Hierarchical Convolutional Features for Visual Tracking Supplementary Document

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1. Comparisons with the State-of-the-art Trackers

We quantitatively evaluate the proposed tracking algorithm on the 100 benchmark sequences [10] with comparisons to 12 state-of-the-art trackers, which can be broadly categorized into three classes:

- 1. Deep learning tracker DLT [8];
- 2. Correlation trackers including the CSK [5], STC [12], and KCF [6] trackers;
- 3. Representative tracking algorithms using single or multiple online classifiers, including the MIL [1], Struck [3], CT [13], LSHT [4], TLD [7], SCM [14], MEEM [11], and TGPR [2] trackers.

These trackers can be downloaded from the authors' websites listed in Table 1 or the tracker benchmark code library [9, 10].

DLT [8]	http://winsty.net/dlt.html
CSK [5]	http://home.isr.uc.pt/~henriques/circulant/
STC [12]	http://www4.comp.polyu.edu.hk/~cslzhang/STC/STC.htm
KCF [6]	http://home.isr.uc.pt/~henriques/circulant/
MIL [1]	http://vision.ucsd.edu/project/tracking-online-multiple-instance-learning
Struck [3]	http://www.samhare.net/research/struck
CT [13]	http://www4.comp.polyu.edu.hk/~cslzhang/CT/CT.htm
LSHT [4]	http://www.shengfenghe.com/visual-tracking-via-locality-sensitive-histograms.html
TLD [7]	http://personal.ee.surrey.ac.uk/Personal/Z.Kalal/tld.html
SCM [14]	http://faculty.ucmerced.edu/mhyang/project/cvpr12_scm.htm
MEEM [11]	http://cs-people.bu.edu/jmzhang/MEEM/MEEM.html
TGPR [2]	http://www.dabi.temple.edu/~hbling/code/TGPR.htm

Table 1. Links to publicly available implementations.

2. Visual Tracking Benchmark Evaluation

In this section, we report complete results of the distance precision rate and overlap success rate in Section 2.1. We then present center location errors for each sequence in Section 2.2. Finally, we report the robustness evaluation results in Section 2.3.

2.1. Distance Precision Rate (DPR) and Overlap Sucess Rate (OSR)

Distance Precision Rate (DPR) Table 2 shows the distance precision rate (DPR) at a threshold of 20 pixels over the first 50 benchmark sequences in [9]. Table 3 shows the distance precision rate of the additional sequences in the 100 sequence dataset in [10].

Overlap Success Rate (OSR) Table 4 shows the overlap success rate (OSR) at a threshold of 0.5 over the first 50 benchmark sequences in [9]. Table 5 shows the overlap success rate of the additional sequences in the 100 sequence dataset in [10].

