Dynamic Semantic-Aware Correlation Modeling for UAV Tracking

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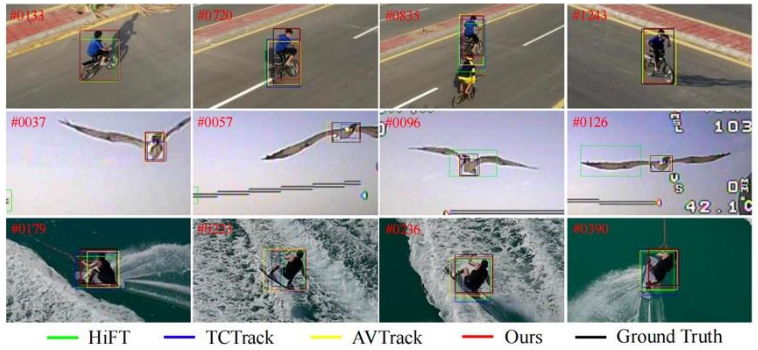
Motivation



Existing UAV tracking methods face several limitations:

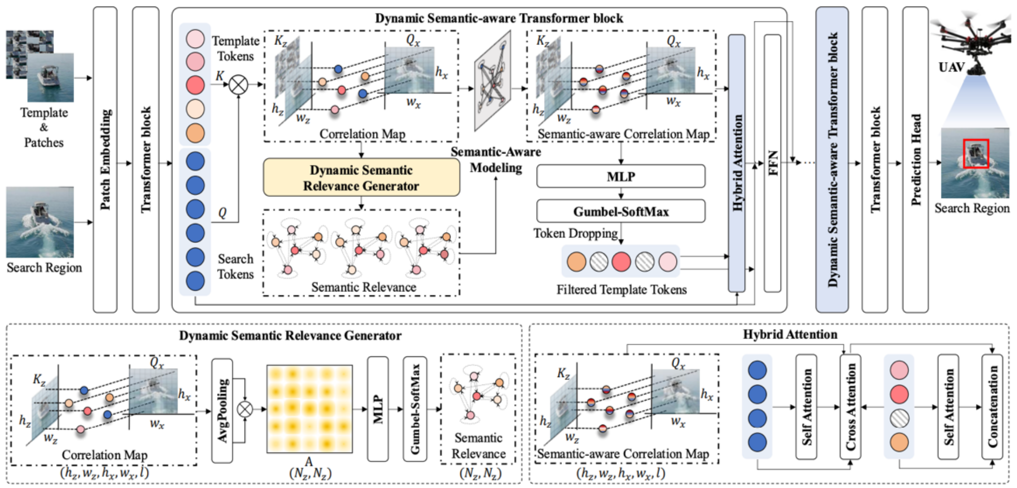
Correlation-filter based: Early UAV trackers enhanced discriminative capability for localization and tracking, but lacked robust representation capabilities.

CNN-based & one-stream Transformers: Although these methods improved accuracy and efficiency, they overlooked the essence of tracking: CNN-based rely on local modeling, while Transformers focus on global modeling.

Overlook semantic relevance: Most methods ignore semantic relevance, causing suboptimal performance in UAV scenarios under camera motion, fast motion, and low resolution.

We propose **DSATrack**, a dynamic semantic-aware correlation modeling framework for UAV tracking.

Method



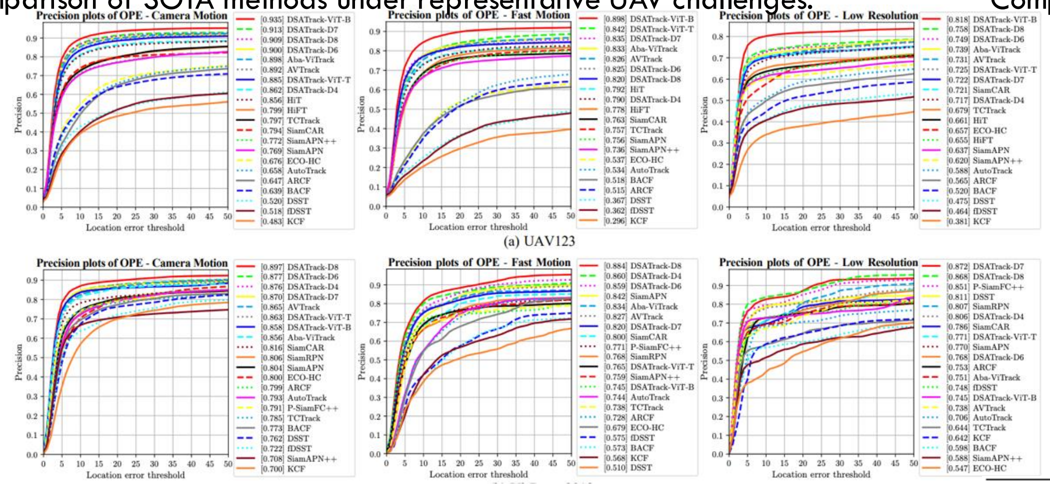
DSATrack consists of several components:

Dynamic Semantic Relevance Generator. As the core of our framework, it works with the Transformer correlation map to model semantic relevance and strengthen the search region's extraction of salient features from the template, improving accuracy and robustness under the above challenges.

