# AutoTrack: Towards High-Performance Visual Tracking for UAV with Automatic Spatio-Temporal Regularization Supplementary Material

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## 1. Sensitivity analysis of hyper parameters

Four hyper parameters in equation 3 and 4 are introduced to enable automatic regularization. The sensitivity analysis, i.e., how the different values for the hyper parameters affect the tracking performance, can be seen in Fig. 1. Noted that we fix the other three hyper parameters and change the value of the analyzed one.

## 2. Attribute-based evaluation

Full attribute-based evaluations on DTB70 [1], UAVDT [2], UAV123@10fps [3] and VisDrone2018-test-dev [4] are displayed from Fig. 2 to Fig. 9, proving competent performance of AutoTrack in various challenging scenarios.

## References

[1] Siyi Li and Dit-Yan Yeung. Visual object tracking for unmanned aerial vehicles: A benchmark and new motion models. In *Thirty-First AAAI Conference on Artificial Intelligence*, pages 1–7, 2017. 1, 2, 3

[2] Dawei Du, Yuankai Qi, Hongyang Yu, Yifan Yang, Kaiwen Duan, Guorong Li, Weigang Zhang, Qingming Huang, and Qi Tian. The unmanned aerial vehicle benchmark: Object detection and tracking. In *Proceedings of the European Conference on Computer Vision (ECCV)*, pages 370–386, 2018. 1, 4, 5

[3] Matthias Mueller, Neil Smith, and Bernard Ghanem. A benchmark and simulator for uav tracking. In *Proceedings of the European Conference on Computer Vision (ECCV)*, pages 445–461. Springer, 2016. 1, 6, 7