booken 1.000 0.086 0.999 0.046 0.029 0.051 1.000 0.224 0.028 0.031 bolt 1.000 0.026 0.999 0.046 0.020 0.031 0.011 0.034 0.844 0.844 0.844 0.844 0.844 0.844 0.866 0.026 cardbark 1.000 0.735 1.000 1.00	Sequences	Ours	DLT	KCF	STC	Struck	SCM	СТ	LSHT	CSK	MIL	TLD	MEEM	TGPR
	basketball	1.000	0.086	0.923	0.560	0.120	0.661	0.299	0.051	1.000	0.284	0.028	0.892	0.993
	bolt	1.000	0.026	0.989	0.046	0.020	0.031	0.011	0.371	0.034	0.014	0.306	0.966	0.026
cardw 0.997 1.000 0.051 0.0355 0.354 0.874 0.684 1.000 carback 0.627 0.714 0.808 0.457 0.647 0.617 0.613 0.000 0.005 0.833 0.150 0.833 0.151 0.848 0.942 cargle 0.221 0.337 0.257 0.086 0.736 0.114 0.639 0.121 0.086 0.677 1.000 0.100 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.0	boy	1.000	1.000	1.000	0.761	1.000	0.440	0.930	0.593	0.844	0.846	1.000	1.000	1.000
carbark 1000 0.715 1000 1.000 1.000 0.005 0.623 0.610 0.639 0.651 0.639 0.651 0.639 0.651 0.639 0.651 0.639 0.651 0.662 0.853 0.051 0.864 0.942 0.942 0.942 0.942 0.942 0.942 0.943 0.943 0.943 0.943 0.943 0.943 0.943 0.943 0.931 0.931 0.931 0.951 0.957 0.951 0.000 0.100 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.000 0.001 0.001 0.000 0.0021 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.0100 0.021 0.001 <	car4	0.997	1.000	0.953	0.967	0.992	0.974	0.281	0.569	0.355	0.354	0.874	0.686	1.000
car8cule 0.627 0.714 0.847 0.647 0.718 0.631 0.621 0.833 0.631 0.833 0.631 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.833 0.51 0.830 0.51 0.830 0.617 1.000 0.851 0.000 0.691 1.000 0.994 0.987 david 1.000 0.711 1.000 1.000 1.000 0.946 0.437 0.574 0.579 0.732 1.000 1.000 1.000 1.000 1.000 0.996 0.766 0.581 1.000 0.991 1.000 0.992 1.000 0.991 0.973 0.831 1.001 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991 0.991	carDark	1.000	0.715	1.000	1.000	1.000	1.000	0.005	0.623	1.000	0.379	0.639	1.000	1.000
code 0.921 0.337 0.158 0.948 0.430 0.113 0.634 0.0137 0.131 0.634 0.973 0.131 0.636 0.673 0.100 1.000 0.107 crossing 1.000 0.201 1.000 0.533 1.000 1.000 0.550 1.000 0.100 0.094 0.987 david 1.000 0.321 1.000 0.030 1.000 0.099 1.000 0.978 1.000 0.996 1.000 0.978 1.000 0.996 1.000 0.978 1.000 0.978 1.000 0.978 1.000 0.978 1.000 0.978 1.000 0.971 1.000 0.972 0.337 0.484 0.387 0.579 0.321 1.000 1.000 1.000 0.926 0.911 0.026 0.851 1.000 0.921 0.203 0.683 0.811 0.000 0.740 0.883 0.810 0.811 0.000 0.740 0.883 0.813 0.813 0.83	carScale	0.627	0.714	0.806	0.647	0.647	0.647	0.718	0.639	0.651	0.627	0.853	0.651	0.806
couple 0.921 0.307 0.237 0.086 0.673 1.000 1.000 1.000 1.000 0.007 crrossing 1.000 0.321 1.000 0.837 0.329 1.000 0.815 0.752 0.499 0.699 1.000 0.904 0.987 david2 1.000 0.711 1.000 0.837 0.329 1.000 0.064 1.000 1.000 0.994 0.778 0.410 1.000 1.000 1.000 0.994 0.971 0.738 0.111 0.996 0.976 0.950 0.851 1.000 0.973 0.982 1.000 1.001 0.998 1.000 0.982 1.000 0.983 0.330 0.330 0.464 0.837 0.732 0.983 0.330 0.330 0.330 0.464 0.837 0.732 0.988 0.977 0.732 0.988 0.971 0.722 0.881 1.000 0.401 1.000 0.401 1.000 0.401 0.001 0.303 0	coke	0.962	0.340	0.838	0.155	0.948	0.430	0.113	0.540	0.873	0.151	0.684	0.945	0.942
crossing 1000 1000 0.533 1000 1000 0.533 1000 0.533 1000 0.533 1000 0.533 1000 0.957 1000 0.957 1000 0.957 1000 0.957 1000 0.957 1000 0.956 0.996 1000 0.956 1000 0.956 0.956 0.956 0.100 0.100 0.956 0.950 0.851 0.000 0.100 0.956 0.950 0.851 0.000 0.100 0.956 0.950 0.851 0.000 0.100 0.958 0.957 0.950 0.851 0.000 0.100 0.952 0.000 0.767 0.554 0.877 0.978 0.843 0.387 0.481 0.379 0.732 0.983 0.981 0.000 0.740 0.722 0.681 0.771 0.772 0.772 0.772 0.772 0.783 0.771 0.733 0.783 0.773 0.783 0.773 0.783 0.771 0.751 0.783 0.771	couple	0.921	0.307	0.257	0.086	0.736	0.114	0.693	0.121	0.086	0.679	1.000	1.000	0.107
david 1.000 0.321 1.000 0.815 0.752 0.499 1.000 0.094 0.094 0.094 0.094 0.094 0.094 0.094 0.094 0.094 0.094 0.095 0.100 1.000 1.000 1.000 1.000 0.995 0.111 0.996 1.000 0.996 1.000 0.996 0.000 0.996 0.000 0.996 0.000 0.996 0.000 0.996 0.000 0.995 0.950 0.851 1.000 0.917 1.000 0.982 0.001 0.917 0.0021 0.6681 0.597 0.957 0.958 0.971 0.533 0.633 0.642 0.337 0.648 0.597 0.722 0.6681 0.597 0.732 0.983 0.333 0.642 0.447 0.221 0.203 0.668 0.597 0.732 0.983 0.333 0.644 0.947 0.221 0.203 0.668 0.597 0.782 0.997 0.784 0.997 0.380 0.401	crossing	1.000	1.000	1.000	0.533	1.000	1.000	1.000	0.550	1.000	1.000	0.617	1.000	0.950
devid2 1.000 0.001 1.000 0.004 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 0.042 1.000 0.028 0.042 0.028 0.042 0.020 0.021 0.000 1.000 0.127 0.732 1.000 0.972 1.000 0.972 1.000 0.972 0.983 0.983 0.983 0.981 1.000 0.978 0.979 0.581 1.000 0.700 0.851 0.873 0.821 0.970 0.383 0.631 0.751 0.733 0.567 0.387 0.560 0.511 <t< td=""><td>david</td><td>1.000</td><td>0.321</td><td>1.000</td><td>0.837</td><td>0.329</td><td>1.000</td><td>0.815</td><td>0.752</td><td>0.499</td><td>0.699</td><td>1.000</td><td>0.904</td><td>0.987</td></t<>	david	1.000	0.321	1.000	0.837	0.329	1.000	0.815	0.752	0.499	0.699	1.000	0.904	0.987
david3 1.000 0.925 0.337 0.496 0.413 0.754 0.659 0.738 0.111 0.996 1.000 deer 1.000 0.942 0.001 0.028 0.002 0.002 0.002 0.001 0.100 0.978 0.111 0.990 0.932 1.000 0.919 1.000 0.919 1.000 0.919 1.000 0.982 0.000 duale 0.905 0.918 0.877 0.554 0.897 0.833 0.438 0.642 0.947 0.221 0.203 0.688 0.837 0.442 0.847 0.221 0.203 0.688 0.838 1.000 0.442 0.856 0.986 0.979 fish 1.000 0.460 0.481 0.000 0.682 0.303 0.542 0.938 0.506 0.591 0.338 0.506 0.591 0.338 0.506 0.591 0.336 0.504 0.921 0.000 0.564 0.391 0.304 0.304 0.304	david2	1.000	0.711	1.000	1.000	1.000	1.000	0.004	1.000	1.000	0.978	1.000	1.000	1.000
deer 1000 0.042 0.817 0.042 1.000 0.028 0.028 1.000 0.127 0.732 1.000 dogl 1.000 0.976 0.956 0.851 1.000 0.919 1.000 0.919 1.000 0.919 0.978 0.957 0.958 0.957 0.958 0.957 0.753 0.933 0.644 0.887 0.579 0.732 0.083 0.881 0.979 0.688 0.577 0.720 0.203 0.681 0.991 1.000 0.688 0.979 0.721 0.231 0.681 0.971 0.271 0.725 0.333 0.642 0.337 0.861 0.979 0.551 0.333 ford 0.334 0.460 0.400 0.438 0.577 0.575 0.353 0.506 0.591 0.333 football 1.000 0.236 0.796 0.801 0.751 0.755 0.738 0.790 0.841 0.997 0.985 0.571 0.303 0.540 0.997 <td>david3</td> <td>1.000</td> <td>0.698</td> <td>1.000</td> <td>0.925</td> <td>0.337</td> <td>0.496</td> <td>0.413</td> <td>0.754</td> <td>0.659</td> <td>0.738</td> <td>0.111</td> <td>0.996</td> <td>1.000</td>	david3	1.000	0.698	1.000	0.925	0.337	0.496	0.413	0.754	0.659	0.738	0.111	0.996	1.000
dogl 1000 0.996 0.976 0.976 0.950 0.851 1.000 0.912 1.000 doll 0.977 0.958 0.978 0.684 0.387 0.579 0.732 0.983 0.985 0.971 duade 0.905 0.918 0.877 0.554 0.887 0.881 0.387 0.624 0.947 0.212 0.203 0.683 0.831 faceocc2 0.994 0.850 0.972 0.974 1.000 0.686 0.681 0.990 1.000 0.403 0.866 0.979 fish 1.000 0.401 1.000 1.000 0.882 1.000 0.042 0.381 1.000 1.000 1.000 0.075 0.381 0.000 0.026 0.376 0.381 0.076 0.383 0.577 0.578 0.383 0.577 0.358 0.550 0.333 foreman1 0.979 0.380 0.402 0.371 0.801 0.598 0.323 0.577	deer	1.000	0.042	0.817	0.042	1.000	0.028	0.042	0.028	1.000	0.127	0.732	1.000	1.000
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dudek 0.901 0.918 0.877 0.583 0.418 0.646 0.807 0.688 0.597 0.792 0.681 faceoccl 0.900 0.462 0.730 0.250 0.575 0.933 0.330 0.642 0.947 0.221 0.203 0.683 0.831 faceoccl 0.994 0.800 0.721 0.741 1.000 0.863 0.882 1.000 0.442 0.387 1.000 1.000 1.000 1.000 1.000 0.441 0.387 1.000 0.042 0.387 1.000 1.000 1.000 1.000 1.000 0.266 0.751 0.765 0.788 0.773 0.790 0.804 0.992 1.000 1.000 1.000 0.568 0.351 0.773 1.000 0.554 1.000 0.997 0.985 1.000 1.000 0.266 0.555 0.939 0.540 0.997 0.985 1.100 1.001 0.000 1.001 1.000 1.001 0.000 1	doll	0.978	0.957	0.968	0.763	0.919	0.978	0.684	0.387	0.579	0.732	0.983	0.985	0.971
faceocc1 0.600 0.462 0.730 0.250 0.575 0.933 0.330 0.642 0.947 0.221 0.203 0.683 0.831 fish 1.000 0.481 0.000 0.860 0.881 0.000 0.485 0.986 0.079 fish 1.000 0.431 0.401 1.000 0.863 0.882 1.000 0.432 0.337 1.000 1.000 1.000 0.684 0.591 0.333 forbiall 1.000 0.680 0.595 0.514 1.000 0.568 0.371 0.773 0.779 0.790 0.804 0.992 1.000 foreman1 0.979 0.380 0.402 0.371 0.781 0.070 0.555 0.939 0.540 0.997 0.985 freeman4 0.434 0.346 0.337 0.337 0.570 0.048 0.572 0.044 0.555 0.399 0.540 0.997 0.985 0.122 gigit 1.000	dudek	0.905	0.918	0.877	0.554	0.897	0.883	0.418	0.646	0.807	0.688	0.597	0.792	0.681
