INFORMATION TECHNOLOGY LABORATORY

ActEV18: Activities in Extended Video

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DIVA

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Outline

- ActEV Overview
- Evaluation Framework
- Tasks and Measures
- ActEV18 Evaluations
- ActEV18 Dataset
- ActEV18 Results and Analyses
- Next Steps

ActEV Overview

What is ActEV?

- ActEV (Activities in Extended Video) is an extension of TRECVID Surveillance Event Detection (SED) evaluations
- Goal
  - To advance video analytics technology that can automatically detect a target activity and identify and track objects associated with the activity.
- A series of challenges are also designed for:
  - Activity detection in a multi-camera environment
  - Temporal (and spatio-temporal) localization of the activity for reasoning

What's New? (SED -> ActEV)

- New activity-annotated and unannotated data for 4 years!
  - DARPA Video and Image Retrieval and Analysis Tool (VIRAT) data (16, 28 hrs)
  - Newly-collected DIVA data (Rough est. ~200 hrs, ~20K hrs)
- New evaluation tasks
  - Activity Detection (AD) : similar to the retrospective SED task
  - Activity and Object Detection (AOD): activity + object detection
  - Activity and Object Detection and Tracking (AODT): activity + object detection + tracking
- A series of evaluations rather than one per year
  - Blind: participants deliver system output (typical TRECVID)
  - Leader board: participants deliver many system output
  - Independent: participants deliver working systems for NIST to test on sequestered data

NIST, IARPA, and Kitware

- NIST developed the ActEV evaluation series to support the metrology needs of the Intelligence Advanced Research Projects Activity (IARPA) Deep Intermodal Video Analytics (DIVA) Program
- The ActEV's datasets collected and annotated by Kitware, Inc.

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Evaluation Framework

Evaluation Framework

- Target applications
  - Retrospective analysis of archives (e.g., forensic analytics)
  - Real-time analysis of live video streams (e.g., alerting)
- Evaluation Type
  - Self-reported evaluation
  - Independent (& sequestered) evaluation
- Evaluation conditions
  - Activity-level (1.A phase evaluation)
  - Reference temporal segmentation
  - Leaderboard

Tasks and Measures
(AD, AOD, AODT)

Evaluation Tasks (AD)

- Activity Detection (AD)
  - Given a target activity, a system automatically 1) detects its presence and then temporally localizes all instances of the activity in video sequences
  - The system output includes:
    - Start and end frames indicating the temporal location of the target activity
    - A presence confidence score that indicates how likely the activity occurred

Evaluation Tasks (AOD)

- Activity and Object Detection (AOD)
  - A system not only 1) detects/localizes the target activity, but also 2) detects the presence of required objects and spatially localizes the objects that are associated with the activity
  - The system output includes:
    - Start and end frames indicating the temporal location of the target activity
    - A presence confidence score that indicates how likely the activity occurred
    - Coordinates of object bounding boxes and object presence confidence scores
  - Scoring protocol: AOD_AD and AOD_AOD.

Evaluation Tasks (AODT)

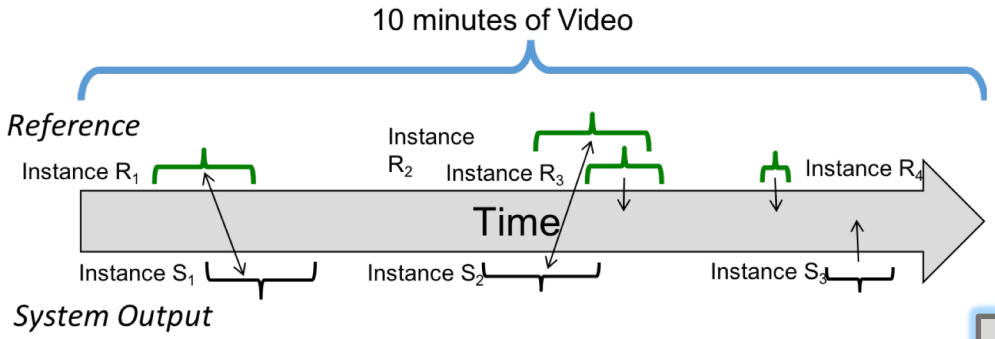
- Activity Object Detection/Tracking (AODT)
  - A system 1) correctly detects/localizes the target activity, 2) correctly detects/localizes the required objects in that activity, and 3) correctly tracks those objects over time.

