MCT 2014

ECCV Workshop on Visual Surveillance and Re-Identification

Multi-Camera Object Tracking Challenge and Results

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September 12th, 2014

Outline

- Background of the Challenge
- Dataset, Experiments & Evaluation
- Participants & Results
- Summary

Background of the Challenge

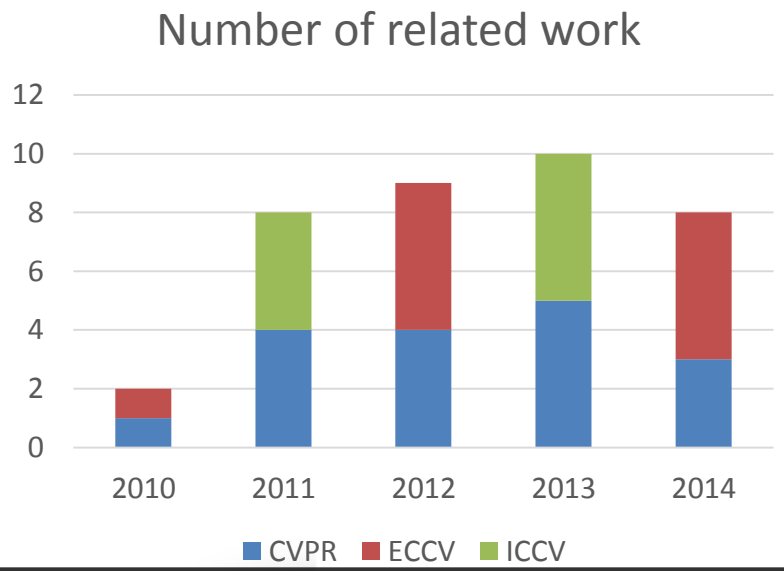
- **Multi-camera visual surveillance**
  - has been widely used in applications
  - has attracted more and more attention

video retrieval

electronic map

multi-camera object tracking

situation evaluation



Background of the Challenge

- Public multi-camera datasets are very few.
- Current methods usually use different datasets and evaluation criterions.

Task	Dataset	Size/length	Characteristic	Weakness	Example
Multi-camera object tracking	PETS2009 [1]	8 scenes, 4 viewpoint/scene	overlapped views, the most popular	controlled scenes, only overlapped views	
Person re-identification	i-LIDS MCTS[2]	119 persons, 476 images	real scenes, serious occlusions	charged	
	ETHZ [3]	146 persons, >10 image/person	Small variance for the same person	only one view for each person	
	PRID 2011 [4]	≈900 persons, 2 views	Pose and illumination variance		
	VIPeR [5]	632 persons, 2 image/person	Challenge, large illumination and viewpoint variance		
	CHUK [6]	>970 persons, >2 image/person	viewpoint variance		

[1] PETS 2009 Benchmark Data, http://www.cvg.rdg.ac.uk/PETS2009/a.html#s2l1
[2] TRECVid 2008, https://www.gov.uk/imagery-library-for-intelligent-detection-systems
[3] ETHZ Dataset, http://www.ssig.dcc.ufmg.br/ethz-dataset-for-appearance-based-modeling/
[4] PRID 2011 Dataset, http://lrs.icg.tugraz.at/datasets/prid/index.php
[5] VIPeR, http://vision.soe.ucsc.edu/?q=node/178
[6] CHUK Person Re-identification Dataset, http://www.ee.cuhk.edu.hk/~xgwang/CUHK_identification.html

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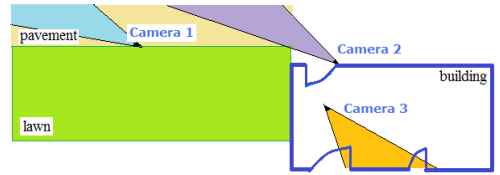
NLPR_MCT Dataset

