

MEEM: Robust Tracking via Multiple Experts using Entropy Minimization

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We provide in this document the following statistics of MEEM and other trackers on the benchmark dataset of [1] in Experiment I and our newly collected sequences in Experiment II.

1. Fig. 1 (Experiment I): the average precision plots and the success plots for the compared trackers (LSHT [2], LSST [3] and SPLTT [4]), which are not included in [1]. For the other 29 compared trackers, readers are referred to [1].
2. Fig. 2 (Experiment I): the average precision plot ranking scores and the AUC ranking scores of the five leading trackers on different subsets of test sequences.
3. Fig. 3 and 4 (Experiment I): the precision plot ranking score tables and the AUC ranking score tables for the top five trackers.
4. Fig. 5 and 6 (Experiment I): the precision plot ranking score tables and the AUC ranking score tables for MEEM and its baselines.
5. Fig. 7 (Experiment II): the precision plot ranking score table and the AUC ranking score table for MEEM and the compared algorithms on our newly collected sequences.

Detailed explanations are included in the caption of each figure. For more information about the test sequences, evaluation protocols, and the 29 trackers evaluated in [1], readers are directed to [1] and its project website.

References

1. Wu, Y., Lim, J., Yang, M.H.: Online object tracking: A benchmark. In: CVPR. (2013)
2. He, S., Yang, Q., Lau, R.W., Wang, J., Yang, M.H.: Visual tracking via locality sensitive histograms. In: CVPR. (2013)
3. Wang, D., Lu, H., Yang, M.H.: Least soft-threshold squares tracking. In: CVPR. (2013)
4. Supancic III, J.S., Ramanan, D.: Self-paced learning for long-term tracking. In: CVPR. (2013)
5. Hare, S., Saffari, A., Torr, P.H.: Struck: Structured output tracking with kernels. In: ICCV. (2011)
6. Zhong, W., Lu, H., Yang, M.H.: Robust object tracking via sparsity-based collaborative model. In: CVPR. (2012)
7. Kalal, Z., Matas, J., Mikolajczyk, K.: Pn learning: Bootstrapping binary classifiers by structural constraints. In: CVPR. (2010)
8. Kwon, J., Lee, K.M.: Visual tracking decomposition. In: CVPR. (2010)
9. Kwon, J., Lee, K.M.: Tracking by sampling trackers. In: ICCV. (2011)
10. Jia, X., Lu, H., Yang, M.H.: Visual tracking via adaptive structural local sparse appearance model. In: CVPR. (2012)
11. Dinh, T.B., Vo, N., Medioni, G.: Context tracker: Exploring supporters and distracters in unconstrained environments. In: CVPR. (2011)

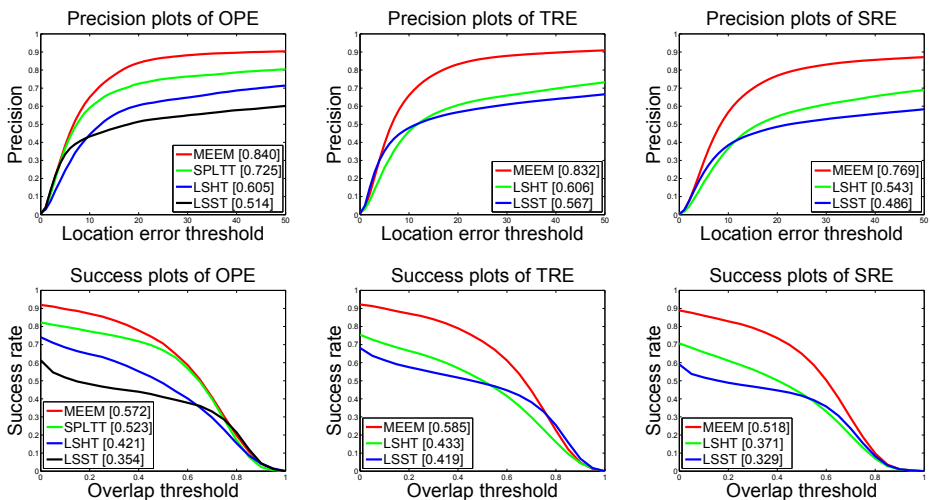


Fig. 1. Average precision plots (top row) and success plots (bottom row) of MEEM and three recent trackers not included in [1] (LSHT [2], LSST [3] and SPLTT [4]) for OPE, SRE and TRE on the benchmark dataset of [1] in Experiment I (best viewed in color). The numbers in the square brackets are the ranking scores of the trackers, averaged over all 50 test sequences. Note that the line style of a curve is determined by the ranking of the corresponding tracker in the plot, not by the name of the tracker. SPLTT is only evaluated for OPE due to limited computational resources. For the other 29 compared trackers, readers are referred to [1].

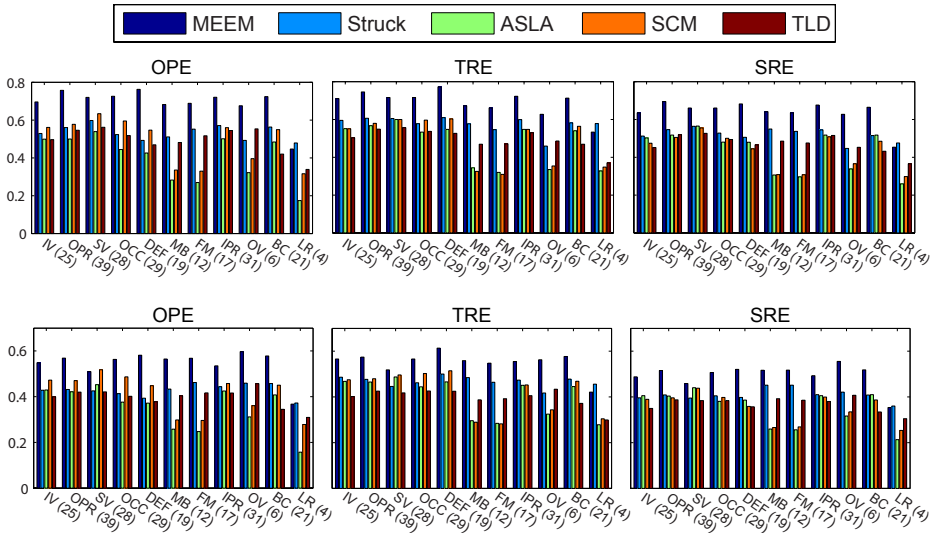


Fig. 2. Average precision plot ranking scores (top) and AUC ranking scores (bottom) of the five leading trackers on different subsets of test sequences in OPE, TRE and SRE on the benchmark dataset of [1] in Experiment I (best viewed in color). Each subset of sequences corresponds to an attribute, such as illumination variation (IV), out-of-plane rotation (OPR), scale variation (SV), occlusion (OCC), deformation (DEF), motion blur (MB), fast motion (FM), in-plane rotation (IPR), out-of-view (OV), background clutter (BC), low resolution (LR). The number after each attribute name is the number of sequences that have this attribute. Trackers displayed here are selected based on their AUC ranking scores in SRE.