[4] Longyin Wen, Pengfei Zhu, Dawei Du, Xiao Bian, Haibin Ling, Qinghua Hu, Chenfeng Liu, Hao Cheng, Xiaoyu Liu, Wenya Ma, et al. Visdrone-sot2018: The vision meets drone single-object tracking challenge results. In *Proceedings of the European Conference on Computer Vision Workshops*, pages 1–27, 2018. 1, 8, 9
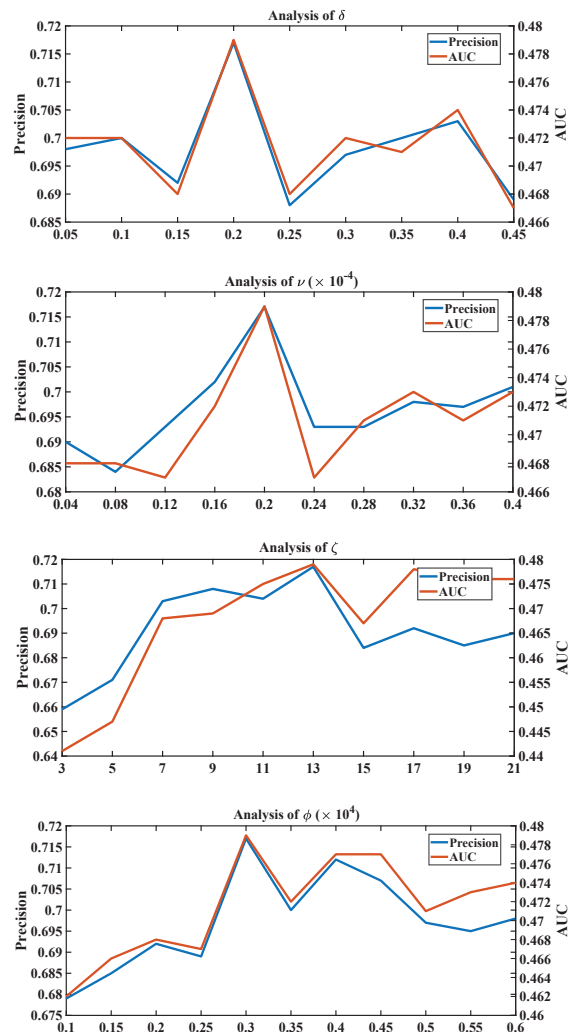
Figure 1. Sensitivity analysis of four hyper parameters ($\delta$, $\nu$, $\zeta$ and $\phi$) on DTB70 [1]. The variations of $\delta$, $\nu$ and $\phi$ have a relatively small impact on tracking performance (the precision and AUC are mostly within the range of 0.68 to 0.72 and 0.465 to 0.48, respectively.), while the change of $\phi$ has a relatively larger influence.
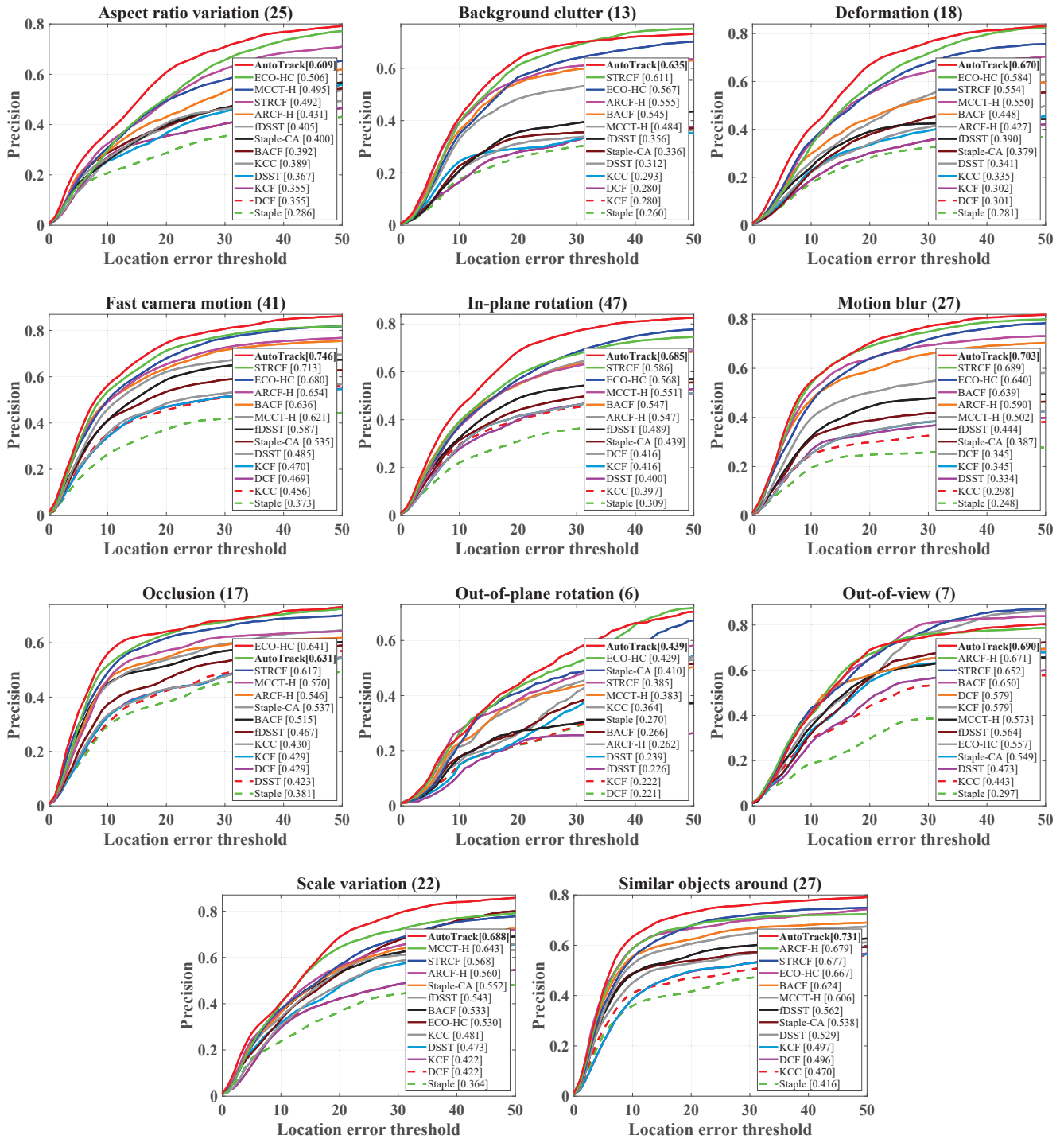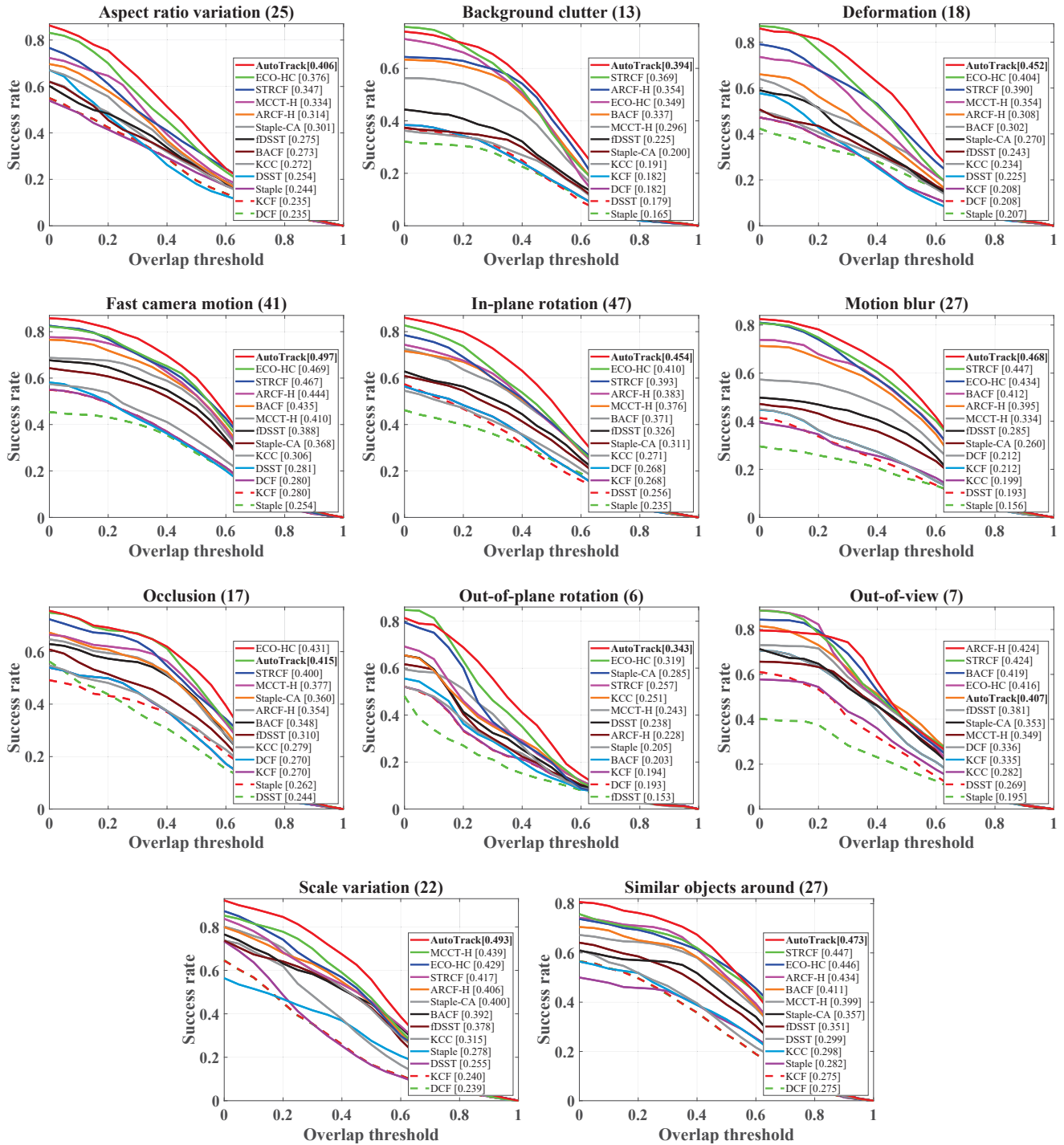
Figure 2. Precision plots of eleven attributes from DTB70 [1].

