebCam used to deploy OSTrack



The GPU is about the same size as a Rubiks Cube, making it great for airborne platforms.

Our prototype tracks objects in real time (16 FPS). A YOLOv8n is used for the initial detection & seed bounding box.



The prototype tracks an airborne object with a bounding box.

Results

Successfully Deployed Functional Prototype
- Proof-of-concept system on NVIDIA Jetson
- Processes live video feed at 16 FPS inference rate

Established Validated Finetuning Pipeline
- Experiments created reusable training pipeline
- Improved performance on VisDrone by 4.5%

Revealed Difficulty of Use Case
- Saw no improvement in performance on AOT data
- Necessitates continued research into advanced model architectures for air-to-air tracking

Mission Impact

18 August 2020: 2 remote-controlled USAF MQ-9 Reapers collide mid air
Source: Forbes

Estimated $66M in damages
Source: Military Times

Our Prototype

= $400

ROI of 165,000:1 by implementing SOT system