	MfEM	SPLTT	Struck	SCM	TLD		MfEM	Struck	SCM	VTD	VTS		MfEM	Struck	ASLA	SCM	TLD
basketball	1.00	0.42	0.12	0.66	0.41	basketball	0.90	0.46	0.46	0.98	0.97	basketball	0.80	0.23	0.42	0.98	0.41
bolt	0.97	0.09	0.02	0.08	0.31	bolt	1.00	0.36	0.45	0.83	0.90	bolt	0.27	0.02	0.06	0.08	0.21
boy	1.00	1.00	1.00	0.44	1.00	boy	1.00	1.00	0.36	0.96	0.96	boy	1.00	1.00	0.43	0.46	1.00
car4	0.83	0.61	0.99	0.97	0.87	car4	0.90	1.00	1.00	0.76	0.66	car4	0.56	0.90	0.87	0.66	0.55
carDark	1.00	0.99	1.00	1.00	0.64	carDark	0.86	1.00	1.00	0.62	0.72	carDark	0.90	1.00	0.96	0.98	0.66
carScale	0.64	0.86	0.65	0.65	0.85	carScale	0.60	0.52	0.58	0.51	0.52	carScale	0.68	0.64	0.73	0.72	0.65
coke	0.95	0.93	0.95	0.43	0.66	coke	0.82	0.65	0.28	0.37	0.40	coke	0.81	0.82	0.18	0.32	0.54
couple	1.00	1.00	0.74	0.11	1.00	couple	1.00	0.59	0.35	0.41	0.22	couple	0.97	0.77	0.30	0.11	0.89
crossing	1.00	1.00	1.00	1.00	0.62	crossing	0.94	0.94	1.00	0.63	0.63	crossing	0.89	0.73	1.00	1.00	0.67
david	0.99	0.83	0.33	1.00	1.00	david	0.99	0.74	0.94	0.89	0.92	david	0.97	0.76	0.98	0.70	0.90
david2	1.00	1.00	1.00	1.00	1.00	david2	1.00	1.00	0.99	1.00	1.00	david2	1.00	1.00	1.00	0.99	0.84
david3	0.99	0.89	0.34	0.50	0.11	david3	0.89	0.67	0.69	0.51	0.44	david3	0.96	0.63	0.53	0.47	0.17
deer	1.00	1.00	1.00	0.03	0.73	deer	1.00	1.00	0.09	0.14	0.15	deer	0.99	1.00	0.04	0.09	0.73
dog1	0.99	0.99	1.00	0.98	1.00	dog1	0.95	0.96	0.89	0.80	0.83	dog1	0.96	0.96	0.98	0.91	0.99
doll	0.98	0.99	0.92	0.98	0.98	doll	0.98	0.81	0.88	0.95	0.96	doll	0.98	0.68	0.90	0.96	0.97
dudek	0.80	0.85	0.90	0.88	0.60	dudek	0.57	0.73	0.59	0.77	0.79	dudek	0.59	0.50	0.66	0.71	0.46
faceocc1	0.65	0.75	0.58	0.93	0.26	faceocc1	0.79	0.90	0.99	0.70	0.69	faceocc1	0.53	0.48	0.33	0.75	0.26
faceocc2	0.87	0.85	1.00	0.86	0.86	faceocc2	0.84	0.99	0.80	0.86	0.84	faceocc2	0.91	0.94	0.87	0.74	0.71
fish	1.00	1.00	1.00	0.86	1.00	fish	1.00	0.97	0.99	0.91	1.00	fish	0.90	0.64	0.95	0.84	0.93
fleetface	0.60	0.64	0.64	0.53	0.51	fleetface	0.46	0.42	0.37	0.45	0.45	fleetface	0.48	0.50	0.47	0.46	0.50
football	0.99	0.30	0.75	0.77	0.80	football	0.92	0.62	0.81	0.67	0.67	football	0.99	0.67	0.78	0.87	0.79
football1	1.00	0.70	1.00	0.57	0.55	football1	1.00	0.86	0.85	0.99	0.99	football1	1.00	0.75	0.84	0.74	0.58
freeman1	0.93	0.64	0.80	0.98	0.54	freeman1	0.81	0.77	0.73	0.75	0.78	freeman1	0.92	0.81	0.73	0.71	0.70
freeman3	0.98	0.82	0.79	1.00	0.77	freeman3	0.98	0.75	0.95	0.85	0.84	freeman3	0.95	0.66	0.96	0.96	0.84
freeman4	0.96	0.30	0.37	0.51	0.41	freeman4	0.83	0.33	0.56	0.44	0.45	freeman4	0.79	0.43	0.35	0.47	0.42
girl	1.00	0.79	1.00	1.00	0.92	girl	0.92	0.99	0.93	0.79	0.75	girl	0.94	0.99	0.87	0.81	0.95
ironman	0.55	0.08	0.11	0.16	0.12	ironman	0.38	0.13	0.15	0.24	0.22	ironman	0.46	0.07	0.17	0.13	0.16
jogging-1	0.96	0.93	0.24	0.23	0.97	jogging-1	0.70	0.78	0.70	0.62	0.62	jogging-1	0.65	0.54	0.23	0.29	0.88
jogging-2	0.97	0.98	0.25	1.00	0.86	jogging-2	0.91	0.76	1.00	0.76	0.76	jogging-2	0.89	0.24	0.24	0.44	0.87
jumping	1.00	1.00	1.00	0.15	1.00	jumping	1.00	1.00	0.22	0.42	0.35	jumping	1.00	1.00	0.18	0.20	1.00
lemming	0.93	0.88	0.63	0.17	0.86	lemming	0.86	0.52	0.18	0.57	0.60	lemming	0.82	0.63	0.17	0.17	0.37
liquor	0.97	0.79	0.39	0.28	0.55	liquor	0.92	0.41	0.30	0.28	0.26	liquor	0.77	0.41	0.26	0.33	0.61
matrix	0.65	0.26	0.12	0.35	0.16	matrix	0.55	0.19	0.22	0.22	0.22	matrix	0.48	0.17	0.18	0.20	0.16
mhyang	1.00	1.00	1.00	1.00	0.98	mhyang	0.99	1.00	1.00	0.99	0.99	mhyang	0.99	1.00	1.00	1.00	0.98
motorRolling	0.63	0.09	0.09	0.04	0.12	motorRolling	0.19	0.38	0.16	0.15	0.14	motorRolling	0.34	0.17	0.08	0.05	0.12
mountainBike	0.91	0.94	0.92	0.97	0.26	mountainBike	0.86	0.91	0.81	0.95	0.92	mountainBike	0.92	0.93	0.97	0.92	0.33
shaking	0.96	0.15	0.19	0.81	0.41	shaking	0.97	0.55	0.77	0.89	0.88	shaking	0.58	0.25	0.42	0.61	0.37
singer1	0.35	0.32	0.64	1.00	1.00	singer1	0.54	0.89	1.00	0.96	0.93	singer1	0.31	0.66	0.97	0.97	0.55
singer2	0.04	0.69	0.04	0.11	0.07	singer2	0.76	0.60	0.57	0.89	0.83	singer2	0.26	0.03	0.47	0.13	0.05
skating1	0.69	0.54	0.47	0.77	0.32	skating1	0.64	0.45	0.78	0.58	0.64	skating1	0.68	0.55	0.78	0.73	0.44
skiing	1.00	0.07	0.04	0.14	0.12	skiing	1.00	0.19	0.23	0.47	0.36	skiing	0.88	0.06	0.13	0.13	0.11
soccer	0.40	0.14	0.25	0.27	0.11	soccer	0.41	0.14	0.28	0.53	0.52	soccer	0.34	0.16	0.22	0.22	0.12
subway	1.00	1.00	0.98	1.00	0.25	subway	1.00	0.57	0.93	0.46	0.45	subway	0.94	0.85	0.67	0.68	0.56
suv	0.63	0.97	0.57	0.98	0.91	suv	0.60	0.53	0.86	0.39	0.36	suv	0.76	0.63	0.73	0.82	0.91
sylvester	0.95	0.91	0.99	0.95	0.95	sylvester	0.89	0.99	0.83	0.75	0.74	sylvester	0.94	0.98	0.84	0.83	0.88
tiger1	0.81	0.97	0.17	0.13	0.46	tiger1	0.81	0.60	0.14	0.19	0.14	tiger1	0.83	0.51	0.16	0.14	0.33
tiger2	0.50	0.91	0.63	0.11	0.39	tiger2	0.73	0.59	0.14	0.32	0.37	tiger2	0.57	0.49	0.14	0.16	0.35
trellis	0.96	0.95	0.88	0.87	0.53	trellis	0.99	0.86	0.80	0.58	0.57	trellis	0.96	0.79	0.90	0.89	0.53
walking	1.00	1.00	1.00	1.00	0.96	walking	1.00	1.00	1.00	1.00	1.00	walking	1.00	1.00	1.00	0.95	0.60
walking2	0.37	0.39	0.98	1.00	0.43	walking2	0.84	0.99	1.00	0.68	0.78	walking2	0.44	0.79	0.75	0.95	0.50
woman	1.00	0.83	1.00	0.94	0.15	woman	1.00	1.00	0.73	0.40	0.35	woman	0.93	0.99	0.57	0.76	0.52
AVG	0.84	0.72	0.66	0.65	0.61	AVG	0.83	0.71	0.65	0.64	0.64	AVG	0.77	0.64	0.58	0.57	0.57