faceocc2 0.994 0.850 0.972 0.974 1.000 0.863 0.881 0.990 1.000 0.740 0.856 0.986 0.979 fish 1.000 0.401 1.000 0.400 0.863 0.882 1.000 0.042 0.387 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 0.559 0.514 1.000 0.568 0.551 0.773 1.000 0.554 1.000 0.982 0.336 0.566 0.555 0.939 0.540 0.997 0.985 freeman1 0.979 0.380 0.402 0.331 0.381 0.000 0.209 0.346 0.575 0.098 0.320 0.344 0.430 0.555 0.939 0.540 0.997 0.985 0.122 freeman4 0.943 0.344 0.534 0.203 0.375 0.509 0.044 0.873 0.187 0.201 0.985 0.1	faceocc1	0.600	0.462	0.730	0.250	0.575	0.933	0.330	0.642	0.947	0.221	0.203	0.683	0.831
fish 1.000 0.401 1.000 1.000 1.000 0.863 0.882 1.000 0.042 0.387 1.000 1.000 1.000 fleetface 0.590 0.434 0.460 0.481 0.639 0.529 0.438 0.577 0.567 0.388 0.506 0.591 0.591 0.551 0.756 0.798 0.790 0.804 0.992 1.000 0.568 0.351 0.797 0.577 1.000 0.554 1.000 0.996 0.790 0.884 0.997 0.985 freeman3 0.811 1.000 0.718 0.789 1.000 0.346 0.572 0.048 0.767 0.885 0.122 girl 1.000 0.776 0.864 0.594 1.000 1.060 0.064 0.873 0.187 0.041 0.556 0.519 girl 1.000 0.766 0.364 0.571 0.716 0.864 0.524 1.020 0.366 0.336 0.138 0.160	faceocc2	0.994	0.850	0.972	0.974	1.000	0.860	0.681	0.990	1.000	0.740	0.856	0.986	0.979
	fish	1.000	0.401	1.000	1.000	1.000	0.863	0.882	1.000	0.042	0.387	1.000	1.000	1.000
football 1.000 0.296 0.796 0.801 0.751 0.765 0.798 0.793 0.790 0.804 0.992 1.000 footballl 1.000 0.608 0.959 0.514 1.000 0.558 0.331 0.757 1.000 0.554 1.000 0.985 freeman1 0.979 0.380 0.402 0.371 0.801 0.982 0.396 0.966 0.555 0.939 0.540 0.997 0.985 freeman3 0.811 1.000 0.716 0.864 0.594 1.000 0.608 0.212 0.524 0.198 0.114 0.105 0.666 0.336 0.133 0.108 0.120 0.565 0.591 0.561 0.572 0.448 0.777 0.505 0.506 0.906 0.336 0.133 0.108 0.120 0.555 0.514 0.200 0.534 0.228 0.231 0.974 0.964 0.225 0.566 0.977 0.468 0.857 0.971 <t< td=""><td>fleetface</td><td>0.590</td><td>0.434</td><td>0.460</td><td>0.481</td><td>0.639</td><td>0.529</td><td>0.438</td><td>0.577</td><td>0.567</td><td>0.358</td><td>0.506</td><td>0.591</td><td>0.393</td></t<>	fleetface	0.590	0.434	0.460	0.481	0.639	0.529	0.438	0.577	0.567	0.358	0.506	0.591	0.393
jootball1 1.000 0.608 0.959 0.514 1.000 0.568 0.351 0.973 0.757 1.000 0.554 1.000 0.986 freeman1 0.979 0.380 0.402 0.371 0.801 0.982 0.396 0.555 0.939 0.540 0.997 0.985 freeman4 0.943 0.346 0.534 0.234 0.376 0.000 0.209 0.346 0.572 0.048 0.767 0.985 0.122 girl 1.000 0.776 0.864 0.594 1.000 1.000 0.608 0.212 0.554 0.714 0.918 1.000 0.904 jorging-1 0.974 0.228 0.233 0.228 0.231 0.262 0.231 0.967 0.228 0.231 0.971 0.997 0.990 1.000 1.000 0.163 0.966 0.133 0.108 0.186 0.857 0.971 0.997 jumping 1.000 0.163 0.026 0.13	football	1.000	0.296	0.796	0.801	0.751	0.765	0.798	0.793	0.798	0.790	0.804	0.992	1.000
freeman1 0.979 0.380 0.402 0.371 0.801 0.982 0.396 0.966 0.555 0.939 0.540 0.997 0.985 freeman3 0.811 1.000 0.911 0.596 0.789 1.000 0.209 0.346 0.572 0.048 0.767 0.985 0.122 freeman4 0.943 0.346 0.534 0.233 0.375 0.509 0.064 0.873 0.181 0.201 0.410 0.565 0.519 girl 1.000 0.776 0.3864 0.594 1.000 1.000 0.068 0.212 0.531 0.974 0.984 0.020 jorgjing-1 0.974 0.228 0.235 0.228 0.234 1.000 0.166 0.166 0.166 0.186 0.186 0.887 0.971 0.997 jiumping 1.000 0.962 0.342 0.054 1.000 0.153 0.967 0.228 0.837 0.971 0.997 jiupur	football1	1.000	0.608	0.959	0.514	1.000	0.568	0.351	0.973	0.757	1.000	0.554	1.000	0.986
jreeman3 0.811 1.000 0.911 0.596 0.789 1.000 0.209 0.346 0.572 0.048 0.767 0.985 0.122 freeman4 0.943 0.346 0.534 0.233 0.375 0.509 0.064 0.873 0.187 0.201 0.410 0.565 0.519 girl 1.000 0.776 0.864 0.594 1.000 1.000 0.664 0.873 0.187 0.201 0.411 0.506 0.036 jogging-1 0.974 0.228 0.221 0.211 0.151 0.096 0.036 0.133 0.108 0.256 0.096 jogging-2 1.000 0.173 0.163 0.186 0.231 0.967 0.228 0.231 0.967 0.248 0.231 0.967 0.228 0.231 0.967 0.000 1.000 0.000 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.	freeman1	0.979	0.380	0.402	0.371	0.801	0.982	0.396	0.966	0.555	0.939	0.540	0.997	0.985
jreeman4 0.943 0.346 0.534 0.233 0.375 0.509 0.064 0.873 0.187 0.201 0.410 0.565 0.519 girl 1.000 0.776 0.864 0.594 1.000 1.000 0.608 0.212 0.554 0.714 0.918 1.000 0.904 ironman 0.645 0.127 0.217 0.151 0.114 0.157 0.096 0.036 0.133 0.108 0.120 0.506 0.096 jogging-2 0.974 0.228 0.221 0.228 0.231 0.977 0.228 0.231 0.971 0.997 1.000 1.0	freeman3	0.811	1.000	0.911	0.596	0.789	1.000	0.209	0.346	0.572	0.048	0.767	0.985	0.122
girl 1.000 0.776 0.864 0.594 1.000 1.000 0.608 0.212 0.554 0.714 0.918 1.000 0.904 ironman 0.645 0.127 0.217 0.151 0.114 0.157 0.096 0.036 0.133 0.108 0.120 0.506 0.096 jogging-1 0.974 0.228 0.231 0.967 0.228 0.231 0.974 0.964 0.225 jogging-2 1.000 0.173 0.163 0.186 0.254 1.000 1.066 0.166 0.186 0.857 0.971 0.9971 jumping 1.000 0.952 0.342 0.054 1.000 0.166 0.166 0.186 0.857 0.971 0.9971 0.0971 0.0971 0.997 liquor 0.816 0.357 0.976 0.403 0.390 0.276 0.209 0.598 0.223 0.199 0.588 0.925 0.657 matrix 0.620 0.010<	freeman4	0.943	0.346	0.534	0.233	0.375	0.509	0.064	0.873	0.187	0.201	0.410	0.565	0.519
ironman 0.645 0.127 0.151 0.114 0.157 0.096 0.036 0.133 0.108 0.120 0.506 0.096 jogging-1 0.974 0.228 0.235 0.228 0.231 0.967 0.228 0.231 0.974 0.964 0.225 jogging-2 1.000 0.173 0.163 0.186 0.254 1.000 0.163 0.096 0.134 0.051 0.997 1.000 1.000 0.109 lemming 0.258 0.288 0.487 0.312 0.628 0.166 0.677 0.406 0.436 0.823 0.897 1.000 1.000 lemming 0.502 0.010 0.170 0.100 0.203 0.390 0.226 0.203 0.199 0.588 0.925 0.657 matrix 0.620 0.010 0.100 1.000 1.000 1.000 1.000 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.011 0.01	girl	1.000	0.776	0.864	0.594	1.000	1.000	0.608	0.212	0.554	0.714	0.918	1.000	0.904
jogging-1 0.974 0.228 0.235 0.228 0.241 0.228 0.231 0.967 0.228 0.231 0.974 0.964 0.225 jogging-2 1.000 0.173 0.163 0.186 0.254 1.000 0.166 0.166 0.186 0.186 0.857 0.971 0.997 jumping 1.000 0.962 0.342 0.624 1.000 0.153 0.096 0.134 0.051 0.997 1.000 1.000 0.109 lemming 0.258 0.298 0.487 0.312 0.628 0.166 0.677 0.406 0.436 0.823 0.859 0.911 0.275 iquor 0.816 0.357 0.976 0.403 0.390 0.276 0.209 0.598 0.223 0.199 0.588 0.925 0.657 matrix 0.620 0.010 1.000 1.000 1.000 0.819 0.987 1.000 0.440 0.971 1.000 motorRolli	ironman	0.645	0.127	0.217	0.151	0.114	0.157	0.096	0.036	0.133	0.108	0.120	0.506	0.096
joging-2 1.000 0.173 0.163 0.186 0.254 1.000 0.166 0.166 0.186 0.857 0.971 0.997 jumping 1.000 0.962 0.342 0.054 1.000 0.153 0.096 0.134 0.051 0.997 1.000 1.000 0.109 lemming 0.258 0.298 0.487 0.312 0.628 0.166 0.677 0.406 0.436 0.823 0.859 0.911 0.275 liquor 0.816 0.357 0.976 0.403 0.390 0.276 0.209 0.598 0.223 0.199 0.588 0.925 0.657 matrix 0.620 0.010 0.100 1.000 1.000 0.000 0.010 0.100 0.043 0.043 0.160 0.660 0.100 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 0.433 0.043 0.043 0.043 0.116<	iogging-1	0.974	0.228	0.235	0.228	0.241	0.228	0.231	0.967	0.228	0.231	0.974	0.964	0.225
jumping 1.000 0.962 0.342 0.054 1.000 0.153 0.096 0.134 0.051 0.997 1.000 1.000 0.109 lemming 0.258 0.298 0.487 0.312 0.628 0.166 0.677 0.406 0.436 0.823 0.859 0.911 0.275 liquor 0.816 0.357 0.976 0.403 0.390 0.276 0.209 0.598 0.223 0.199 0.588 0.925 0.657 matrix 0.620 0.010 0.170 0.100 1.200 0.350 0.020 0.110 0.010 0.160 0.640 0.978 1.000 motorRolling 0.945 0.043 0.044 0.073 0.085 0.037 0.037 0.049 0.043 0.160 0.981 1.000 shking 0.868 0.926 0.019 0.981 0.192 0.814 0.047 0.712 0.564 0.282 0.405 0.995 0.641 <tr< td=""><td>iogging-2</td><td>1.000</td><td>0.173</td><td>0.163</td><td>0.186</td><td>0.254</td><td>1.000</td><td>0.166</td><td>0.166</td><td>0.186</td><td>0.186</td><td>0.857</td><td>0.971</td><td>0.997</td></tr<>	iogging-2	1.000	0.173	0.163	0.186	0.254	1.000	0.166	0.166	0.186	0.186	0.857	0.971	0.997
Imping 0.052 0.052 0.052 0.052 0.052 0.053 0.010 0.050 0.667 0.031 0.060 0.010 0.010 0.010 0.010 0.011 </td <td>iumning</td> <td>1.000</td> <td>0.962</td> <td>0.342</td> <td>0.054</td> <td>1.000</td> <td>0.153</td> <td>0.096</td> <td>0.134</td> <td>0.051</td> <td>0.997</td> <td>1.000</td> <td>1.000</td> <td>0.109</td>	iumning	1.000	0.962	0.342	0.054	1.000	0.153	0.096	0.134	0.051	0.997	1.000	1.000	0.109
liquor 0.816 0.357 0.976 0.403 0.390 0.276 0.209 0.598 0.223 0.199 0.588 0.925 0.657 matrix 0.620 0.010 0.170 0.100 1.200 0.350 0.020 0.110 0.010 0.180 0.640 0.640 0.110 mhyang 1.000 1.000 1.000 1.000 1.000 0.819 0.987 1.000 0.460 0.978 1.000 1.000 1.000 motorRolling 0.945 0.043 0.049 0.073 0.085 0.037 0.037 0.043 0.043 0.043 0.116 0.061 mountainBike 1.000 0.811 1.000 1.000 0.921 0.969 0.175 1.000 1.0667 0.259 0.917 1.000 shaking 0.868 0.926 0.019 0.981 0.122 0.840 0.413 0.670 0.501 1.000 0.421 singer1 1.000 0	lemming	0.258	0.298	0.487	0.312	0.628	0.166	0.677	0.406	0.436	0.823	0.859	0.911	0.275
