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Teleidoscope

UAV SOT Benchmark

Benchmark of non-deep learning state of the art CPU based visual tracking algorithms commonly used by UAVs.

DATASET NAME: VisDrone2019-SOT-test-dev

FRAME COUNT: 32,958

RESOLUTION RANGE: 960x540 - 2688x1512

AVG GROUND TRUTH SIZE: 47x63 (normalized to the average resolution of each frame 1476x830)

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Purpose

The purpose of this document is to compare Teleidoscope's core Visual Tracking algorithm (RAD) to other state of the art non-deep learning tracking algorithms capable of running on CPU, making them popular choices for UAVs.

The dataset selected was chosen because it fits a wide variety of common scenarios for UAVs.

Testing Conditions

Each tracker was initialized using the first bounding box of each sequences ground truth and **was not** reinitialized at any point. The intent is to provide a better metric of the relationship between the precision and long-term tracking success scores without ground truth reinitialization.

This provides results that are most representative of real-world environments.

Summary of Results

Teleidoscope's Visual Tracking Algorithm (RAD) achieved a higher precision and higher long-term tracking score, and lower occlusion recovery error when compared to other trackers considered state of the art.

These superior results are due to RAD's auto calibrating, self-diagnostics feature which allows it to adapt to a wide variety of targets in different environments.

Results

TRACKER	SUCCESS SCORE	PRECISION SCORE	RECOVERY ERROR	INTERSECTION	SPATIAL OVERLAP
RAD	88.39%	91.06%	26.7305	0.834782	0.567633
CSRT	78.59%	81.71%	63.7435	0.800988	0.478049
KCF	49.09%	51.13%	122.856	0.547186	0.298008
MIL	46.83%	52.02%	145.553	0.486872	0.275398
TLD	32.94%	33.98%	415.423	0.299427	0.17223

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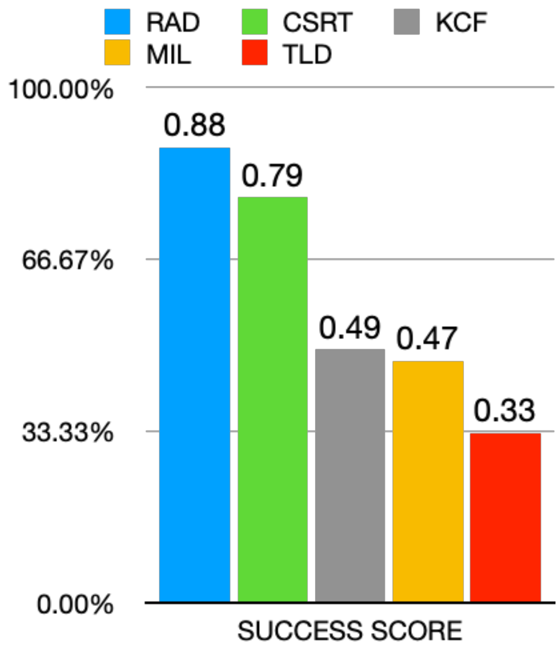