Selective pruning. Removing selected Transformer blocks with minimal accuracy loss balances precision and speed and supports resource-aware deployment.

Experimens

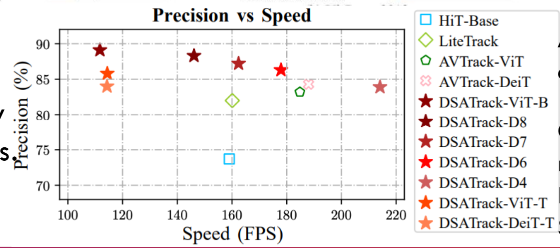
Comparison of SOTA methods under representative UAV challenges.



Comparisons with SOTA methods on UAV tracking datasets.

Method	Source	DTB70		UAVDT		VisDrone2018		UAV123	
		Prec.	Succ.	Prec.	Succ.	Prec.	Succ.	Prec.	Succ.
SiamAPN[18]	ICRA21	78.4	58.5	71.1	51.7	81.5	58.5	76.5	57.5
SiamAPN++[3]	IROS21	78.9	59.4	76.9	55.6	73.5	53.2	76.8	58.2
HiFT [2]	ICCV21	80.2	59.4	65.2	47.5	71.9	52.6	78.7	58.9
P-SiamFC++[48]	ICME22	80.3	60.4	80.7	56.6	80.1	58.5	74.5	48.9
TCTrack[4]	CVPR22	81.2	62.2	72.5	53.0	79.9	59.4	80.0	60.4
UDAT[55]	CVPR22	80.6	61.8	80.1	59.2	81.6	61.9	76.1	59.0
ABDNet[60]	RAL23	76.8	59.6	75.5	55.3	75.0	57.2	79.3	60.7
DRCI[56]	ICME23	81.4	61.8	84.0	59.0	83.4	60.0	-	-
HiT[28]	ICCV23	75.1	59.2	62.3	47.1	74.8	58.7	82.5	63.3
DDCTrack[16]	ICPR24	79.0	51.1	-	-	81.2	48.7	79.1	50.1
SMAT[21]	WACV24	81.9	63.8	80.8	58.7	82.5	63.4	81.8	64.6
LiteTrack[49]	ICRA24	82.5	63.9	81.6	59.3	79.7	61.4	84.2	65.9
LightFC-ViT[37]	KBS 24	82.8	64.0	83.4	60.6	82.7	62.8	84.2	65.5
AVTrack-ViT[36]	ICML24	81.3	63.3	79.9	57.7	86.4	65.9	84.0	66.2
AVTrack-DeiT[36]	ICML24	84.3	65.0	82.1	58.7	85.9	65.4	84.8	66.8
DSATrack-ViT-B	Ours	**91.2**	**70.6**	**88.1**	**66.3**	87.1	67.0	**90.2**	**69.4**
DSATrack-D8	Ours	89.3	69.5	85.7	63.4	**90.8**	**69.1**	87.6	67.0
DSATrack-D7	Ours	88.1	68.4	84.6	62.1	88.6	68.0	87.3	66.6
DSATrack-D6	Ours	86.6	67.3	83.5	60.6	87.0	65.7	86.9	66.0
DSATrack-D4	Ours	84.5	65.9	82.3	58.9	84.8	64.1	84.1	63.0
DSATrack-ViT-T	Ours	86.6	67.4	84.3	61.6	84.8	64.1	85.5	65.5
DSATrack-DeiT-T	Ours	84.5	65.7	85.0	62.0	82.0	60.8	84.4	64.5

Comparison of speed & accuracy with SOTA methods.



Ablation study on correlation modeling.

Variant	Method	DTB70		UAVDT		VisDrone2018		UAV123	
		Prec.	Succ.	Prec.	Succ.	Prec.	Succ.	Prec.	Succ.
DSATrack-ViT-B	Baseline	87.7	67.9	85.0	63.3	86.5	65.7	87.3	67.2
	Baseline+SSAM	88.0	68.3	85.5	62.6	**87.8**	66.6	88.8	68.5
	Baseline+DSAM	**91.2**	**70.6**	**88.1**	**66.3**	87.1	**67.0**	**90.2**	**69.4**

Comparisons of Hierarchical Contribution Ranking Pruning and Sequential Pruning.

Backbone	Method	DTB70		UAVDT		VisDrone2018		UAV123		FPS
		Prec.	Succ.	Prec.	Succ.	Prec.	Succ.	Prec.	Succ.	
D7	Sequential Pruning	86.8	67.0	82.9	60.9	86.2	64.0	85.1	64.0	162.1
	Contribution Ranking Pruning	**88.1**	**68.4**	**84.6**	**62.1**	**88.6**	**68.0**	**87.3**	**66.6**	**162.4**
D4	Sequential Pruning	80.6	62.1	77.6	55.0	81.9	60.3	82.8	60.3	210.7
	Contribution Ranking Pruning	**84.5**	**65.9**	**82.3**	**58.9**	**84.8**	**64.1**	**84.1**	**63.0**	**214.1**