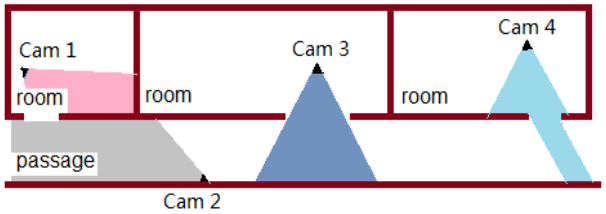
- Roadmap
  - 2008, set up a non-overlapping multi-camera system with 3 cameras, and collect time synchronization videos
  - 2011, set up non-overlapping multi-camera systems with 4 cameras and 5 cameras successively, and collect time synchronization videos
  - 2012, release all the videos
  - 2012-2014, annotate each person frame by frame, camera by camera
  - 2014/5/13, release the annotations

NLPR_MCT Dataset

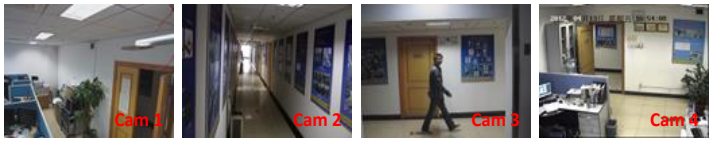
- The NLPR_MCT dataset consists of **four sub-datasets** corresponding to different non-overlapping multi-camera networks.