OPE

TRE

SRE

Fig. 3. Precision plot ranking scores of the top five trackers in OPE, TRE and SRE on the benchmark dataset of [1] in Experiment I. The trackers shown in this figure are SPLTT [4], Struck [5], SCM [6], TLD [7], VTD [8], VTS [9] and ASLA [10]. Our tracker tends to better handle the sequences like “basketball”, “bolt”, “david3”, “football”, “football1”, “freeman4”, “ironman”, “lemming”, “liquor”, “matrix”, “skiing”, “soccer”, “subway”, “tiger1” and “tiger2”, in which the target often undergoes different levels of occlusion, non-rigid motion and out-of-plane rotation.

	MEEM	SPLTT	SCM	Struck	TLD		MEEM	Struck	SCM	ASLA	CXT		MEEM	Struck	ASLA	SCM	TLD
basketball	0.80	0.29	0.46	0.21	0.11	basketball	0.58	0.36	0.34	0.36	0.19	basketball	0.35	0.78	0.29	0.05	0.07
bolt	0.43	0.01	0.02	0.01	0.16	bolt	0.74	0.27	0.34	0.34	0.08	bolt	0.16	0.01	0.03	0.06	0.12
boy	0.78	0.68	0.37	0.75	0.65	boy	0.70	0.67	0.28	0.25	0.64	boy	0.69	0.67	0.32	0.34	0.60
car4	0.46	0.38	0.75	0.49	0.63	car4	0.60	0.65	0.82	0.81	0.67	car4	0.33	0.44	0.62	0.49	0.36
carDark	0.84	0.73	0.83	0.87	0.44	carDark	0.67	0.84	0.83	0.79	0.50	carDark	0.67	0.73	0.68	0.72	0.39
carScale	0.39	0.65	0.59	0.42	0.45	carScale	0.37	0.37	0.55	0.54	0.54	carScale	0.39	0.40	0.58	0.55	0.44
coke	0.66	0.57	0.32	0.66	0.40	coke	0.63	0.55	0.27	0.23	0.41	coke	0.58	0.57	0.17	0.26	0.34
couple	0.60	0.66	0.10	0.53	0.76	couple	0.64	0.48	0.25	0.21	0.43	couple	0.58	0.52	0.21	0.09	0.61
crossing	0.71	0.68	0.77	0.67	0.40	crossing	0.65	0.66	0.78	0.77	0.45	crossing	0.57	0.46	0.74	0.71	0.37
david	0.53	0.47	0.71	0.25	0.71	david	0.64	0.52	0.70	0.67	0.68	david	0.51	0.43	0.65	0.49	0.54
david2	0.83	0.72	0.73	0.85	0.68	david2	0.80	0.82	0.77	0.82	0.83	david2	0.75	0.74	0.67	0.63	0.55
david3	0.67	0.70	0.39	0.29	0.10	david3	0.63	0.49	0.51	0.31	0.23	david3	0.68	0.46	0.38	0.35	0.12
deer	0.73	0.68	0.07	0.73	0.59	deer	0.75	0.77	0.11	0.14	0.63	deer	0.67	0.67	0.05	0.10	0.52
dog1	0.55	0.73	0.69	0.54	0.58	dog1	0.50	0.50	0.63	0.64	0.76	dog1	0.53	0.53	0.67	0.62	0.57
doll	0.57	0.77	0.81	0.54	0.57	doll	0.66	0.57	0.73	0.80	0.73	doll	0.56	0.42	0.69	0.71	0.54
dudek	0.71	0.74	0.76	0.72	0.64	dudek	0.61	0.64	0.62	0.63	0.64	dudek	0.65	0.61	0.65	0.68	0.56
faceocc1	0.72	0.72	0.78	0.72	0.58	faceocc1	0.75	0.77	0.84	0.52	0.64	faceocc1	0.67	0.67	0.47	0.70	0.53
faceocc2	0.69	0.63	0.72	0.77	0.61	faceocc2	0.66	0.73	0.66	0.61	0.61	faceocc2	0.66	0.67	0.64	0.58	0.56
fish	0.75	0.79	0.74	0.84	0.80	fish	0.81	0.83	0.83	0.84	0.80	fish	0.67	0.54	0.71	0.66	0.59
fleeftace	0.60	0.55	0.60	0.60	0.49	fleeftace	0.55	0.51	0.53	0.52	0.49	fleeftace	0.56	0.55	0.55	0.54	0.47
football	0.68	0.19	0.48	0.53	0.49	football	0.61	0.41	0.48	0.45	0.44	football	0.64	0.43	0.49	0.53	0.52
football1	0.67	0.49	0.40	0.66	0.37	football1	0.69	0.55	0.51	0.54	0.67	football1	0.67	0.46	0.47	0.43	0.37
freeman1	0.38	0.41	0.61	0.34	0.28	freeman1	0.43	0.40	0.43	0.42	0.42	freeman1	0.37	0.35	0.42	0.43	0.33
freeman3	0.35	0.57	0.71	0.26	0.44	freeman3	0.37	0.32	0.61	0.65	0.68	freeman3	0.34	0.23	0.63	0.59	0.44
freeman4	0.42	0.14	0.26	0.17	0.22	freeman4	0.43	0.19	0.37	0.32	0.23	freeman4	0.36	0.20	0.17	0.25	0.20
girl	0.70	0.56	0.67	0.73	0.57	girl	0.55	0.65	0.65	0.61	0.54	girl	0.61	0.67	0.53	0.52	0.55
ironman	0.37	0.07	0.12	0.09	0.11	ironman	0.26	0.12	0.12	0.11	0.07	ironman	0.30	0.07	0.13	0.10	0.09
jogging-1	0.66	0.63	0.18	0.17	0.76	jogging-1	0.50	0.55	0.55	0.51	0.66	jogging-1	0.46	0.37	0.16	0.19	0.62
jogging-2	0.63	0.71	0.72	0.20	0.65	jogging-2	0.68	0.62	0.83	0.63	0.68	jogging-2	0.61	0.17	0.16	0.29	0.60
jumping	0.69	0.74	0.12	0.61	0.66	jumping	0.69	0.68	0.17	0.19	0.61	jumping	0.65	0.64	0.11	0.13	0.65
lemming	0.67	0.70	0.14	0.48	0.53	lemming	0.64	0.40	0.16	0.20	0.35	lemming	0.59	0.47	0.13	0.14	0.26
liquor	0.77	0.64	0.32	0.40	0.51	liquor	0.74	0.38	0.31	0.32	0.28	liquor	0.68	0.43	0.31	0.33	0.58
matrix	0.39	0.15	0.26	0.10	0.16	matrix	0.35	0.15	0.17	0.14	0.08	matrix	0.31	0.11	0.16	0.15	0.17
mhyang	0.77	0.83	0.79	0.80	0.63	mhyang	0.72	0.76	0.82	0.84	0.81	mhyang	0.70	0.73	0.76	0.74	0.64
motorRolling	0.10	0.27	0.11	0.16	0.23	motorRolling	0.14	0.33	0.17	0.21	0.15	motorRolling	0.10	0.25	0.13	0.10	0.20
mountainBike	0.59	0.64	0.66	0.70	0.20	mountainBike	0.64	0.67	0.59	0.69	0.42	mountainBike	0.62	0.64	0.67	0.61	0.23
shaking	0.69	0.13	0.68	0.36	0.39	shaking	0.67	0.44	0.60	0.68	0.48	shaking	0.49	0.27	0.39	0.50	0.35
singer1	0.29	0.27	0.85	0.36	0.71	singer1	0.38	0.46	0.83	0.71	0.64	singer1	0.29	0.33	0.66	0.75	0.63
singer2	0.04	0.57	0.17	0.04	0.22	singer2	0.60	0.50	0.52	0.44	0.10	singer2	0.20	0.04	0.35	0.17	0.11
skating1	0.40	0.37	0.47	0.31	0.19	skating1	0.39	0.29	0.51	0.43	0.28	skating1	0.38	0.32	0.49	0.46	0.26
skiing	0.41	0.04	0.08	0.04	0.07	skiing	0.40	0.10	0.13	0.12	0.10	skiing	0.36	0.04	0.08	0.08	0.06
soccer	0.32	0.13	0.24	0.19	0.13	soccer	0.28	0.11	0.21	0.22	0.14	soccer	0.24	0.14	0.16	0.20	0.12
subway	0.67	0.57	0.71	0.65	0.18	subway	0.75	0.43	0.71	0.38	0.31	subway	0.60	0.55	0.44	0.44	0.36
suv	0.53	0.72	0.74	0.51	0.68	suv	0.49	0.45	0.69	0.50	0.70	suv	0.56	0.49	0.53	0.58	0.67
sylvester	0.67	0.62	0.68	0.71	0.67	sylvester	0.64	0.69	0.59	0.56	0.48	sylvester	0.64	0.64	0.56	0.56	0.57
tiger1	0.64	0.72	0.16	0.15	0.38	tiger1	0.64	0.50	0.19	0.22	0.34	tiger1	0.64	0.46	0.20	0.18	0.33
tiger2	0.54	0.66	0.09	0.54	0.27	tiger2	0.63	0.51	0.17	0.19	0.38	tiger2	0.55	0.45	0.15	0.18	0.28
trellis	0.61	0.54	0.67	0.61	0.48	trellis	0.74	0.66	0.67	0.70	0.57	trellis	0.57	0.50	0.67	0.65	0.37
walking	0.54	0.49	0.70	0.57	0.45	walking	0.62	0.61	0.75	0.77	0.43	walking	0.51	0.53	0.70	0.62	0.33
walking2	0.27	0.29	0.80	0.51	0.31	walking2	0.53	0.60	0.81	0.66	0.40	walking2	0.35	0.46	0.54	0.70	0.41
woman	0.70	0.60	0.65	0.72	0.13	woman	0.67	0.70	0.53	0.51	0.21	woman	0.61	0.67	0.35	0.48	0.33
AVG	0.57	0.52	0.50	0.47	0.44	AVG	0.59	0.51	0.51	0.48	0.46	AVG	0.52	0.44	0.42	0.42	0.40

