Real-Time Object Tracking Algorithms for UAV Companion Computers

Andrii Matsevytyi

Supervisor: Andrew Kurochkin

Research Motivation & Background

Literature Analysis

- Traditional and Siamese-Network-based concepts analyzed
- 9 trackers deeply analysed
- 5 selected for further experiments

Approach: Environments

Approach: Dataset

- 6 datasets analyzed, UAV123 chosen

Approach: Metrics

- Software (Success Score, Containment Score, Recovery Rate, Mean Outliers)

$$Hardware\_Efficiency = (FPS \times CPU\_Usage \times Normalized\_RAM\_Usage \times \times Frames\_Per\_Watt)^{1/4}$$

- Hardware (FPS, normalized RAM, CPU utilization, Frames Per Watt)

$$Tracking\_Goodness = (Success\_Score \times Recovery\_Rate \times Containment\_Score \times \times Mean\_Precision\_Outliers)^{1/4}$$

$$Final\_Combined\_Metric = \frac{Tracking\_Goodness}{\max(1, Hardware\_Efficiency)}$$

Solution

- Lucas-Kanade Tracker implemented based on literature analysis
- Purpose-fit metrics designed and coded
- Pipeline that included dataset processing, trackers deployment and their further evaluation created

Evaluation: General Observations

TABLE 5.1: Overall Performance: Main Representative Metrics

Tracker	Final Metric	Containment Score	Frames per Watt	FPS
CPU Environment				
KLT	0.0052	0.0129	10.8925	102.32
MOSSE	0.0046	0.0282	5.3922	142.39
CSRT	0.1307	0.2905	2.5793	30.88
DaSiamRPN	0.2437	0.5123	0.3921	2.01
NanoTrack	0.2280	0.5881	2.3352	32.88
GPU Environment				
KLT	0.0052	0.0129	8.695	109.04
MOSSE	0.0046	0.0282	6.957	141.24
CSRT	0.1307	0.2905	2.0406	35.34
DaSiamRPN	0.2425	0.5107	3.084	55.01
NanoTrack	0.2278	0.5889	3.1078	53.11

Evaluation: Domain-Specific Observations

Tracker	General Metrics	Success Score	Recovery Rate	Frames/Watt (GPU)
KLT	0.0000	0.0000	0.0000	3.6379
MOSSE	0.0000	0.0000	0.0000	2.9107
CSRT	0.0351	0.0227	0.0252	0.8537
DaSiamRPN	0.0399	0.0379	0.0667	1.2903
Nanotrack	0.0195	0.0265	0.0254	1.3

TABLE 5.6: Tracking performance on uav sequences.

Tracker	General Metrics	Success Score	Recovery Rate	Frames/Watt (GPU)
Human				
KLT	0.0068	0.0167	0.0015	9.9215
MOSSE	0.0257	0.1681	0.0019	7.9383
CSRT	0.2444	0.2028	0.3333	2.3284
DaSiamRPN	0.2875	0.5625	0.1176	3.5191
Nanotrack	0.2734	0.6278	0.0870	3.5461
Car				
KLT	0.0000	0.0028	0.0000	14.5515
MOSSE	0.0000	0.0000	0.0000	11.6428
CSRT	0.0161	0.0426	0.0011	3.4149
DaSiamRPN	0.7426	0.9848	1.0000	5.1613
Nanotrack	0.7619	0.9820	1.0000	5.2009

TABLE 5.5: Performance metrics for person and car related sequences

Evaluation: Derived Algorithms Selection Guidelines

- High-Performance Reconnaissance UAVs
- Small Low-Cost UAVs with Severe Resource Constraints
- Specialized Tracking Scenarios

Conclusions: Contribution and Summary

Conclusions: Future Work

- Evaluation on Actual UAV Hardware
- Specialized Dataset Collection
- Tracking Algorithms Improvement
- Integration with Flight Control Systems