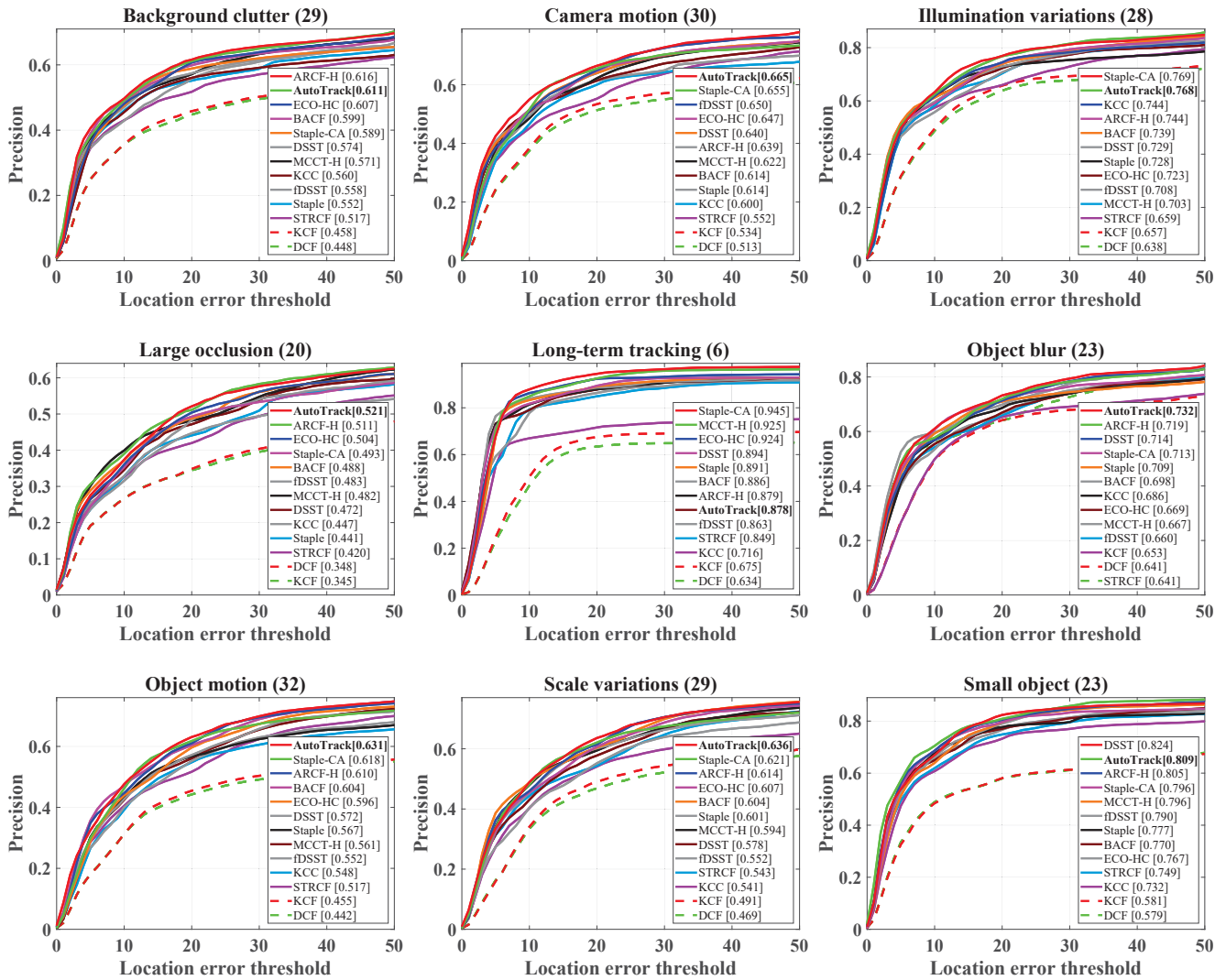Figure 3. Success plots of eleven attributes from DTB70 [1].