matrix 0.620 0.010 0.170 0.100 0.120 0.010 0.110 0.010 0.110 0.010 0.120 0.011 0.010 0.110 0.010 0.110 0.010 0.110 0.010 0.180 0.160 0.641 0.000 0.811 1.000 1.000 0.851 0.037 0.037 0.047 0.712 0.564 0.282 0.405 0.995 0.641 mountainBike 1.000 0.841 1.000 0.841 0.007 0.712 0.564 0.282 0.405 0.995 0.641 singer1 1.000 0.843 1.000 0.641 1.000 0.413 0.670 0.535 <	liquor	0.816	0.357	0.976	0.403	0.390	0.276	0.209	0.598	0.223	0.199	0.588	0.925	0.657
mkrist 0.020 0.010 0.010 0.010 0.000 0.043 0.043 0.043 0.013 0.016 0.001 mountainBike 1.000 0.811 1.000 1.000 0.921 0.969 0.175 1.000 1.000 0.667 0.259 0.917 1.000 shaking 0.868 0.926 0.019 0.981 0.192 0.814 0.047 0.712 0.564 0.282 0.405 0.995 0.641 singer1 1.000 1.000 0.843 1.000 0.641 1.000 0.840 0.413 0.670 0.501 1.000 0.470 0.219 singer2 0.041 0.036 0.948 0.571 0.036 0.123 0	matrix	0.620	0.010	0.170	0.100	0.120	0.350	0.020	0.110	0.010	0.180	0.160	0.640	0.110
motorRolling 0.945 0.043 0.049 0.073 0.085 0.037 0.037 0.043 0.043 0.116 0.061 0.061 mountainBike 1.000 0.811 1.000 0.991 0.959 0.175 1.000 1.000 0.021 0.969 0.175 1.000 0.667 0.259 0.917 1.000 shaking 0.868 0.926 0.019 0.981 0.192 0.814 0.047 0.712 0.564 0.282 0.405 0.995 0.641 singer1 1.000 1.000 0.843 1.000 0.641 1.000 0.840 0.413 0.670 0.501 1.000 0.470 0.219 singer2 0.041 0.036 0.948 0.571 0.036 0.112 0.005 0.986 0.036 0.404 0.071 0.038 0.954 skating1 1.000 0.763 1.000 0.690 0.465 0.768 0.909 0.135 0.191 0.115	mhyang	1.000	1.000	1.000	1.000	1.000	1.000	0.819	0.987	1.000	0.460	0.978	1.000	1.000
Initial initial Initial	motorRolling	0.945	0.043	0.049	0.073	0.085	0.037	0.037	0.049	0.043	0.043	0.116	0.061	0.061
Initial field Initial	mountainRike	1.000	0.811	1 000	1 000	0.921	0.969	0.175	1 000	1 000	0.667	0.259	0.001	1 000
singer1 1.000 0.843 1.000 0.641 1.000 0.840 0.413 0.670 0.501 1.000 0.470 0.219 singer2 0.041 0.036 0.948 0.571 0.036 0.112 0.005 0.986 0.036 0.404 0.071 0.038 0.954 skating1 1.000 0.763 1.000 0.640 0.465 0.768 0.090 0.535 0.988 0.130 0.318 0.693 0.700 skiing 0.988 0.123 0.074 0.136 0.037 0.136 0.086 0.123 0.099 0.74 0.123 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.135 0.191 0.115 0.314 0.143 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.240 0.994 0.251 1.000 1.000 subway 1.000	shaking	0.868	0.926	0.019	0.981	0.192	0.814	0.047	0.712	0.564	0.282	0.405	0.995	0.641
singer2 0.041 0.036 0.948 0.571 0.036 0.112 0.005 0.986 0.036 0.404 0.071 0.038 0.954 skating1 1.000 0.763 1.000 0.690 0.465 0.768 0.090 0.535 0.988 0.130 0.318 0.693 0.700 skiing 0.988 0.123 0.074 0.136 0.037 0.136 0.0866 0.123 0.099 0.074 0.123 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.135 0.112 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.999 0.135 0.111 0.111 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.240 0.994 0.251 1.000 1.000 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.240 0.994 0.251 1.000	singerl	1.000	1.000	0.843	1.000	0.641	1.000	0.840	0.413	0.670	0.501	1.000	0.470	0.219
skating1 1.000 0.763 1.000 0.690 0.465 0.768 0.090 0.535 0.988 0.130 0.311 0.091 skating1 1.000 0.763 1.000 0.690 0.465 0.768 0.090 0.535 0.988 0.130 0.318 0.693 0.700 skiing 0.988 0.123 0.074 0.136 0.037 0.136 0.086 0.123 0.099 0.074 0.123 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.135 0.191 0.115 0.314 0.143 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.989 1.000 0.240 0.994 0.251 1.000 1.000 subway 1.000 0.979 0.805 0.572 0.978 0.250 0.524 0.568 0.123 0.909 0.743 0.531 sylvester 0.852 0.770 0.843 0.897 0.995 0.946 0.901 <	singer?	0.041	0.036	0.948	0.571	0.036	0.112	0.005	0.986	0.036	0.404	0.071	0.038	0.954
skiing 0.988 0.123 0.074 0.136 0.037 0.136 0.086 0.123 0.099 0.074 0.123 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.074 0.123 1.000 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.074 0.123 1.000 0.111 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.989 1.000 0.240 0.994 0.251 1.000 1.000 subway 1.000 0.979 0.805 0.572 0.978 0.250 0.524 0.568 0.123 0.909 0.743 0.531 sylvester 0.852 0.770 0.843 0.897 0.995 0.946 0.901 0.949 0.910 0.651 0.949 0.954 0.946 tiger1 0.811	skating l	1.000	0.763	1.000	0.690	0.465	0.768	0.090	0.535	0.988	0.130	0.318	0.693	0.700
soccer 0.816 0.125 0.135 0.125 0.125 0.135 0.125 0.135 0.125 0.135 0.125 0.135 0.125 0.135 0.125 0.135 0.125 0.135 0.125 0.135 0.115 0.111 soccer 0.816 0.138 0.791 0.135 0.253 0.268 0.219 0.099 0.135 0.191 0.115 0.314 0.143 subway 1.000 0.023 1.000 0.246 0.983 1.000 0.240 0.994 0.251 1.000 1.000 suv 0.979 1.000 0.979 0.805 0.572 0.978 0.250 0.524 0.568 0.123 0.909 0.743 0.531 sylvester 0.852 0.770 0.843 0.897 0.995 0.946 0.901 0.949 0.910 0.651 0.949 0.954 0.946 tiger1 0.811 0.433 0.851 0.261 0.175 0.126	skiing	0.988	0.103	0.074	0.136	0.037	0.136	0.086	0.123	0.099	0.074	0.123	1.000	0.111
solution 0.130 0.130 0.133 0.133 0.123 0.123 0.130 0.113 0.131 0.131 0.131 0.131 0.131 0.131 0.131 0.131 0.131	soccer	0.900	0.123	0.791	0.135	0.057	0.150	0.000	0.099	0.135	0.191	0.115	0.314	0.143
shibitity 1.000 0.0210 0.0210 0.000 1.000 0.0210 0.0210 0.000	subway	1.000	0.023	1.000	0.135	0.233	1.000	0.989	1 000	0.133	0.191	0.251	1.000	1 000
str 0.577 1.000 0.577 0.000 0.572 0.576 0.524 0.506 0.125 0.709 0.145 0.531 sylvester 0.852 0.770 0.843 0.897 0.995 0.946 0.901 0.949 0.910 0.651 0.949 0.949 0.946 0.946 tiger1 0.811 0.433 0.851 0.261 0.175 0.126 0.215 0.074 0.255 0.095 0.456 0.822 0.269 tiger2 0.567 0.329 0.356 0.145 0.630 0.112 0.364 0.093 0.110 0.414 0.386 0.488 0.792 trellis 1.000 0.339 1.000 0.738 0.877 0.873 0.387 0.450 0.810 0.230 0.529 0.968 0.981 walking 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 0.432 0.400 0.468	sin	0.979	1 000	0.979	0.805	0.572	0.978	0.250	0.524	0.568	0.123	0.909	0.743	0.531
syrtal 0.002 0.110 0.003 0.001 0.004 0.001 0.004 0.001 0.004 0.001 0.004 0.001 0.004 0.001 0.004 0.001 0.004 0.001 0.004 0.001 <t< td=""><td>sulvester</td><td>0.852</td><td>0.770</td><td>0.843</td><td>0.807</td><td>0.995</td><td>0.946</td><td>0.250</td><td>0.949</td><td>0.910</td><td>0.651</td><td>0.949</td><td>0.954</td><td>0.946</td></t<>	sulvester	0.852	0.770	0.843	0.807	0.995	0.946	0.250	0.949	0.910	0.651	0.949	0.954	0.946
tiger2 0.567 0.329 0.356 0.145 0.630 0.112 0.364 0.093 0.110 0.414 0.386 0.488 0.792 trellis 1.000 0.339 1.000 0.738 0.877 0.873 0.387 0.450 0.810 0.230 0.529 0.968 0.981 walking 1.000 0.748 1.000 0.	tigarl	0.811	0.433	0.851	0.357	0.175	0.126	0.215	0.074	0.255	0.091	0.149	0.934	0.240
trellis 1.000 0.339 1.000 0.738 0.877 0.873 0.387 0.450 0.110 0.414 0.360 0.488 0.792 trellis 1.000 0.339 1.000 0.738 0.877 0.873 0.387 0.450 0.810 0.230 0.529 0.968 0.981 walking 1.000 0.748 1.000 1	tiger?	0.567	0.435	0.356	0.145	0.630	0.120	0.213	0.093	0.110	0.093	0.450	0.822	0.209
walking 1.000 0.738 0.877 0.375 0.430 0.430 0.230 0.329 0.908 0.981 walking 1.000 0.748 1.000 <td< td=""><td>trollis</td><td>1,000</td><td>0.329</td><td>1,000</td><td>0.738</td><td>0.030</td><td>0.873</td><td>0.304</td><td>0.095</td><td>0.110</td><td>0.414</td><td>0.500</td><td>0.400</td><td>0.092</td></td<>	trollis	1,000	0.329	1,000	0.738	0.030	0.873	0.304	0.095	0.110	0.414	0.500	0.400	0.092
waking 1.000 0.748 1.000 0.432 0.400 0.468 0.406 0.426 0.392 0.996 0.996 0.940 0.250 0.206 0.191 0.963 0.940 0.406 0.545 0.475 0.608 0.830 0.705 0.608 0.620 <t< td=""><td>walking</td><td>1.000</td><td>0.339</td><td>1.000</td><td>1,000</td><td>1,000</td><td>1 000</td><td>1,000</td><td>1.000</td><td>1.000</td><td>1.000</td><td>0.529</td><td>1,000</td><td>1,000</td></t<>	walking	1.000	0.339	1.000	1,000	1,000	1 000	1,000	1.000	1.000	1.000	0.529	1,000	1,000
watching2 1.000 0.434 0.794 0.952 1.000 0.432 0.400 0.406 0.400 0.420 0.392 0.996 woman 0.940 0.938 0.938 0.615 1.000 0.940 0.204 0.940 0.250 0.206 0.191 0.963 0.940 Average 0.891 0.548 0.741 0.547 0.656 0.649 0.406 0.545 0.475 0.692 0.930 0.755	walking	1.000	1.000	0.424	0.704	0.082	1.000	0.422	0.400	0.468	0.406	0.204	0.202	0.006
woman 0.540 0.550 0.550 0.015 1.000 0.244 0.540 0.250 0.200 0.191 0.903 0.940 Average 0.891 0.548 0.741 0.547 0.656 0.640 0.405 0.545 0.475 0.602 0.930 0.940	waiking2	0.940	0.038	0.434	0.794	1.000	0.040	0.432	0.400	0.408	0.400	0.420	0.392	0.990
	Avonago	0.940	0.530	0.730	0.015	0.656	0.540	0.204	0.540	0.230	0.200	0.191	0.905	0.740