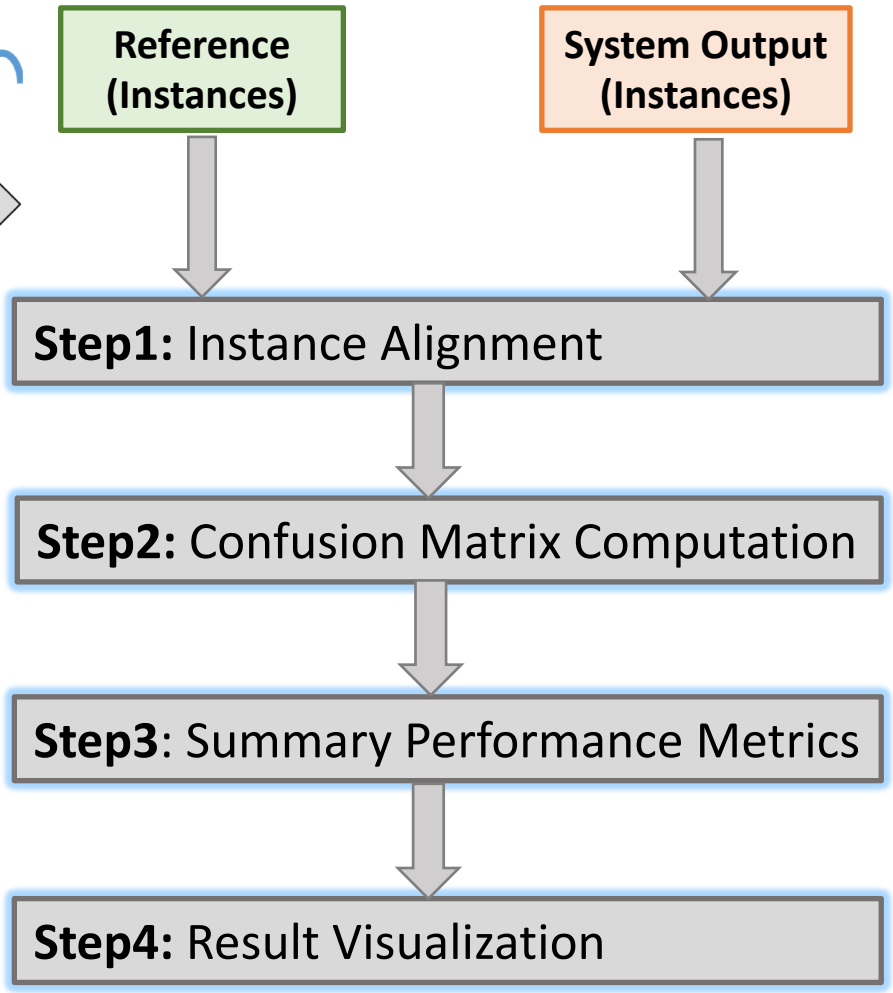
  - The AODT task is NOT addressed in ActEV18 evaluations

Performance Measures (AD)

- Primary metrics
  - J. Fiscus, “TRECVID Surveillance Event Detection Evaluation.” https://www.nist.gov/itl/iad/mig/trecvid-2017-evaluation-surveillance-event-detection
- Secondary metrics
  - K. Bernardin and R. Stiefelhagen, “Evaluating Multiple Object Tracking Performance: The CLEAR MOT Metrics,” *EURASIP J. Image Video Process.*, vol. 2008

Primary: Activity Occurrence Detection



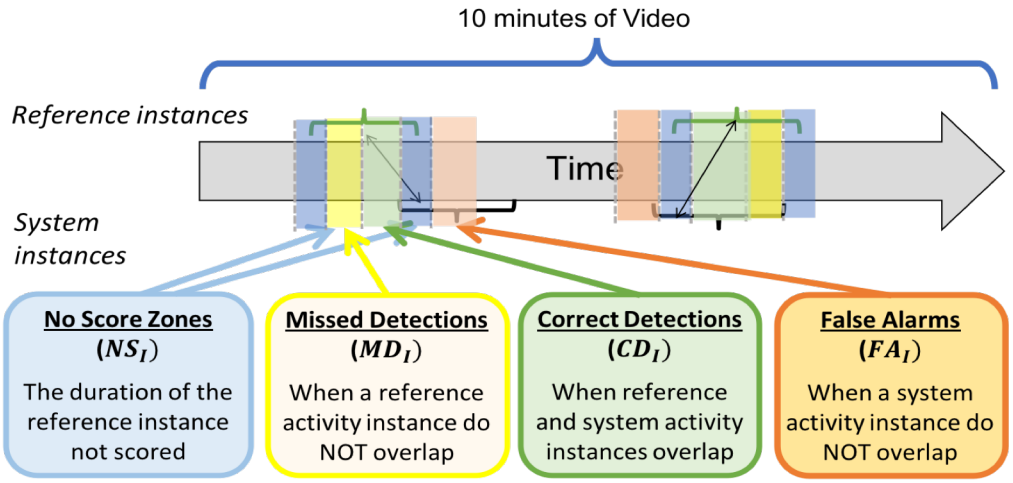


$$P_{miss}(\tau) = \frac{N_{MD}(\tau)}{N_{TrueInstance}}$$

$$R_{FA}(\tau) = \frac{N_{FA}(\tau)}{VideoDurInMinutes}$$

- P_{miss} at $R_{FA} = 0.15$
- Further details in "ActEV 2018 Evaluation Plan", https://actev.nist.gov/