Figure 4. Precision plots of nine attributes from UAVDT [2].

## Background clutter (29)

AutoTrack[0.384]
BACF [0.367]
ECO-HC [0.364]
ARCF-H [0.352]
MCCT-H [0.343]
STRCF [0.340]
KCC [0.332]
fDSST [0.363]
Staple-CA [0.326]
fDSST [0.315]
Staple [0.313]
DSST [0.304]
DCF [0.236]
KCF [0.235]

## Camera motion (30)

AutoTrack[0.422]
BACF [0.387]
ECO-HC [0.379]
ARCF-H [0.372]
MCCT-H [0.367]
STRCF [0.365]
fDSST [0.363]
KCC [0.351]
Staple-CA [0.349]
Staple [0.335]
DSST [0.329]
KCF [0.267]
DCF [0.261]

## Illumination variations (28)

BACF [0.460]
AutoTrack[0.456]
ECO-HC [0.434]
KCC [0.431]
Staple-CA [0.428]
STRCF [0.421]
ARCF-H [0.416]
MCCT-H [0.415]
Staple [0.413]
fDSST [0.395]
DSST [0.379]
KCF [0.312]
DCF [0.308]

## Large occlusion (20)

AutoTrack[0.369]
MCCT-H [0.348]
ECO-HC [0.347]
BACF [0.340]
ARCF-H [0.339]
fDSST [0.332]
Staple-CA [0.324]
STRCF [0.319]
Staple [0.308]
KCC [0.304]
DSST [0.299]
DCF [0.232]
KCF [0.229]

## Long-term tracking (6)

BACF [0.581]
ECO-HC [0.573]
ARCF-H [0.569]
MCCT-H [0.565]
AutoTrack[0.558]
Staple-CA [0.539]
STRCF [0.525]
fDSST [0.518]
Staple [0.517]
KCC [0.480]
DSST [0.408]
KCF [0.312]
DCF [0.289]

## Object blur (23)

BACF [0.443]
AutoTrack[0.439]
STRCF [0.406]
Staple-CA [0.405]
Staple [0.401]
KCC [0.398]
ARCF-H [0.398]
ECO-HC [0.391]
MCCT-H [0.390]
fDSST [0.369]
DSST [0.357]
KCF [0.298]
DCF [0.292]

## Object motion (32)

AutoTrack[0.389]
BACF [0.371]
ECO-HC [0.358]
ARCF-H [0.347]
Staple-CA [0.344]
MCCT-H [0.342]
STRCF [0.341]
Staple [0.330]
KCC [0.322]
fDSST [0.312]
DSST [0.288]
KCF [0.244]
DCF [0.243]

## Scale variations (29)

AutoTrack[0.426]
BACF [0.408]
ECO-HC [0.389]
STRCF [0.388]
ARCF-H [0.386]
MCCT-H [0.383]
Staple-CA [0.366]
Staple [0.358]
KCC [0.340]
fDSST [0.337]
DSST [0.296]
KCF [0.254]
DCF [0.249]