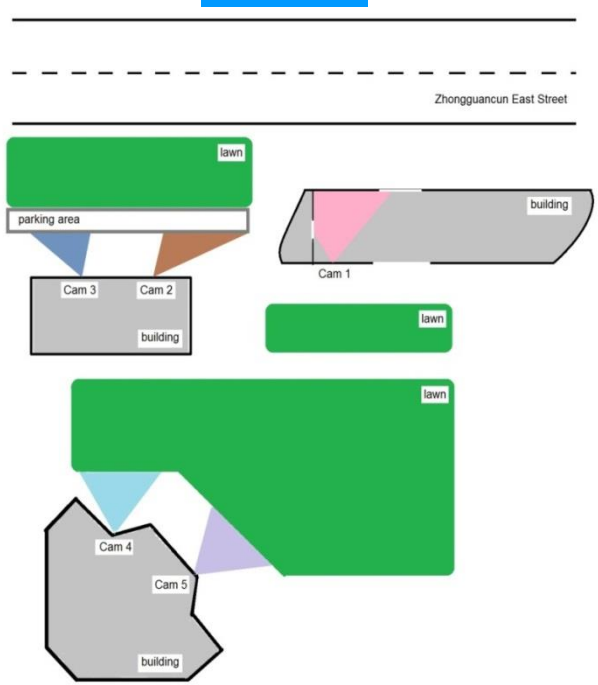
Dataset1&
Dataset2



Dataset3



Dataset4

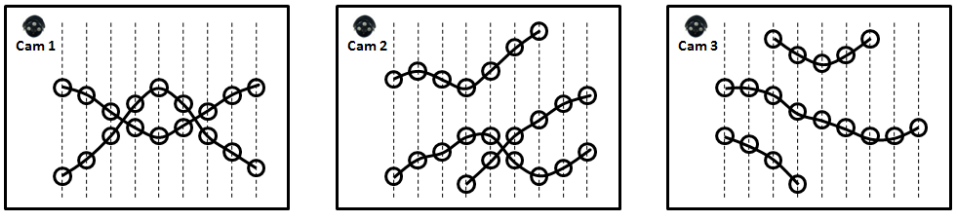


NLPR_MCT Dataset

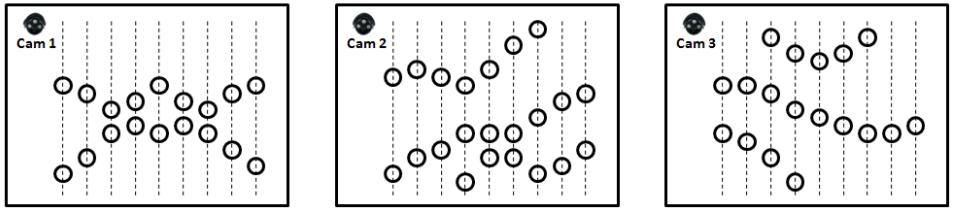
sub-dataset	number of cameras	duration	size	resolution, frame rate	viewpoint changes	Illumination variations	occlusion
Dataset1	3	20 min	235 persons 72187 blobs	320×240, 20 fps	very large	serious	serious
Dataset2	3	20 min	255 persons 88827 blobs	320×240, 20 fps	very large	serious	serious
Dataset3	4	≈4 min	14 persons 18339 blobs	320×240, 25 fps	very large	very serious	very serious
Dataset4	5	≈25 min	49 persons 42871 blobs	320×240, 25 fps	small	serious	not serious

Characteristic:
Non-overlapping views, videos, **large-scale blob images (tens of thousands),** large viewpoint changes (front & back), illumination changes (indoor & outdoor), various multi-camera scenarios (indoor & outdoor, real scenes & controlled scenes)

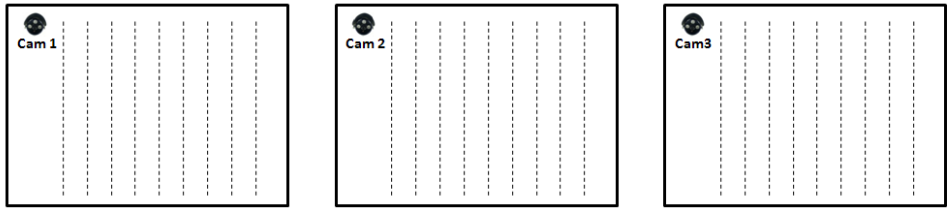
Experiment



(a) Available groundtruth in Experiment 1



(b) Available groundtruth in Experiment 2



(c) Available groundtruth in Experiment 3

Experiment 1

- The groundtruth of single camera object tracking is available.
- Data association across cameras needs to be solved.

Experiment 2

- Only the groundtruth of object detection is available.
- Object tracking both in single cameras and across cameras are need to be solved.

Experiment 3

- No groundtruth is available.
- Object detection, single camera object tracking, and data association across cameras are need to be solved.

easy

difficult

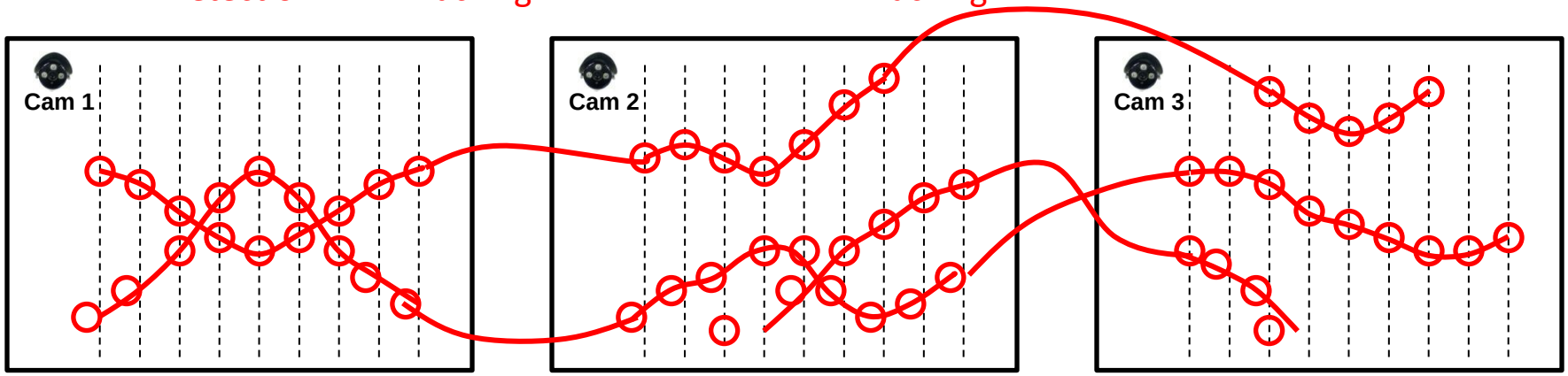
Each circle denotes a detection (or bounding box) of an object in a frame.
Line means the trajectory of the same object in single cameras.