OPE

TRE

SRE

Fig. 4. AUC ranking scores of the top five trackers in OPE, TRE and SRE on the benchmark dataset of [1] in Experiment I. The trackers shown in this figure are SPLTT [4], Struck [5], SCM [6], TLD [7], ASLA [10] and CXT [11]. Our tracker tends to better handle the sequences like “basketball”, “bolt”, “david3”, “football”, “football1”, “freeman4”, “ironman”, “lemming”, “liquor”, “matrix”, “skiing”, “soccer”, “subway”, “tiger1” and “tiger2”, in which the target often undergoes different levels of occlusion, non-rigid motion and out-of-plane rotation.

	MEEM	MEEM-1kh	SVM-avg	SVM-base	MEEM-gray		MEEM	MEEM-1kh	SVM-avg	SVM-base	MEEM-gray		MEEM	MEEM-1kh	SVM-avg	SVM-base	MEEM-gray
basketball	1.00	1.00	0.98	0.98	0.97	basketball	0.90	0.94	0.91	0.91	0.93	basketball	0.80	0.78	0.80	0.77	0.43
bolt	0.97	0.98	0.90	0.90	0.90	bolt	1.00	1.00	0.99	0.99	0.60	bolt	0.27	0.27	0.27	0.27	0.14
boy	1.00	1.00	1.00	1.00	1.00	boy	1.00	1.00	1.00	1.00	1.00	boy	1.00	1.00	1.00	1.00	1.00
car4	0.83	0.71	0.57	0.57	0.83	car4	0.90	0.83	0.88	0.88	0.90	car4	0.56	0.41	0.45	0.45	0.56
carDark	1.00	1.00	1.00	1.00	1.00	carDark	0.86	0.86	0.86	0.86	0.75	carDark	0.90	0.98	0.98	0.93	0.95
carScale	0.64	0.71	0.64	0.64	0.66	carScale	0.60	0.61	0.61	0.61	0.59	carScale	0.68	0.68	0.68	0.68	0.69
coke	0.95	0.87	0.88	0.88	0.94	coke	0.82	0.72	0.74	0.74	0.85	coke	0.81	0.78	0.78	0.79	0.94
couple	1.00	1.00	1.00	1.00	1.00	couple	1.00	1.00	1.00	1.00	0.97	couple	0.97	0.97	0.97	0.97	0.94
crossing	1.00	1.00	1.00	1.00	1.00	crossing	0.94	0.94	0.94	0.94	1.00	crossing	0.99	0.89	0.89	0.89	1.00
david	0.99	0.99	0.99	0.99	0.98	david	0.99	0.99	0.99	0.99	0.98	david	0.97	0.97	0.97	0.97	0.94
david2	1.00	1.00	1.00	1.00	1.00	david2	1.00	1.00	1.00	1.00	1.00	david2	1.00	1.00	1.00	1.00	1.00
david3	0.99	0.99	0.75	0.75	0.97	david3	0.89	0.78	0.76	0.76	0.72	david3	0.96	0.85	0.79	0.83	0.83
deer	1.00	1.00	1.00	1.00	1.00	deer	1.00	1.00	1.00	1.00	1.00	deer	0.99	0.99	0.99	0.99	1.00
dog1	0.99	0.99	0.99	0.99	0.99	dog1	0.95	0.95	0.95	0.95	0.95	dog1	0.96	0.97	0.96	0.96	0.96
doll	0.98	0.99	0.98	0.98	0.97	doll	0.98	0.98	0.98	0.98	0.95	doll	0.98	0.98	0.98	0.98	0.96
dudek	0.80	0.80	0.78	0.78	0.80	dudek	0.57	0.60	0.60	0.60	0.57	dudek	0.59	0.59	0.61	0.60	0.59
faceocc1	0.65	0.65	0.65	0.65	0.68	faceocc1	0.79	0.79	0.79	0.79	0.80	faceocc1	0.53	0.53	0.53	0.53	0.50
faceocc2	0.87	0.87	0.96	0.96	0.87	faceocc2	0.84	0.92	0.93	0.93	0.84	faceocc2	0.91	0.92	0.95	0.93	0.91
fish	1.00	1.00	1.00	1.00	1.00	fish	1.00	1.00	1.00	1.00	1.00	fish	0.90	0.98	0.98	0.98	0.90
fleeftace	0.60	0.60	0.60	0.60	0.66	fleeftace	0.46	0.45	0.45	0.45	0.46	fleeftace	0.48	0.49	0.48	0.49	0.48
football	0.99	0.99	1.00	1.00	0.99	football	0.92	0.90	0.92	0.92	0.92	football	0.99	1.00	0.97	0.98	0.99
football1	1.00	1.00	1.00	1.00	1.00	football1	1.00	1.00	1.00	1.00	0.98	football1	1.00	1.00	1.00	1.00	0.99
freeman1	0.93	0.93	0.41	0.41	0.93	freeman1	0.81	0.87	0.83	0.83	0.81	freeman1	0.92	0.98	0.96	0.97	0.92