## Small object (23)

AutoTrack[0.467]
BACF [0.428]
STRCF [0.421]
ARCF-H [0.402]
KCC [0.390]
MCCT-H [0.389]
fDSST [0.380]
Staple-CA [0.379]
ECO-HC [0.375]
Staple [0.370]
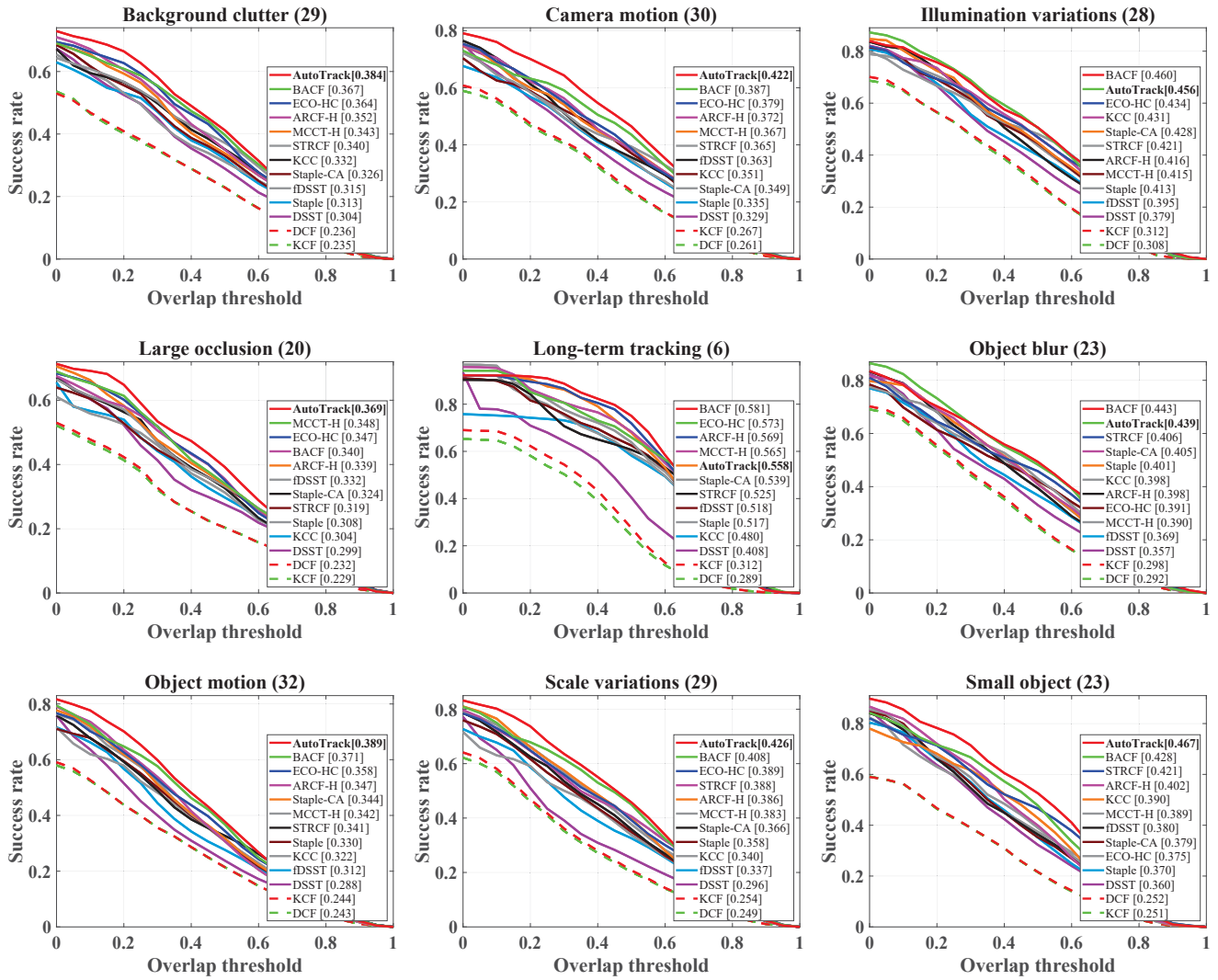DSST [0.360]
DCF [0.252]
KCF [0.251]