Evaluation Criterion

- **Multi-Camera Tracking Accuracy (MCTA)**

$$MCTA = \left(\frac{2*\text{Precision}*\text{Recall}}{\text{Precision}+\text{Recall}}\right)\left(1-\frac{\sum_t mme_t^s}{\sum_t tp_t^s}\right)\left(1-\frac{\sum_t mme_t^c}{\sum_t tp_t^c}\right), \text{ where Precision} = \left(1-\frac{\sum_t fp_t}{\sum_t r_t}\right) \text{ and Precision} = \left(1-\frac{\sum_t fp_t}{\sum_t r_t}\right)$$

Detection — Tracking^{single_camera} — Tracking^{cross_camera}



Step1: MCTA
Evaluate the performance of a single experiment on a single dataset.

Step2: Average
Evaluate the performance on a single dataset by averaging over MCTA of the experiments.

rank

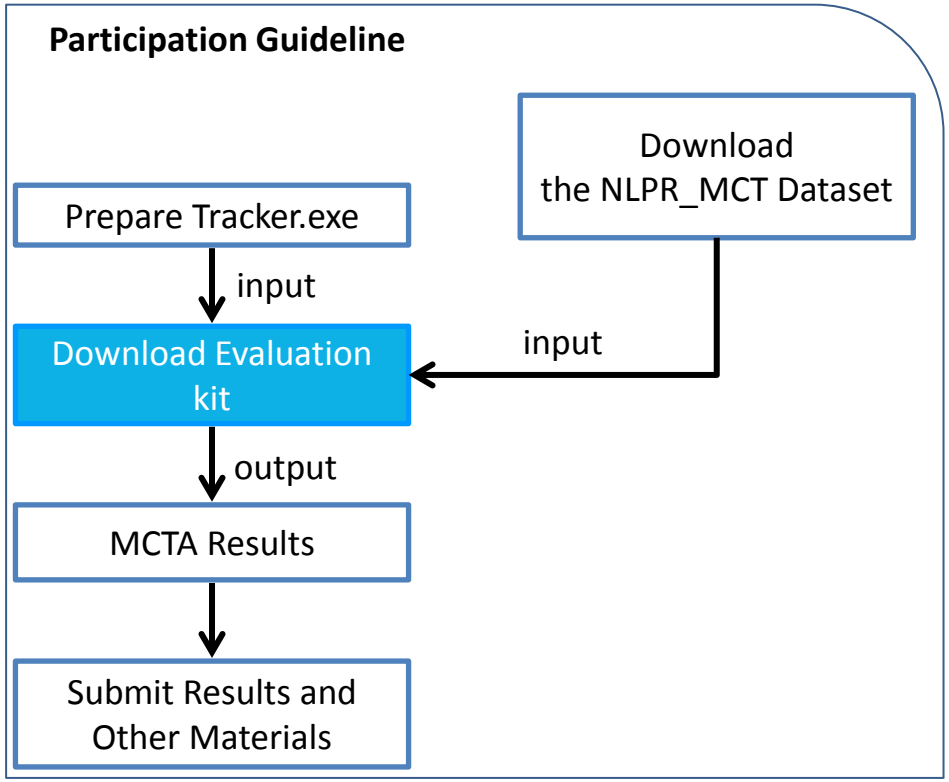
Step3: Average
Evaluate the final performance by averaging over the rankings of Step 2.

Final rank

[1] Keni B, Rainer S. Evaluating multiple object tracking performance: the CLEAR MOT metrics[J]. EURASIP Journal on Image and Video Processing, 2008.
[2] Van Rijsbergen, C. J. (1979). Information Retrieval (2nd ed.). Butterworth.

Evaluation Kit

- The MCT challenge provides an evaluation kit. Participants can use it to evaluate their algorithms (available for Matlab and C algorithms).
- The algorithms submitted have to be integrated and run with the MCT challenge evaluation kit, which will automatically perform the chosen experiment by the evaluation criterion on the NLPR_MCT dataset.