Table 2. Distance precision rate at a threshold of 20 pixels on the first 50 benchmark sequences [9]. The proposed algorithm performs favorably against the state-of-the-art algorithms.

Sequences	Ours	DLT	KCF	STC	Struck	SCM	СТ	LSHT	CSK	MIL	TLD	MEEM	TGPR
biker	0.521	0.958	0.507	0.514	0.556	0.500	0.099	0.303	0.514	0.514	0.514	0.535	0.514
bird1	0.392	0.588	0.069	0.015	0.150	0.517	0.578	0.235	0.029	0.461	0.010	0.289	0.811
bird2	0.980	0.202	0.475	0.505	0.545	0.899	0.101	0.980	0.515	0.646	0.859	1.000	0.737
blurBody	0.991	0.045	0.584	0.165	0.814	0.093	0.009	0.117	0.428	0.015	0.449	0.886	0.790
blurCar1	0.995	0.026	0.995	0.962	0.996	0.022	0.057	0.009	0.012	0.049	0.821	0.993	0.035
blurCar2	0.961	0.749	0.938	0.990	0.916	0.099	0.164	0.137	0.925	0.166	0.979	0.959	0.962
blurCar3	1.000	0.252	0.994	0.406	1.000	0.157	0.207	0.232	0.549	0.328	0.952	1.000	0.042
blurCar4	1.000	0.563	0.997	0.574	0.997	0.179	0.021	0.095	1.000	0.037	0.803	0.976	0.937
blurFace	1.000	0.191	1.000	0.629	0.436	0.112	0.116	0.089	0.996	0.191	1.000	0.990	0.990
blurOwl	0.962	0.070	0.228	0.114	0.989	0.190	0.071	0.057	0.162	0.100	0.713	0.995	0.512
board	0.870	0.570	0.656	0.092	0.752	0.441	0.069	0.126	0.089	0.170	0.011	0.605	0.053
bolt2	0.952	0.973	0.017	0.980	0.109	0.014	0.638	0.666	1.000	1.000	0.014	0.017	0.020
box	0.394	0.396	0.415	0.390	0.239	0.153	0.630	0.369	0.080	0.140	0.742	0.370	0.294
carl	0.391	1.000	0.739	0.275	0.334	1.000	0.145	0.229	0.260	0.241	0.417	0.196	0.337
car2	1.000	1.000	1.000	1.000	1.000	1.000	0.411	0.998	1.000	0.074	1.000	1.000	0.074
car24	1.000	1.000	1.000	0.926	0.170	1.000	0.549	0.587	0.863	0.548	1.000	1.000	0.992
clifBar	0.915	0.464	0.445	0.468	0.182	0.121	0.201	0.081	0.210	0.169	0.208	0.941	0.146
coupon	1.000	0.382	1.000	1.000	1.000	1.000	0.459	1.000	1.000	0.410	0.740	0.394	0.388
crowds	1.000	0.916	1.000	1.000	0.911	1.000	0.012	1.000	1.000	0.086	1.000	1.000	1.000
dancer	1.000	0.964	1.000	0.907	0.987	1.000	0.956	0.947	1.000	0.947	0.951	0.916	0.964
dancer2	1.000	1.000	1.000	1.000	1.000	1.000	0.973	1.000	1.000	0.933	0.853	0.980	0.993
diving	0.753	0.256	0.535	0.340	0.521	0.540	0.042	0.186	0.367	0.288	0.158	0.209	0.214
dog	1.000	0.961	0.992	1.000	0.945	0.953	0.992	0.764	1.000	0.882	1.000	1.000	0.992
dragonBaby	0.867	0.372	0.336	0.221	0.106	0.283	0.257	0.168	0.212	0.115	0.257	0.823	0.752
girl2	0.076	0.074	0.071	0.071	0.272	0.343	0.108	0.073	0.071	0.073	0.077	0.801	0.577
gym	0.988	0.146	0.795	0.549	0.597	0.342	0.192	0.919	0.522	0.828	0.641	0.913	0.858
human2	0.540	0.556	0.171	0.154	0.432	0.354	0.117	0.148	0.129	0.107	0.257	0.180	0.738
human3	0.035	0.009	0.006	0.019	0.010	0.009	0.020	0.020	0.016	0.019	0.008	0.866	0.010
human4	0.852	0.205	0.534	0.193	0.211	0.192	0.198	0.208	0.204	0.192	0.118	0.504	0.508
human5	0.245	0.891	0.265	0.321	0.990	0.933	0.244	0.163	0.244	0.334	1.000	0.997	0.993
human6	0.381	0.446	0.290	0.299	0.255	0.322	0.260	0.284	0.294	0.293	0.458	0.663	0.295
human7	1.000	0.436	0.472	0.332	1.000	0.368	0.312	0.372	0.656	1.000	1.000	1.000	0.856
human8	1.000	0.219	1.000	0.297	0.195	1.000	0.078	0.086	0.289	0.156	0.188	1.000	0.188
human9	1.000	0.321	0.725	0.190	0.282	0.203	0.246	0.672	0.197	0.449	0.213	0.498	0.639
jump	0.082	0.066	0.057	0.074	0.082	0.074	0.008	0.057	0.074	0.033	0.066	0.066	0.066
kiteSurf	0.464	0.286	0.333	0.286	0.905	0.333	0.452	0.583	0.345	0.595	0.464	1.000	0.440
man	1.000	1.000	1.000	1.000	1.000	1.000	0.246	1.000	1.000	0.231	1.000	1.000	0.970
panda	0.973	0.996	0.364	0.529	1.000	0.993	0.984	0.586	0.159	0.995	0.729	1.000	1.000
redTeam	1.000	1.000	1.000	0.798	1.000	1.000	1.000	0.995	1.000	1.000	0.721	1.000	1.000
rubik	0.897	0.359	0.969	0.305	0.307	0.216	0.122	0.422	0.338	0.794	0.989	0.536	0.156
skater	0.994	0.981	0.938	0.625	0.994	0.781	0.394	0.975	0.731	0.931	0.925	0.925	0.963
skater2	0.903	0.237	0.694	0.333	0.726	0.694	0.028	0.030	0.655	0.308	0.379	0.913	0.352
skating2-1	0.725	0.040	0.383	0.066	0.190	0.061	0.082	0.199	0.080	0.099	0.034	0.273	0.268
skating2-2	0.444	0.114	0.490	0.091	0.292	0.283	0.089	0.256	0.095	0.032	0.025	0.178	0.262
surfer	1.000	0.585	0.910	0.324	0.971	0.707	0.279	0.455	0.016	0.715	1.000	0.987	0.992
toy	0.830	0.214	0.985	0.055	0.897	0.258	0.380	0.727	0.491	0.365	0.934	0.745	0.690
trans	0.298	0.185	0.306	0.371	0.226	0.250	0.194	0.516	0.266	0.137	0.419	0.210	0.250
twinnings	0.989	0.998	0.907	0.409	1.000	0.725	0.746	0.731	0.979	0.994	0.623	0.987	0.994
vase	0.624	0.413	0.793	0.649	0.513	0.376	0.679	0.295	0.760	0.539	0.531	0.476	0.779
Average	0.837	0.526	0.692	0.507	0.635	0.572	0.359	0.497	0.516	0.439	0.592	0.781	0.643