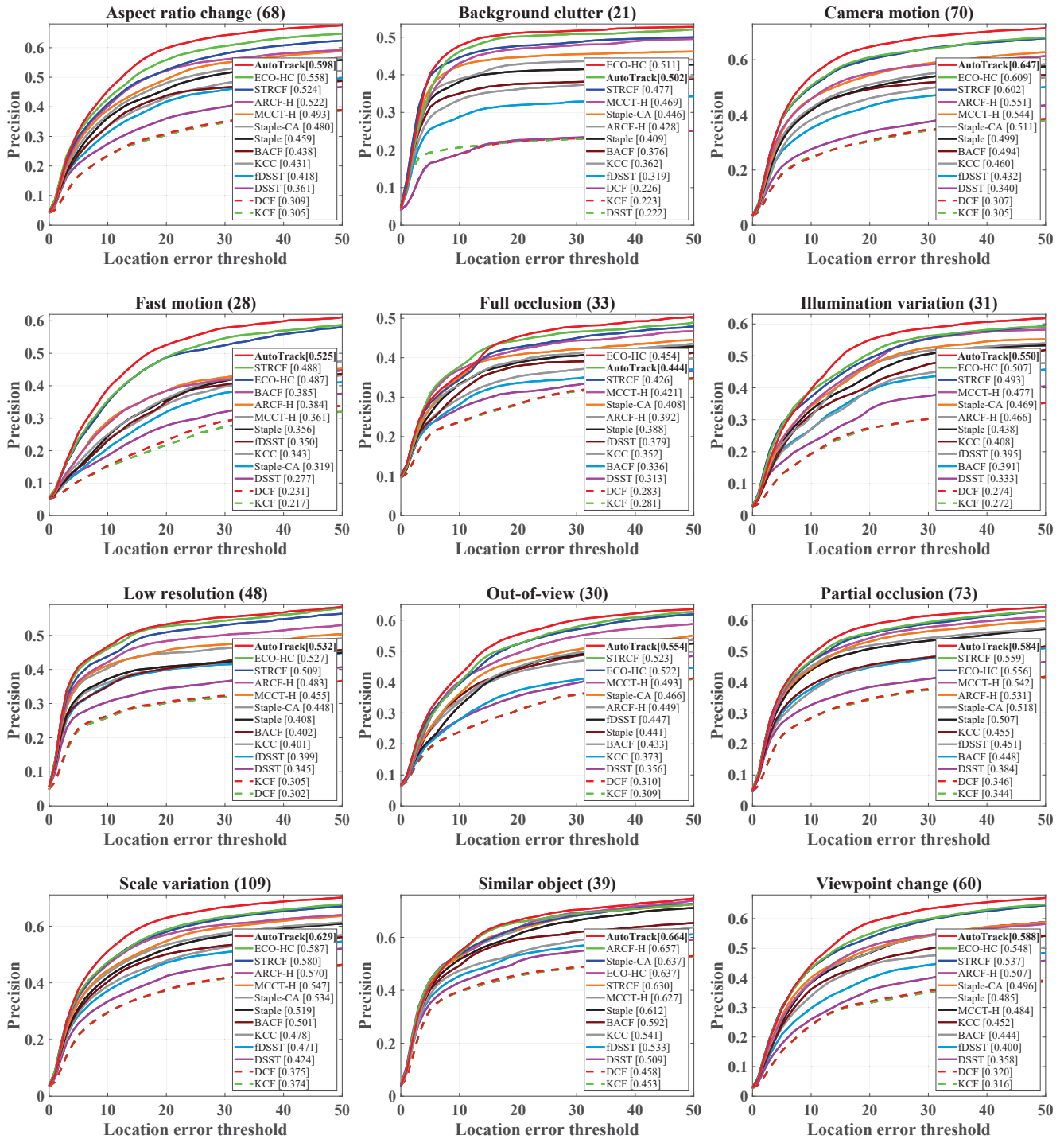Figure 5. Success plots of nine attributes from UAVDT [2].

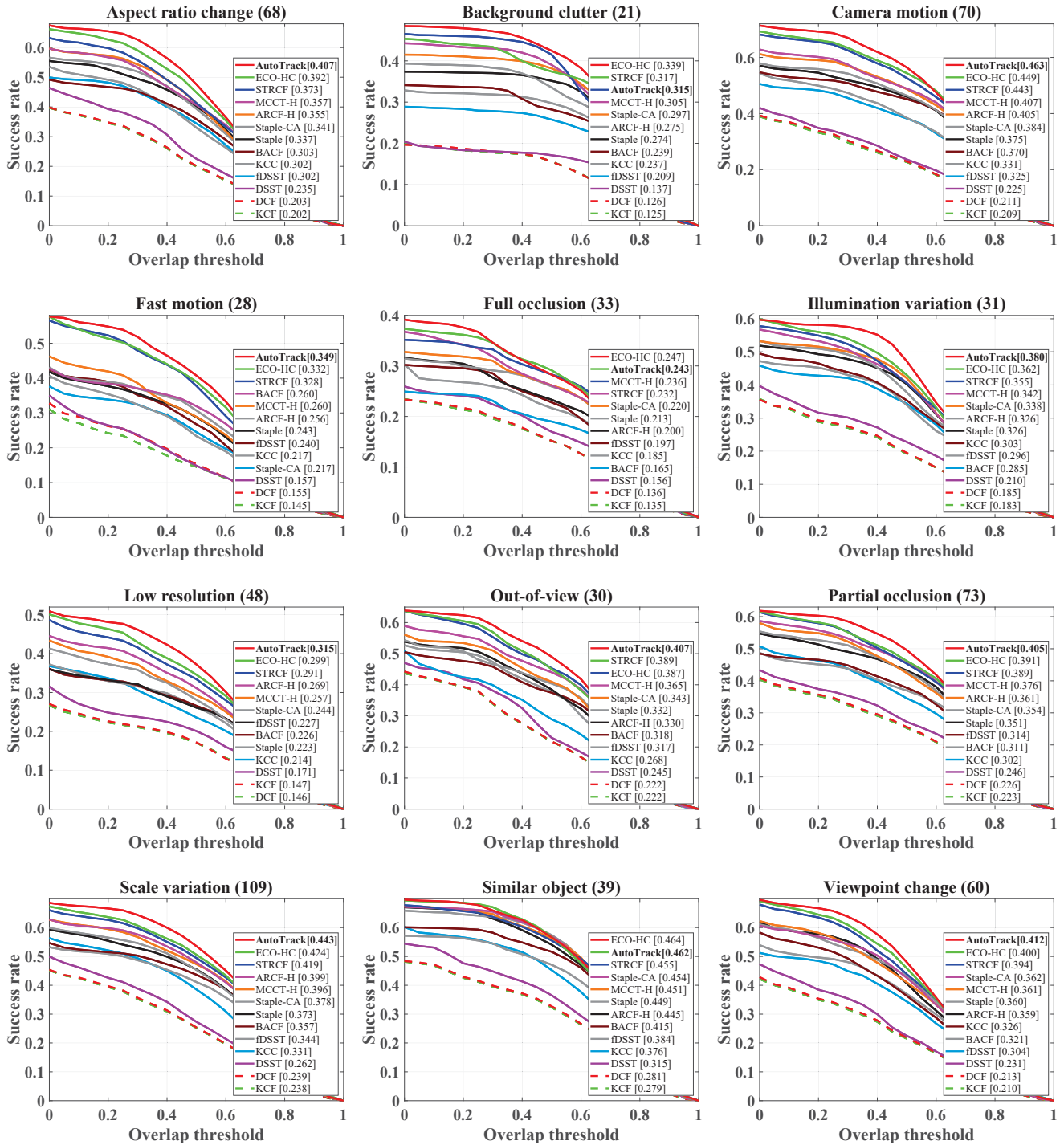Figure 6. Precision plots of twelve attributes from UAV123@10fps [3].