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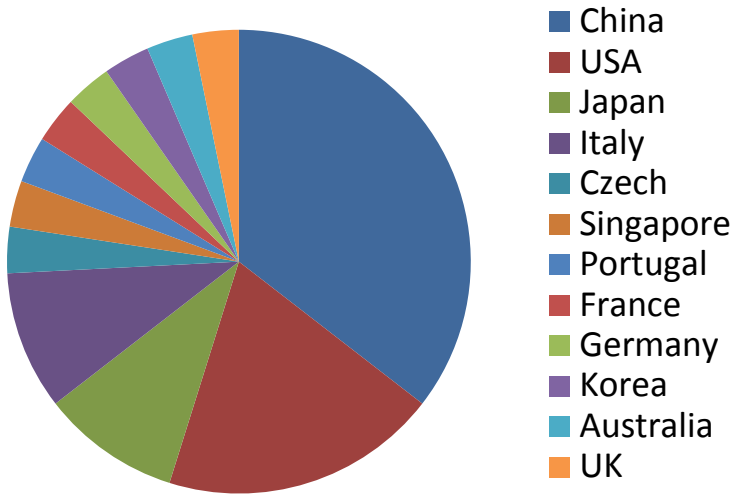
Participants

- Registered
  - Up to 4th September, 34 teams from 31 organizations and 12 countries have been registered to download the NLPR_MCT dataset.
- Submited
  - Four organizations participate in all the experiments and submitted the results.
    - Team: USC_Vision, from University of Southern California
    - Team: hfutdspmct, from Hefei University of Technology
    - Team: CRIPAC_MCT, from Institute of Automation, Chinese Academy of Sciences
    - Team: AdbTeam, from Adobe System Incorporation



Ranking Report

Tracker description

		USC_Vision	hfutdspmct	CRIPAC_MCT	AdbTeam
Foreground detection		collaborative learning, JRoG features [1]	VIBE algorithm	omega-shape features [4]	frame difference method
Object tracking	Single camera	hierarchical association [2]	center location bi-directional matching	global MAP, piecewise MCSHR [5]	greedy algorithm, color histogram
	Across cameras	exploring context information [3]	adjacency constrained patch matching, bi-directional weighted matching		