Secondary: Temporal Localization



- N_MIDE (Normalized Multiple Instance Detection Error)

$$N_{MIDE} = \sum_{I=1}^{N_{mapped}} \frac{(C_{MD} * \frac{MD_I}{MD_I + CD_I} + C_{FA} * \frac{FA_I}{Dur_V - (MD_I + CD_I + NS_I)})}{N_{mapped}}$$

Further detail in "ActEV 2018 Evaluation Plan", https://actev.nist.gov/

Performance Measures (AOD)

- Primary
  - Similar to AD, however, instance alignment step uses an additional term for the object detection congruence
- Secondary
  - N_MODE (Normalized Multiple Object Detection Error)

$$N_{MODE(\tau)} = \sum_{t=1}^{N_{frames}} \frac{\left(C_{MD} * MD_t(\tau) + C_{FA} * FA_t(\tau)\right)}{\sum_{t=1}^{N_{frames}} N_R^t}$$

  - The minimum N_MODE value (minMODE) is calculated for object detection performance
  - 1-minMODE is used for the object detection congruence term

Performance Measures (AODT)

- Primary
  - Similar to AD, however, instance alignment step uses an additional term for the object tracking congruence
- Secondary
  - MOTE (Multiple Object Tracking Error)

$$MOTE(\tau) = \sum_{t=1}^{N_{frames}} \frac{(C_{MD} * MD_t(\tau) + C_{FA} * FA_t(\tau) + C_{ID} * \boldsymbol{IDSwitchs_t}(\tau)}{\sum_{t=1}^{N_{frames}} N_R^t}$$

  - The minimum MOTE value (minMOTE) is calculated for object tracking performance
  - 1-minMOTE is used for the tracking congruence term

ActEV18 Evaluations

ActEV18 Evaluations are focusing on

- The AD and AOD tasks only
- Retrospective analysis applications in mind
- The single camera view and at the activity observation level
- Self-reported evaluation only
- A series of the evaluations:
  - Activity-level
  - Reference temporal segmentation (RefSeg)
  - Leaderboard

ActEV18 Dataset

Activities and Number of Instances

VIRAT V1 dataset

12 activities for activity-level/RefSeg

Activity Type	Train	Validation
Closing	126	132
Closing_trunk	31	21
Entering	70	71
Exiting	72	65
Loading	38	37
Open_Trunk	35	22
Opening	125	127
Transport_HeavyCarry	45	31
Unloading	44	32
Vehicle_turning_left	152	133
Vehicle_turning_right	165	137
Vehicle_u_turn	13	8

Additional 7 activities for leaderboard

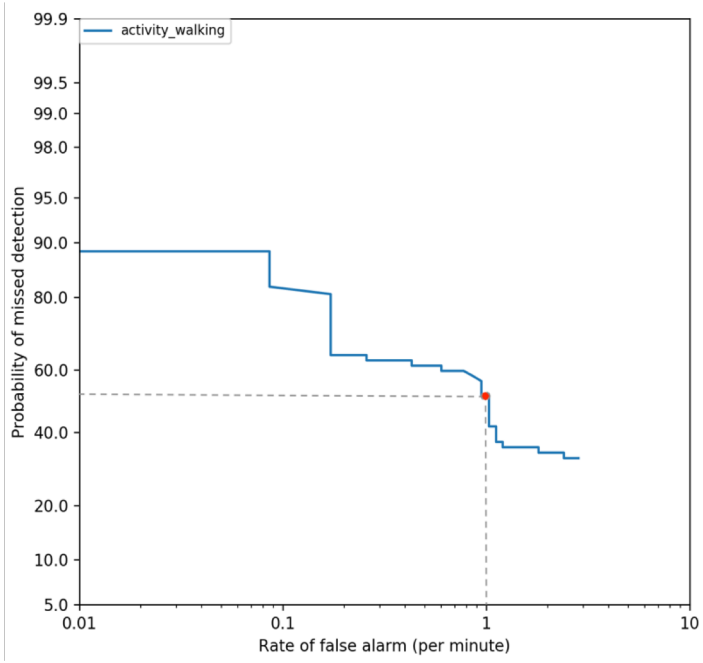
Activity Type	Train	Validation
Interacts	88	101
Pull	21	22
Riding	21	22
Talking	67	41
Activity_carrying	364	237
Specialized_talking_phone	16	17
Specialized_texting_phone	20	5