freeman3	0.98	0.97	1.00	1.00	0.98	freeman3	0.98	0.96	0.98	0.98	0.98	freeman3	0.95	0.97	0.97	0.97	0.95
freeman4	0.96	0.96	0.99	0.99	0.96	freeman4	0.83	0.74	0.86	0.86	0.83	freeman4	0.79	0.86	0.85	0.83	0.79
girl	1.00	0.92	1.00	1.00	1.00	girl	0.92	0.92	0.93	0.93	0.95	girl	0.94	0.95	0.96	0.96	0.97
ironman	0.55	0.65	0.67	0.67	0.60	ironman	0.38	0.37	0.39	0.39	0.21	ironman	0.46	0.46	0.45	0.45	0.11
jogging-1	0.96	0.23	0.23	0.23	0.23	jogging-1	0.70	0.62	0.62	0.62	0.81	jogging-1	0.65	0.35	0.35	0.35	0.83
jogging-2	0.97	0.97	0.97	0.97	0.93	jogging-2	0.91	0.83	0.83	0.83	0.99	jogging-2	0.89	0.48	0.49	0.48	0.96
jumping	1.00	1.00	1.00	1.00	1.00	jumping	1.00	1.00	1.00	1.00	1.00	jumping	1.00	1.00	1.00	1.00	1.00
lemming	0.93	0.26	0.57	0.57	0.83	lemming	0.86	0.54	0.54	0.54	0.70	lemming	0.82	0.47	0.50	0.52	0.77
liquor	0.97	0.89	0.97	0.97	0.71	liquor	0.92	0.90	0.87	0.87	0.52	liquor	0.77	0.77	0.79	0.78	0.52
matrix	0.65	0.66	0.65	0.65	0.11	matrix	0.55	0.55	0.55	0.55	0.21	matrix	0.48	0.47	0.50	0.48	0.11
mhyang	1.00	1.00	1.00	1.00	1.00	mhyang	0.99	0.99	0.99	0.99	0.99	mhyang	0.99	0.99	0.99	0.99	0.99
motorRolling	0.05	0.06	0.06	0.06	0.06	motorRolling	0.13	0.13	0.13	0.13	0.11	motorRolling	0.04	0.04	0.05	0.05	0.06
mountainBike	0.91	0.91	0.91	0.91	0.93	mountainBike	0.86	0.86	0.86	0.86	0.83	mountainBike	0.92	0.93	0.93	0.92	0.92
shaking	0.96	0.99	0.97	0.97	0.95	shaking	0.97	0.98	0.98	0.98	0.96	shaking	0.58	0.64	0.54	0.54	0.48
singer1	0.35	0.36	0.35	0.35	0.34	singer1	0.54	0.52	0.51	0.51	0.61	singer1	0.31	0.29	0.29	0.30	0.34
singer2	0.04	0.04	0.04	0.04	0.04	singer2	0.76	0.72	0.71	0.71	0.69	singer2	0.26	0.25	0.26	0.26	0.22
skating1	0.69	0.88	0.69	0.69	0.69	skating1	0.64	0.79	0.72	0.72	0.66	skating1	0.68	0.71	0.71	0.75	0.54
skiing	1.00	1.00	1.00	1.00	0.11	skiing	1.00	1.00	0.94	0.94	0.21	skiing	0.88	0.88	0.88	0.88	0.11
soccer	0.40	0.27	0.40	0.40	0.43	soccer	0.41	0.44	0.42	0.42	0.29	soccer	0.34	0.37	0.28	0.30	0.22
subway	1.00	1.00	1.00	1.00	1.00	subway	1.00	1.00	1.00	1.00	1.00	subway	0.94	0.88	0.88	0.88	1.00
suv	0.63	0.79	0.79	0.79	0.63	suv	0.60	0.64	0.56	0.56	0.60	suv	0.76	0.69	0.65	0.70	0.76
sylvester	0.95	0.95	0.97	0.97	0.95	sylvester	0.89	0.94	0.94	0.94	0.89	sylvester	0.94	0.95	0.94	0.95	0.94
tiger1	0.81	0.82	0.81	0.81	0.81	tiger1	0.81	0.69	0.69	0.69	0.70	tiger1	0.83	0.83	0.83	0.83	0.77
tiger2	0.50	0.50	0.50	0.50	0.52	tiger2	0.73	0.73	0.73	0.73	0.72	tiger2	0.57	0.59	0.59	0.59	0.56
trellis	0.96	0.96	0.96	0.96	0.95	trellis	0.99	0.99	0.99	0.99	0.87	trellis	0.96	0.97	0.96	0.96	0.94
walking	1.00	1.00	1.00	1.00	1.00	walking	1.00	1.00	1.00	1.00	1.00	walking	1.00	0.94	0.94	1.00	1.00
walking2	0.37	0.45	0.39	0.39	0.43	walking2	0.84	0.80	0.75	0.75	0.71	walking2	0.44	0.41	0.48	0.49	0.38
woman	1.00	1.00	1.00	1.00	1.00	woman	1.00	1.00	1.00	1.00	0.95	woman	0.93	1.00	1.00	0.93	1.00
AVG	0.84	0.81	0.80	0.80	0.75	AVG	0.83	0.82	0.82	0.82	0.77	AVG	0.77	0.75	0.75	0.75	0.72