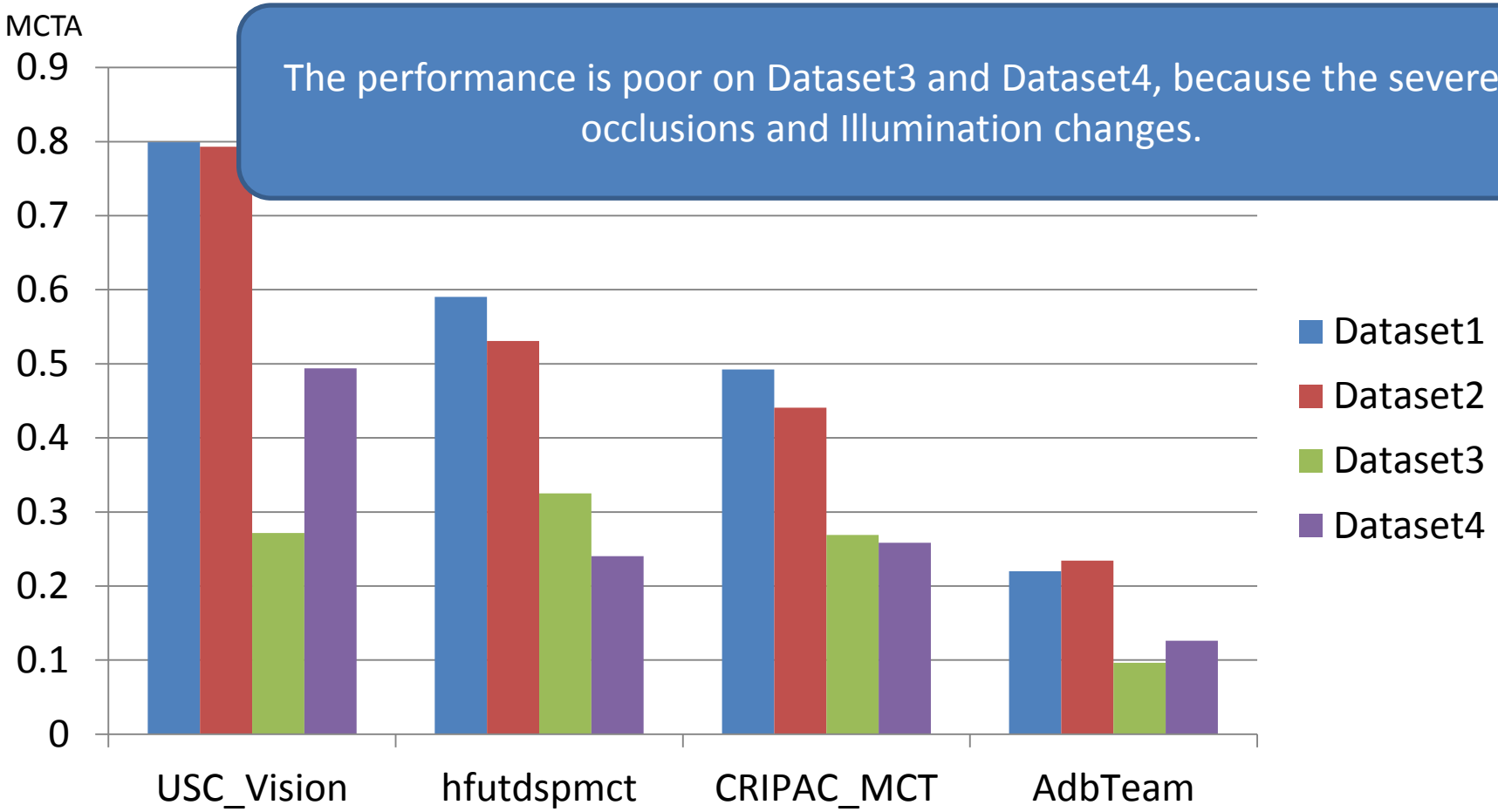
[1] Chang Huang and Ram Nevatia, High performance object detection by collaborative learning of joint ranking of granules features, CVPR, 2010.
[2] Chang Huang, Bo Wu, and Ramakant N, Robust object tracking by hierarchical association of detection responses, ECCV, 2008.
[3] Yinghao Cai, Gérard Medioni, Exploring context information for inter-camera multiple target tracking, WACV, 2014.
[4] M. Li, Z. Zhang, K. Huang, and T. Tan, Rapid and robust human detection and tracking based on omega-shape features, ICIP, 2009.
[5] W. Chen, L. Cao, X. Chen, and K. Huang, A novel solution for multi-camera object tracking, ICIP, 2014.

Ranking Report

Team Ranks '*' denotes the results have been checked.