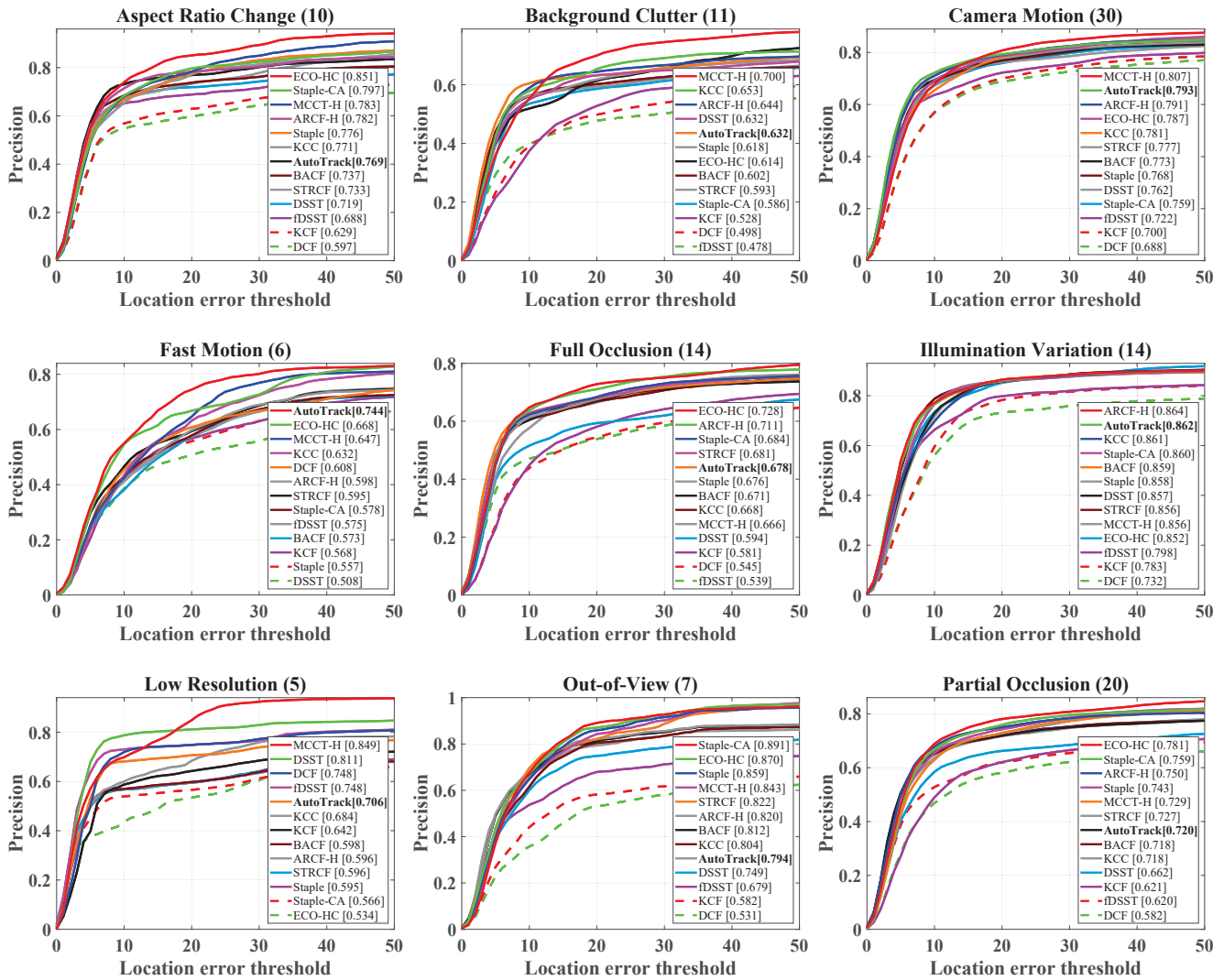Figure 7. Success plots of twelve attributes from UAV123@10fps [3].