OPE

TRE

SRE

Fig. 5. Precision plot ranking scores of MEEM and its baselines in OPE, TRE and SRE on the benchmark dataset of [1] in Experiment I. Besides the baselines evaluated in our paper, we also report another baseline MEEM-gray, which is the full implementation of MEEM, but only uses the gray-scale images as input. MEEM-gray generally gives lower scores than MEEM, but on average it still compares favorably with the state-of-the-art trackers in Fig. 3. Significant improvement of MEEM over SVM-base is observed on such sequences as “david3” (OPE, TRE and SRE), “lemming” (OPE, TRE and SRE), “jogging-1” (OPE and SRE) and “jogging2” (SRE), where challenges like occlusions and large appearance variations, could lead to model drift.

	MEEM	MEEM-ikh	SVM-avg	SVM-base	MEEM-gray		MEEM	MEEM-ikh	SVM-avg	SVM-base	MEEM-gray		MEEM	MEEM-ikh	SVM-avg	SVM-base	MEEM-gray
basketball	0.30	0.69	0.70	0.70	0.10	basketball	0.58	0.61	0.57	0.57	0.37	basketball	0.55	0.54	0.56	0.53	0.37
bolt	0.43	0.46	0.43	0.43	0.02	bolt	0.74	0.75	0.74	0.74	0.45	bolt	0.16	0.16	0.16	0.16	0.02
boy	0.78	0.78	0.78	0.78	0.78	boy	0.70	0.70	0.70	0.70	0.70	boy	0.69	0.69	0.69	0.69	0.69
car4	0.46	0.47	0.47	0.47	0.46	car4	0.60	0.58	0.60	0.60	0.60	car4	0.33	0.31	0.30	0.30	0.33
carDark	0.84	0.84	0.84	0.84	0.85	carDark	0.67	0.67	0.67	0.67	0.57	carDark	0.67	0.72	0.72	0.68	0.70
carScale	0.39	0.42	0.39	0.39	0.38	carScale	0.37	0.37	0.37	0.37	0.37	carScale	0.39	0.39	0.39	0.39	0.39
coke	0.66	0.61	0.63	0.63	0.68	coke	0.63	0.56	0.58	0.58	0.67	coke	0.58	0.56	0.56	0.56	0.65
couple	0.60	0.60	0.60	0.60	0.62	couple	0.64	0.64	0.64	0.64	0.64	couple	0.58	0.58	0.58	0.58	0.52
crossing	0.71	0.70	0.71	0.71	0.71	crossing	0.65	0.65	0.65	0.65	0.70	crossing	0.57	0.57	0.57	0.57	0.65
david	0.53	0.53	0.53	0.53	0.53	david	0.64	0.64	0.64	0.64	0.64	david	0.51	0.50	0.51	0.51	0.49
david2	0.83	0.84	0.83	0.83	0.83	david2	0.80	0.81	0.80	0.80	0.80	david2	0.75	0.75	0.75	0.75	0.75
david3	0.67	0.69	0.53	0.53	0.67	david3	0.63	0.55	0.54	0.54	0.50	david3	0.68	0.61	0.58	0.59	0.59
deer	0.73	0.73	0.73	0.73	0.73	deer	0.75	0.75	0.75	0.75	0.75	deer	0.67	0.67	0.67	0.67	0.66
dog1	0.55	0.55	0.55	0.55	0.55	dog1	0.50	0.50	0.50	0.50	0.50	dog1	0.53	0.53	0.53	0.53	0.53
doll	0.57	0.57	0.57	0.57	0.56	doll	0.66	0.66	0.66	0.66	0.65	doll	0.56	0.56	0.57	0.56	0.56
dudek	0.71	0.71	0.71	0.71	0.71	dudek	0.61	0.63	0.63	0.63	0.61	dudek	0.65	0.65	0.66	0.66	0.65
faceocc1	0.72	0.72	0.72	0.72	0.74	faceocc1	0.75	0.75	0.75	0.75	0.75	faceocc1	0.67	0.67	0.67	0.67	0.67
faceocc2	0.69	0.69	0.72	0.72	0.69	faceocc2	0.66	0.70	0.70	0.70	0.66	faceocc2	0.66	0.66	0.67	0.66	0.66
fish	0.75	0.75	0.75	0.75	0.75	fish	0.81	0.81	0.81	0.81	0.81	fish	0.67	0.70	0.70	0.70	0.67
fleeftace	0.60	0.64	0.64	0.64	0.66	fleeftace	0.55	0.57	0.57	0.55	0.55	fleeftace	0.56	0.59	0.57	0.58	0.56
football	0.68	0.69	0.72	0.72	0.68	football	0.61	0.60	0.61	0.61	0.61	football	0.64	0.65	0.62	0.64	0.64
football1	0.67	0.67	0.67	0.67	0.67	football1	0.69	0.69	0.69	0.69	0.69	football1	0.67	0.67	0.67	0.67	0.67