Table 3. Distance precision rate at a threshold of 20 pixels on additional benchmark sequences [10]. The average scores are computed from the 100 sequences. The proposed algorithm performs favorably against the state-of-the-art algorithms.

DLT KCF STC Struck SCM СТ LSHT CSK MIL TLD MEEM TGPR Sequences Ours 0.236 basketball 0.999 0.057 0.898 0.102 0.259 0.047 0.274 0.025 0.850 0.611 0.874 0.861 bolt 0.980 0.017 0.934 0.043 0.017 0.014 0.006 0.326 0.017 0.011 0.146 0.283 0.014 0.990 boy 1.000 0.992 0.663 0.975 0.439 0.688 0.502 0.842 0.385 0.935 0.990 0.990 car4 0.396 1.000 0.367 0.225 0.398 0.973 0.275 0.276 0.276 0.276 0.792 0.349 0.398 0.883 0.682 0.723 0.997 1.000 0.997 0.003 0.608 0.992 0.178 0.529 1.000 1.000 carDark 0.706 0.444 0.444 0.528 0.433 0.448 0.448 0.437 0.373 0.421 carScale 0.651 0.448 0.448 0.093 0.914 0.326 0.722 0.089 0.942 0.450 0.117 0.289 0.921 0.914 coke 0.337 0.739 0.743 0.286 0.243 0.086 0.543 0.107 0.686 0.071 0.086 0.671 1.000 0.757 0.107 couple crossing 0.950 0.992 0.925 0.175 0.942 1.000 0.983 0.400 0.317 0.983 0.517 0.958 0.808 0.236 0.601 0.270 0.584 0.913 0.427 0.291 0.236 0.229 0.970 0.597 0.771 david 0.622 0.324 0.922 0.752 1.000 0.911 0.002 0.996 0.952 1.000 david2 0.475 1.000 1.000 1.000 1.000 0.504 0.992 0.484 0.349 0.679 0.103 0.988 david3 0.333 0.337 0.627 0.683 0.933 1.000 0.042 0.817 0.042 1.000 0.028 0.042 0.028 1.000 0.127 0.732 1.000 1.000 deer dog1 0.652 0.884 0.653 0.573 0.653 0.847 0.652 0.547 0.653 0.650 0.673 0.653 0.713 0.729 0.960 0.552 0.100 0.688 0.987 0.531 0.229 0.218 0.433 0.624 0.730 0.714 doll0.976 0.978 0.976 0.724 0.980 0.976 0.852 0.886 0.947 0.857 0.842 0.978 0.879 dudek 0.942 0.591 0.834 0.982 faceocc1 1.000 0.243 1.000 1.000 0.854 0.796 1.000 0.765 1.000 faceocc2 1.000 0.736 0.996 0.980 1.000 0.874 0.744 1.000 1.000 0.936 0.829 0.996 0.993 fish 1.000 0.372 1.000 0.372 1.0000.863 0.889 1.000 0.042 0.387 0.964 1.000 1.0000.629 0.567 fleetface 0.618 0.421 0.669 0.463 0.666 0.706 0.638 0.676 0.537 0.777 0.610 0.983 0.293 0.619 0.586 0.773 0.657 0.412 0.959 0.970 football 0.682 0.660 0.785 0.738 1.000 0.324 0.959 0.351 0.878 0.405 0.081 0.716 0.392 0.784 0.392 0.838 0.811 football1 freeman1 0.298 0.334 0.160 0.169 0.215 0.807 0.101 0.181 0.144 0.153 0.212 0.212 0.218 freeman3 0.296 0.852 0.274 0.207 0.200 0.930 0.002 0.135 0.330 0.009 0.580 0.309 0.067 freeman4 0.459 0.155 0.184 0.170 0.155 0.244 0.004 0.180 0.170 0.021 0.269 0.329 0.332 0.974 girl 0.666 0.756 0.302 0.980 0.882 0.178 0.146 0.398 0.294 0.7640.948 0.882 ironman 0.608 0.060 0.157 0.042 0.048 0.133 0.090 0.024 0.127 0.048 0.066 0.434 0.060 jogging-1 0.964 0.221 0.225 0.208 0.225 0.212 0.225 0.827 0.225 0.225 0.967 0.909 0.225 1.000 0.156 0.160 0.173 0.248 0.990 0.140 0.160 0.182 0.163 0.831 0.909 0.990 jogging-2 0.799 0.994 0.700 0.281 0.048 0.121 0.006 0.067 0.048 0.476 0.847 0.987 0.096 jumping 0.395 0.429 0.594 lemming 0.267 0.243 0.431 0.153 0.640 0.166 0.680 0.811 0.853 0.268 0.812 0.363 0.982 0.251 0.406 0.321 0.209 0.597 0.278 0.201 0.582 0.978 0.681 liquor 0.390 0.010 0.130 0.100 0.120 0.300 0.020 0.020 0.010 0.110 0.070 0.380 0.040 matrix 1.000 1.000 1.000 1.000 0.997 0.730 0.969 1.000 0.389 0.893 0.997 0.982 0.860 mhyang 0.598 0.073 0.079 0.140 0.159 0.055 0.098 0.073 0.073 0.171 0.110 0.073 0.110 motorRolling mountainBike 1.000 0.320 0.991 0.873 0.855 0.961 0.171 1.000 1.000 0.575 0.259 0.838 1.000 0.855 0.926 0.014 0.852 0.896 0.041 0.699 0.581 0.227 0.400 0.956 0.433 shaking 0.167 0.276 1.000 0.276 0.507 0.299 1.000 0.248 0.276 0.296 0.276 0.991 0.271 0.228 singerl 0.036 0.041 0.036 0.970 0.459 0.164 0.011 1.000 0.036 0.475 0.101 0.038 1.000 singer2 0.375 0.485 0.363 0.230 0.423 0.188 0.368 0.103 0.228 0.385 0.535 skating1 0.370 0.100 0.420 0.111 0.062 0.111 0.037 0.086 0.074 0.025 0.074 0.074 0.074 0.321 0.086 skiing 0.467 0.138 0.390 0.115 0.156 0.237 0.202 0.099 0.138 0.156 0.122 0.301 0.130 soccer 1.000 0.017 0.994 0.223 0.909 0.994 0.766 0.840 0.223 0.794 0.229 0.966 0.994 subway 0.535 0.983 1.000 0.985 0.513 0.575 0.984 0.231 0.529 0.575 0.130 0.839 0.749 suv sylvester 0.847 0.512 0.819 0.610 0.929 0.886 0.828 0.930 0.717 0.546 0.928 0.913 0.923 0.814 0.298 0.857 0.052 0.183 0.129 0.246 0.077 0.264 0.097 0.456 0.917 0.272 tigerl 0.556 0.181 0.364 0.090 0.649 0.112 0.370 0.082 0.107 0.447 0.173 0.496 0.816 tiger2 trellis 0.318 0.784 0.350 0.439 0.591 0.793 0.835 0.840 0.580 0.854 0.244 0.473 0.819 0.532 0.721 0.566 0.959 0.459 0.541 0.383 0.517 0.738 walking 0.464 0.515 0.502 0.519 walking2 0.414 1.000 0.378 0.442 0.434 1.000 0.384 0.384 0.388 0.380 0.340 0.352 0.706 0.935 0.802 0.936 0.258 0.935 0.858 0.159 0.781 0.245 0.188 0.166 0.333 0.935 woman 0.740 0.478 0.457 0.373 0.696 0.628 Average 0.622 0.365 0.559 0.616 0.341 0.443 0.521