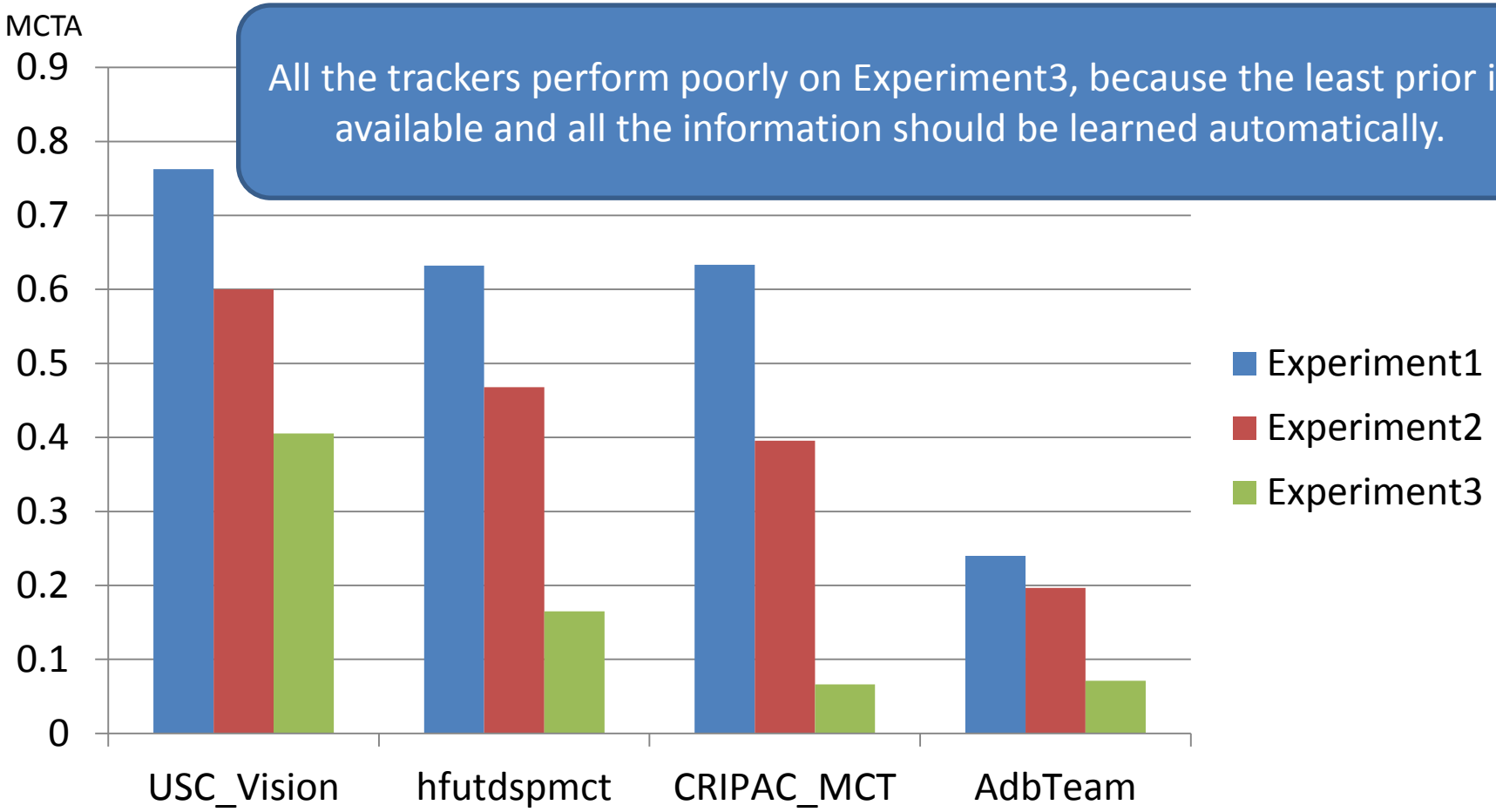
Team name	Dataset1 rank	Dataset2 rank	Dataset3 rank	Dataset4 rank	average	Final rank
USC_Vision*	1	1	2	1	1.25	**1 Winner**
hfutdspmct*	2	2	1	3	2	2
CRIPAC_MCT*	3	3	3	2	2.75	3
AdbTeam*	4	4	4	4	4	4

Ranking Report



The performance is poor on Dataset3 and Dataset4, because the severe occlusions and Illumination changes.

Ranking Report



All the trackers perform poorly on Experiment3, because the least prior is available and all the information should be learned automatically.

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Summary

- The MCT challenge is held for the first time in this year, and it has caught widespread attention.
- This challenge reveals the great importance of the low-level algorithms, for example, foreground detection. And some traditional problems are still a bottleneck for object tracking, such as occlusions.
- As the organizer, we make mistakes and make improvements consequently. Thank all the participants for their suggestions and questions. We have great confidence that the next MCT challenge will be organized much better.

THANK YOU

For more information, you can visit http://www.mct2014.com

Suggestions Questions