freeman1	0.38	0.38	0.21	0.21	0.38	freeman1	0.43	0.45	0.43	0.43	0.43	freeman1	0.37	0.39	0.38	0.38	0.34
freeman3	0.35	0.35	0.35	0.35	0.35	freeman3	0.37	0.37	0.37	0.37	0.37	freeman3	0.34	0.34	0.34	0.34	0.34
freeman4	0.42	0.41	0.43	0.43	0.42	freeman4	0.43	0.40	0.43	0.43	0.43	freeman4	0.36	0.39	0.38	0.38	0.36
girl	0.70	0.64	0.70	0.70	0.70	girl	0.55	0.55	0.56	0.56	0.59	girl	0.61	0.60	0.61	0.61	0.64
ironman	0.37	0.45	0.45	0.45	0.00	ironman	0.26	0.26	0.27	0.27	0.10	ironman	0.30	0.29	0.29	0.29	0.00
jogging-1	0.66	0.17	0.17	0.17	0.10	jogging-1	0.50	0.45	0.45	0.45	0.57	jogging-1	0.46	0.24	0.24	0.24	0.56
jogging-2	0.63	0.62	0.63	0.63	0.60	jogging-2	0.68	0.62	0.62	0.62	0.74	jogging-2	0.61	0.31	0.32	0.34	0.62
jumping	0.69	0.69	0.69	0.69	0.69	jumping	0.69	0.69	0.69	0.69	0.69	jumping	0.65	0.65	0.65	0.65	0.65
lemming	0.67	0.22	0.42	0.42	0.61	lemming	0.64	0.42	0.43	0.43	0.54	lemming	0.59	0.35	0.38	0.39	0.56
liquor	0.77	0.73	0.76	0.76	0.61	liquor	0.74	0.73	0.70	0.70	0.48	liquor	0.68	0.68	0.69	0.69	0.46
matrix	0.39	0.41	0.40	0.40	0.00	matrix	0.35	0.34	0.34	0.34	0.10	matrix	0.31	0.29	0.31	0.31	0.10
mhyang	0.77	0.77	0.77	0.77	0.77	mhyang	0.72	0.72	0.72	0.72	0.72	mhyang	0.70	0.70	0.70	0.70	0.70
motorRolling	0.10	0.11	0.09	0.09	0.05	motorRolling	0.14	0.14	0.14	0.14	0.10	motorRolling	0.10	0.10	0.10	0.10	0.10
mountainBike	0.59	0.59	0.59	0.59	0.59	mountainBike	0.64	0.64	0.64	0.64	0.63	mountainBike	0.62	0.62	0.62	0.62	0.61
shaking	0.69	0.69	0.69	0.69	0.70	shaking	0.67	0.67	0.67	0.67	0.67	shaking	0.49	0.46	0.47	0.47	0.43
singer1	0.29	0.31	0.30	0.30	0.30	singer1	0.38	0.38	0.38	0.38	0.41	singer1	0.29	0.29	0.29	0.29	0.30
singer2	0.04	0.04	0.04	0.04	0.00	singer2	0.60	0.57	0.57	0.57	0.55	singer2	0.20	0.20	0.20	0.20	0.10
skating1	0.40	0.46	0.39	0.39	0.39	skating1	0.39	0.46	0.42	0.42	0.41	skating1	0.38	0.40	0.40	0.40	0.31
skiing	0.41	0.41	0.41	0.41	0.00	skiing	0.40	0.40	0.38	0.38	0.10	skiing	0.36	0.36	0.36	0.36	0.00
soccer	0.32	0.26	0.29	0.29	0.32	soccer	0.28	0.29	0.28	0.28	0.20	soccer	0.24	0.25	0.22	0.22	0.10
subway	0.67	0.67	0.67	0.67	0.56	subway	0.75	0.75	0.75	0.75	0.71	subway	0.60	0.57	0.57	0.57	0.60
suv	0.53	0.64	0.64	0.64	0.53	suv	0.49	0.51	0.46	0.46	0.49	suv	0.56	0.51	0.49	0.51	0.50
sylvester	0.67	0.67	0.69	0.69	0.67	sylvester	0.64	0.67	0.67	0.67	0.64	sylvester	0.64	0.65	0.63	0.64	0.64
tiger1	0.64	0.64	0.64	0.64	0.64	tiger1	0.64	0.57	0.56	0.56	0.57	tiger1	0.64	0.64	0.64	0.64	0.61
tiger2	0.54	0.53	0.54	0.54	0.45	tiger2	0.63	0.63	0.63	0.63	0.63	tiger2	0.55	0.55	0.55	0.55	0.52
trellis	0.61	0.61	0.61	0.61	0.61	trellis	0.74	0.74	0.74	0.74	0.66	trellis	0.57	0.58	0.57	0.57	0.57
walking	0.54	0.54	0.54	0.54	0.54	walking	0.62	0.62	0.62	0.62	0.63	walking	0.51	0.48	0.48	0.51	0.50
walking2	0.27	0.45	0.45	0.45	0.45	walking2	0.53	0.54	0.52	0.52	0.49	walking2	0.35	0.40	0.43	0.43	0.34
woman	0.70	0.71	0.71	0.71	0.73	woman	0.67	0.66	0.65	0.65	0.65	woman	0.61	0.66	0.66	0.61	0.65
AVG	0.57	0.56	0.56	0.56	0.52	AVG	0.59	0.58	0.57	0.57	0.55	AVG	0.52	0.50	0.50	0.50	0.49