Table 4. Overlaps success rate at a threshold of 0.5 on the first 50 benchmark sequences [9]. The proposed algorithm performs favorably against the state-of-the-art algorithms.

Sequences	Ours	DLT	KCF	STC	Struck	SCM	СТ	LSHT	CSK	MIL	TLD	MEEM	TGPR
biker	0.246	0.500	0.254	0.204	0.254	0.444	0.007	0.070	0.254	0.246	0.310	0.254	0.366
bird1	0.199	0.017	0.064	0.029	0.105	0.159	0.390	0.123	0.022	0.343	0.005	0.083	0.542
bird2	0.990	0.141	0.465	0.374	0.525	0.889	0.101	0.970	0.525	0.596	0.707	1.000	0.727
blurBody	0.991	0.090	0.587	0.060	0.988	0.174	0.015	0.257	0.590	0.024	0.629	0.988	0.973
blurCar1	0.997	0.030	1.000	0.028	0.999	0.028	0.084	0.012	0.012	0.049	0.849	1.000	0.038
blurCar2	0.947	0.863	0.947	0.311	0.938	0.144	0.232	0.198	0.947	0.352	0.998	0.947	0.932
blurCar3	1.000	0.252	0.994	0.070	1.000	0.182	0.218	0.235	0.549	0.328	0.952	1.000	0.045
blurCar4	1.000	0.771	1.000	0.134	1.000	0.326	0.037	0.316	1.000	0.037	0.882	1.000	0.984
blurFace	1.000	0.203	1.000	0.525	0.436	0.132	0.150	0.120	1.000	0.195	1.000	1.000	1.000
blurOwl	0.965	0.071	0.228	0.074	0.986	0.216	0.084	0.067	0.165	0.116	0.735	0.995	0.512
board	0.946	0.605	0.854	0.219	0.789	0.663	0.483	0.605	0.476	0.380	0.107	0.761	0.129
bolt2	0.884	0.413	0.007	0.515	0.041	0.007	0.420	0.522	0.338	0.966	0.007	0.007	0.010
box	0.337	0.396	0.357	0.128	0.234	0.176	0.718	0.347	0.071	0.165	0.760	0.339	0.241
car1	0.054	0.999	0.054	0.088	0.054	0.987	0.008	0.054	0.054	0.054	0.319	0.054	0.078
car2	1.000	1.000	1.000	0.559	1.000	1.000	0.114	0.985	1.000	0.074	1.000	1.000	0.074
car24	0.173	0.976	0.173	0.706	0.170	1.000	0.169	0.173	0.173	0.172	0.483	0.173	0.715
clifBar	0.417	0.288	0.301	0.165	0.061	0.042	0.070	0.032	0.087	0.028	0.051	0.606	0.104
coupon	1.000	0.382	1.000	1.000	1.000	1.000	0.520	1.000	1.000	0.933	0.740	0.394	0.388
crowds	0.991	0.352	0.997	0.507	0.769	0.735	0.003	0.380	0.994	0.075	0.994	0.879	0.919
dancer	0.916	0.929	0.916	0.249	0.849	0.991	0.840	0.876	0.907	0.889	0.360	0.827	0.964
dancer?	1.000	0.480	1.000	0.920	1.000	1.000	1.000	1.000	1.000	1.000	0.853	1.000	0.993
diving	0.186	0.153	0.186	0.288	0.181	0.177	0.005	0.172	0.186	0.186	0.167	0.172	0.181
dog	0.134	0.472	0.142	0.394	0.157	0.213	0.197	0.173	0.142	0.197	0.709	0.142	0.173
dragonBaby	0.788	0.336	0.112	0.204	0.088	0.210	0.239	0.159	0.212	0.088	0.257	0.805	0.735
girl2	0.075	0.073	0.070	0.069	0.199	0.232	0.331	0.082	0.071	0.199	0.080	0.686	0.562
gvm	0.408	0.042	0.343	0.207	0.219	0.145	0.029	0.316	0.091	0.329	0.205	0.287	0.378
human?	0.804	0.554	0.183	0.116	0.699	0.546	0.029	0.166	0.178	0.206	0.525	0.472	0.953
human3	0.032	0.005	0.005	0.033	0.006	0.005	0.019	0.012	0.006	0.013	0.005	0.741	0.005
human4	0.609	0.0027	0.513	0.033	0.000	0.120	0.192	0.187	0.000	0.183	0.009	0.496	0.504
human5	0.240	0.281	0.236	0.243	0.341	0.415	0.237	0.043	0.243	0.285	0.512	0.339	0.348
human6	0.225	0.437	0.225	0.208	0.223	0.283	0.217	0.133	0.216	0.213	0.346	0.223	0.237
human7	0.408	0.432	0.408	0.328	0.408	0.368	0.152	0.232	0.312	0.412	0.844	0.412	0.400
human8	0.305	0.109	0.305	0.242	0.133	1.000	0.008	0.086	0.203	0.156	0.133	0.305	0.133
human9	0.239	0.125	0.239	0.170	0.049	0.203	0.003	0.174	0.180	0.187	0.193	0.197	0.305
iump	0.098	0.057	0.074	0.090	0.098	0.074	0.008	0.057	0.082	0.057	0.074	0.082	0.082
kiteSurf	0.452	0.286	0.310	0.274	0.905	0.321	0.345	0.405	0.321	0.381	0.429	0.988	0.393
man	1.000	1.000	1.000	1.000	1.000	1.000	0.216	1.000	1.000	0.209	1.000	1.000	0.254
panda	0.204	0.427	0.146	0.221	0.360	0.392	0.366	0.475	0.136	0.551	0.385	0.391	0.735
redTeam	0.296	0.956	0.376	0.277	0.398	0.391	0.351	0.287	0.397	0.187	0.283	0.408	0.517
ruhik	0.729	0.112	0.814	0.116	0.268	0.195	0.108	0.344	0.254	0.538	0.622	0.441	0.156
skater	0.888	0.650	0.813	0.231	0.838	0.506	0.138	0.838	0.556	0.819	0.294	0.694	0.713
skater?	0.834	0.154	0.621	0.138	0.720	0.425	0.009	0.030	0.772	0.356	0.262	0.867	0.418
skatino?-1	0.469	0.047	0.279	0.036	0.186	0.068	0.144	0.218	0.061	0.116	0.032	0.093	0.296
skating2.7	0.252	0.144	0.279	0.023	0.330	0.438	0.209	0.304	0.228	0.078	0.032	0.197	0.317
surfor	0.436	0.521	0.300	0.023	0.157	0.407	0.003	0.027	0.005	0.088	0.899	0.386	0.513
tov	0.410	0.125	0.432	0.037	0.491	0.221	0.003	0.358	0.332	0.000	0.37	0.362	0.292
trans	0.435	0.323	0.476	0.218	0.403	0.323	0.452	0.403	0.540	0.202	0.395	0.435	0.339
twinnings	0.435	0.864	0.542	0.358	0.405	0.644	0.322	0.377	0.434	0.434	0.373	0.433	0.636
Vase	0.162	0.122	0.162	0.100	0.140	0.107	0.166	0.129	0.166	0.166	0.550	0.144	0.181
Average	0.655	0.430	0.548	0.314	0.516	0.512	0.278	0.388	0.413	0.331	0.497	0.622	0.535