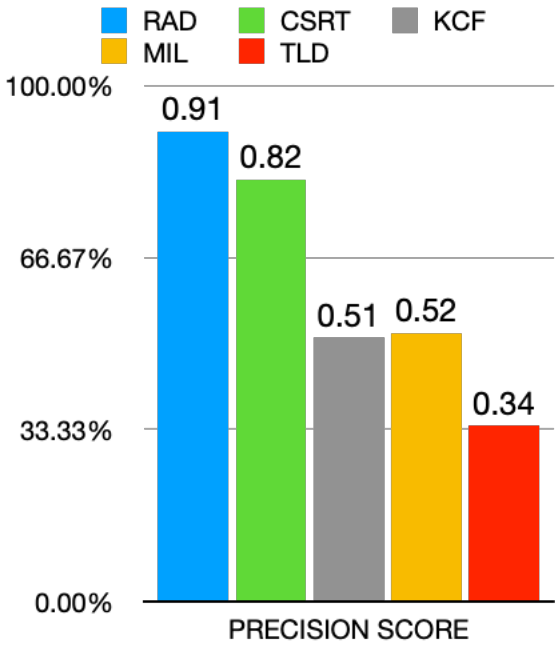

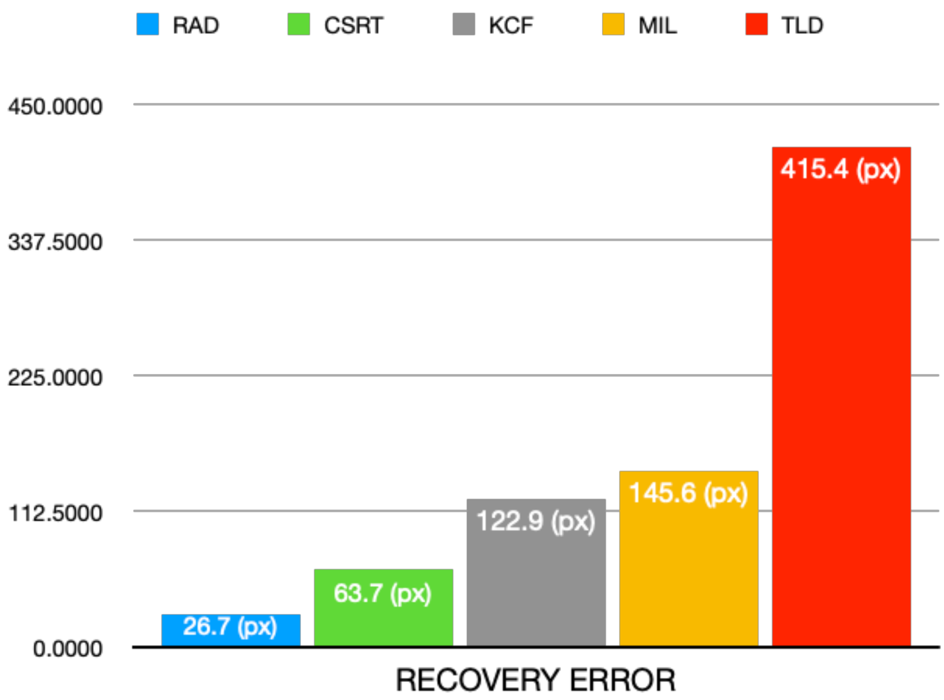

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Legend

Estimate (E): The estimate location of the object

Ground Truth(GT): The true location of the object

True positive(TP): Estimates matches the ground truth determined by the scoring threshold criteria

False positive(FP): Estimates **do not** match the ground truth determined by the scoring threshold criteria.

Success Score: TP / Number of frames

TP Threshold Criteria = Spatial overlap greater 0.33

Precision Score: TP / (TP + FP).

TP Threshold Criteria = Distance between E and GT less than 20px while reporting a successful track.

Occlusion/Recovery Error: Mean distance from ground truth during occlusion and after occlusion. Approximates how well a tracker estimates under occlusion and how accurately it will recover (if supported). Lower is better.

Perfect: distance == 0

Very Good: distance < sqrt(AGT_area)/2 = 27

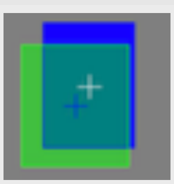
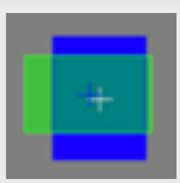
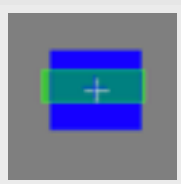
Good: distance < hypot(AGT_width, AGT_height)/2 = 39 (Recovery very likely)

Okay: distance <= hypot(AGT_width, A_height) = 79

Poor: distance > hypot(AGT_width, A_height) = 79

Intersection: Average area of intersection between E and GT over the min box. Approximates how much of the tracked patch is centered on the ground truth.

Spatial Overlap: Mean intersection over union which approximates how well the shape matches the ground truth. A table of spatial overlap examples is below. The white cross and blue box is the ground truth and green box and blue cross is the estimated position.

Spatial Overlap	**0.56**	**0.46**	**0.37**
Example			

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Additional Considerations

This benchmark specifically focuses on quality and ability to maintain track over long periods in common UAV scenarios. It **does not** consider resource utilization which is covered in a separate benchmark.

Resource utilization is an important consideration for UAVs, and should be considered along with quality metrics. Resource utilization benchmarks include:

- CPU utilization
- Memory utilization
- Frames per second/ Estimate Duration

In addition to quality of track, Teleidoscope has focused on minimizing resource utilization. This is covered in a separate benchmark.