OPE

TRE

SRE

Fig. 6. AUC ranking scores of MEEM and its baselines in OPE, TRE and SRE on the benchmark dataset of [1] in Experiment I. Besides the baselines evaluated in our paper, we also report another baseline MEEM-gray, which is the full implementation of MEEM, but only uses the gray-scale images as input. MEEM-gray generally gives lower scores than MEEM, but on average it still compares favorably with most of the top trackers in Fig. 4. Significant improvement of MEEM over SVM-base is observed on such sequences as “david3” (OPE, TRE and SRE), “lemming” (OPE, TRE and SRE), “jogging-1” (OPE and SRE) and “jogging2” (SRE), where challenges like occlusions and large appearance variations, could lead to model drift.

	latin	ball	carRace	dance	boxing1	boxing2	ped1	ped2	rocky	billieJean	AVG	
MEEM	0.98	0.96	0.82	0.83	0.94	0.74	1.00	0.96	0.99	0.78	0.90	OPE
MEEM-lkh	0.96	0.96	0.87	0.73	0.69	0.71	0.59	0.15	0.99	0.79	0.74	
SVM-avg	0.90	0.96	0.87	0.24	0.81	0.59	0.59	0.15	0.99	0.89	0.70	
SVM-base	0.90	0.95	0.34	0.24	0.71	0.59	0.59	0.15	0.99	0.89	0.64	
ASLA	0.34	0.07	0.72	0.39	0.50	0.22	0.56	0.95	1.00	0.15	0.49	
Struck	0.27	0.36	0.37	0.27	0.36	0.56	0.53	0.23	0.98	0.12	0.41	
TLD	0.33	0.15	0.16	0.18	0.06	0.47	0.68	0.04	0.32	0.53	0.29	
MEEM	0.74	0.90	0.58	0.56	0.75	0.69	0.98	0.76	0.88	0.84	0.77	SRE
MEEM-lkh	0.71	0.94	0.65	0.37	0.53	0.65	0.70	0.14	0.89	0.83	0.64	
SVM-avg	0.71	0.94	0.64	0.30	0.49	0.57	0.74	0.13	0.96	0.84	0.63	
SVM-base	0.71	0.94	0.64	0.30	0.49	0.57	0.74	0.13	0.96	0.84	0.63	
ASLA	0.29	0.10	0.59	0.19	0.43	0.22	0.79	0.26	1.00	0.24	0.41	
Struck	0.20	0.38	0.39	0.15	0.34	0.39	0.94	0.43	0.70	0.26	0.42	
TLD	0.27	0.14	0.17	0.17	0.07	0.21	0.56	0.05	0.27	0.57	0.25	
	latin	ball	carRace	dance	boxing1	boxing2	ped1	ped2	rocky	billieJean	AVG	
MEEM	0.78	0.78	0.72	0.74	0.73	0.66	0.81	0.63	0.77	0.56	0.72	OPE
MEEM-lkh	0.79	0.78	0.76	0.67	0.54	0.62	0.48	0.22	0.79	0.58	0.62	
SVM-avg	0.77	0.78	0.73	0.28	0.63	0.54	0.48	0.22	0.80	0.62	0.58	
SVM-base	0.77	0.78	0.29	0.28	0.55	0.54	0.48	0.22	0.80	0.62	0.53	
ASLA	0.21	0.09	0.67	0.42	0.37	0.24	0.43	0.71	0.78	0.13	0.40	
Struck	0.29	0.36	0.34	0.39	0.30	0.52	0.45	0.57	0.63	0.11	0.40	
TLD	0.32	0.13	0.33	0.36	0.07	0.49	0.42	0.04	0.27	0.41	0.29	
MEEM	0.65	0.71	0.54	0.63	0.59	0.63	0.73	0.53	0.61	0.56	0.62	SRE
MEEM-lkh	0.67	0.74	0.60	0.45	0.43	0.61	0.52	0.18	0.61	0.57	0.54	
SVM-avg	0.66	0.73	0.59	0.36	0.40	0.53	0.55	0.16	0.66	0.57	0.52	
SVM-base	0.66	0.73	0.59	0.36	0.40	0.53	0.55	0.16	0.66	0.57	0.52	
ASLA	0.28	0.13	0.55	0.35	0.34	0.26	0.59	0.27	0.74	0.19	0.37	
Struck	0.26	0.34	0.39	0.28	0.29	0.43	0.73	0.45	0.48	0.21	0.39	
TLD	0.31	0.13	0.39	0.36	0.10	0.39	0.36	0.06	0.18	0.41	0.27	

Fig. 7. Precision plot ranking scores (top) and AUC ranking scores (bottom) of MEEM, MEEM-lkh, SVM-avg, SVM-base and other state-of-the-art trackers on our newly collected sequences in Experiment II.