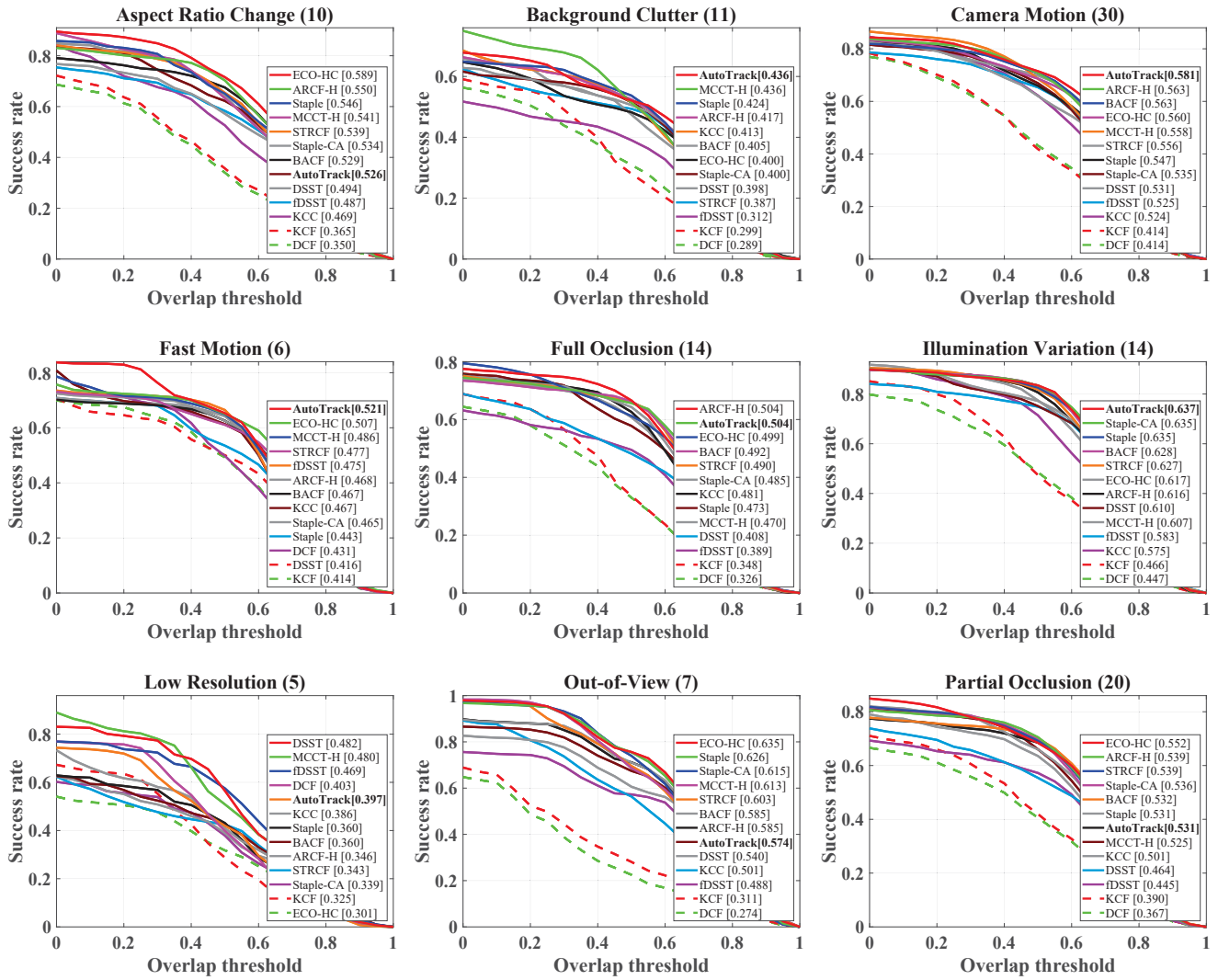Figure 8. Precision plots of nine attributes from VisDrone2018-test-dev [4].

Figure 9. Success plots of nine attributes from VisDrone2018-test-dev [4].