Table 5. Overlaps success rate at a threshold of 0.5 on additional benchmark sequences [10]. The average scores are computed on the entire 100 sequences. The proposed algorithm performs favorably against the state-of-the-art algorithms.

2.2. Center Location Error

We show tracking results on eight sample frames with equal temporal intervals and compare the center location error frame-by-frame on the entire 100 sequences in Figure 1-25. To avoid cluttered plots, we compare only four other representative trackers: (1) MEEM [11]; (2) KCF [6]; (3) DLT [8]; (4) Struck [3].



Figure 1. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Basketball, Bolt, Boy, Car4 sequences.



Figure 2. Tracking results and fame-by-frame comparison of center location errors (in pixels) on CarDark, CarScale, Coke, Couple sequences.



Figure 3. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Crossing, David, David2, David3 sequences.



Figure 4. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Deer, Dog1, Doll, Dudek sequences.



Figure 5. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Faceocc1, Faceocc2, Fish, Fleetface sequences.



Figure 6. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Football*, *Football*, *Freeman1*, *Freeman3* sequences.



Figure 7. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Freeman4*, *Girl*, *Ironman*, *Jogging-1* sequences.



Figure 8. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Jogging-2*, *Jumping*, *Lemming*, *Liquor* sequences.



Figure 9. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Matrix, Mhyang, MotorRolling, MountainBike* sequences.



Figure 10. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Shaking*, *Singer1*, *Singer2*, *Skating1* sequences.



Figure 11. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Skiing, Soccer, Subway, Suv sequences.



Figure 12. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Sylvester, Tiger1, Tiger2, Trellis sequences.



Figure 13. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Walking, Walking2, Woman, Biker sequences.



Figure 14. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Bird1*, *Bird2*, *BlurBody*, *BlurCar1* sequences.



Figure 15. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *BlurCar2*, *BlurCar3*, *BlurCar4*, *BlurFace* sequences.



Figure 16. Tracking results and fame-by-frame comparison of center location errors (in pixels) on BlurOwl, Board, Bolt2, Box sequences.



Figure 17. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Car1, Car2, Car24, ClifBar sequences.



Figure 18. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Coupon, Crowds, Dancer, Dancer2* sequences.



Figure 19. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Diving*, *Dog*, *DragonBaby*, *Girl2* sequences.



Figure 20. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Gym*, *Human2*, *Human3*, *Human4* sequences.



Figure 21. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Human5*, *Human6*, *Human7*, *Human8* sequences.



Figure 22. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Human9, Jump, KiteSurf, Man sequences.



Figure 23. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Panda*, *RedTeam*, *Rubik*, *Skater* sequences.



Figure 24. Tracking results and fame-by-frame comparison of center location errors (in pixels) on *Skater2*, *Skating2-1*, *Skating2-2*, *Surfer* sequences.



Figure 25. Tracking results and fame-by-frame comparison of center location errors (in pixels) on Toy, Trans, Twinnings, Vase sequences.

2.3. Robustness Evaluation

Here we evaluate the robustness of trackers using the one-pass evaluation (OPE), temporal robustness evaluation (TRE) and spatial robustness evaluation (SRE) as described in [9]. Figure 26 shows the distance precision and overlap success plots using OPE, TRE and SRE. In Figure 27 to 38, we further report the robustness evaluation results for each video attribute: fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. Each tracker is color coded.



Figure 26. Distance precision and overlap success plots over first 50 benchmark sequences [9] using one-pass evaluation (OPE), temporal robustness evaluation (TRE) and spatial robustness evaluation (SRE). The legends in the distance precision plots contain the average distance precision rate (DPR) using a threshold at 20 pixels. The legends in the overlap success plots contain the area-under-the-curve (AUC) scores. The proposed algorithm performs favorably against the state-of-the-art trackers.



Figure 27. Distance precision plots on the 50 benchmark sequences [9] using one-pass evaluation (OPE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the average distance precision rate (DPR) using a threshold at 20 pixels. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 28. Overlap success plots on the 50 benchmark sequences [9] using one-pass evaluation (OPE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 29. Distance precision plots on the 50 benchmark sequences [9] using temporal robustness evaluation (TRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the distance precision rate (DPR) at a threshold of 20 pixels for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 30. Overlap success plots on the 50 benchmark sequences [9] using temporal robustness evaluation (TRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 31. Distance precision plots on the 50 benchmark sequences [9] using spatial robustness evaluation (SRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the distance precision rate (DPR) at a threshold of 20 pixels for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 32. Overlap success plots on the 50 benchmark sequences [9] using spatial robustness evaluation (SRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 33. Distance precision plots on the 100 benchmark sequences [10] using one-pass evaluation (OPE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the distance precision rate at a threshold of 20 pixels for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 34. Overlap success plots on the 100 benchmark sequences [10] using one-pass evaluation (OPE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legend contains the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 35. Distance precision plots on the 100 benchmark sequences [10] using TRE validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, blur, out-of-plane rotation and out-of-view. The legends contain the distance precision rate (DPR) at a threshold of 20 pixels for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 36. Overlap success plots on 100 benchmark sequences [10] using temporal robustness evaluation (TRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 37. Distance precision plots on 100 benchmark sequences [10] using spatial robustness evaluation (SRE) validation over eleven tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the distance precision rate (DPR) at a threshold of 20 pixels for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.



Figure 38. Overlap success plots on 100 benchmark sequences [10] using spatial robustness evaluation (SRE) validation over 11 tracking challenges of fast motion, background clutter, scale variation, deformation, illumination variation, occlusion, in-plane rotation, low resolution, motion blur, out-of-plane rotation and out-of-view. The legends contain the scores of the area under the curve (AUC) for each tracker. The proposed algorithm performs favorably against the state-of-the-art trackers with these challenging attributes.

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