Due to ongoing evaluations, the test sets are not included in the table

ActEV18
Results and Analyses

ActEV18 Activity-Level Evaluation

- 15 Participants from the academic and industrial sectors
- AD
  - 20 systems from 13 teams (including baseline)
  - Activity Detection (Primary):
    - P_{miss} at $R_{FA} = 0.15$, P_{miss} at $R_{FA} = 1$
  - Temporal Localization (Secondary):
    - N_{MIDE} at $R_{FA} = 0.15$, N_{MIDE} at $R_{FA} = 1$
- AOD
  - 16 systems from 11 teams
  - Two scoring protocols
    - AOD_AD: the same with the AD task
    - AOD_AOD: In addition to the AD metrics, $\mu ObjectP_{miss}$ at $R_{FA} = 0.5$ is used for object detection



Detection Error Tradeoff (DET) curve

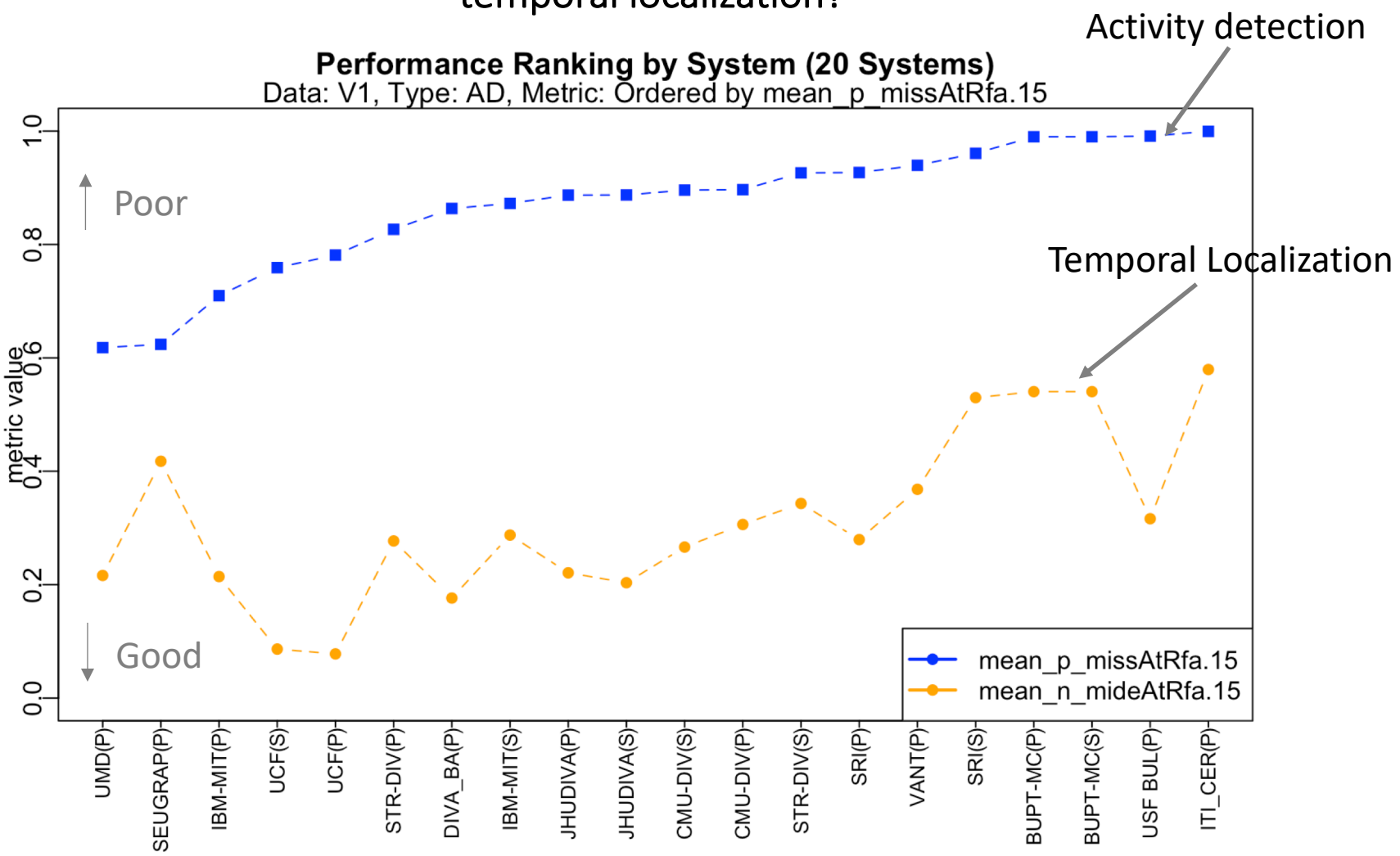
ActEV18 activity-level evaluation results

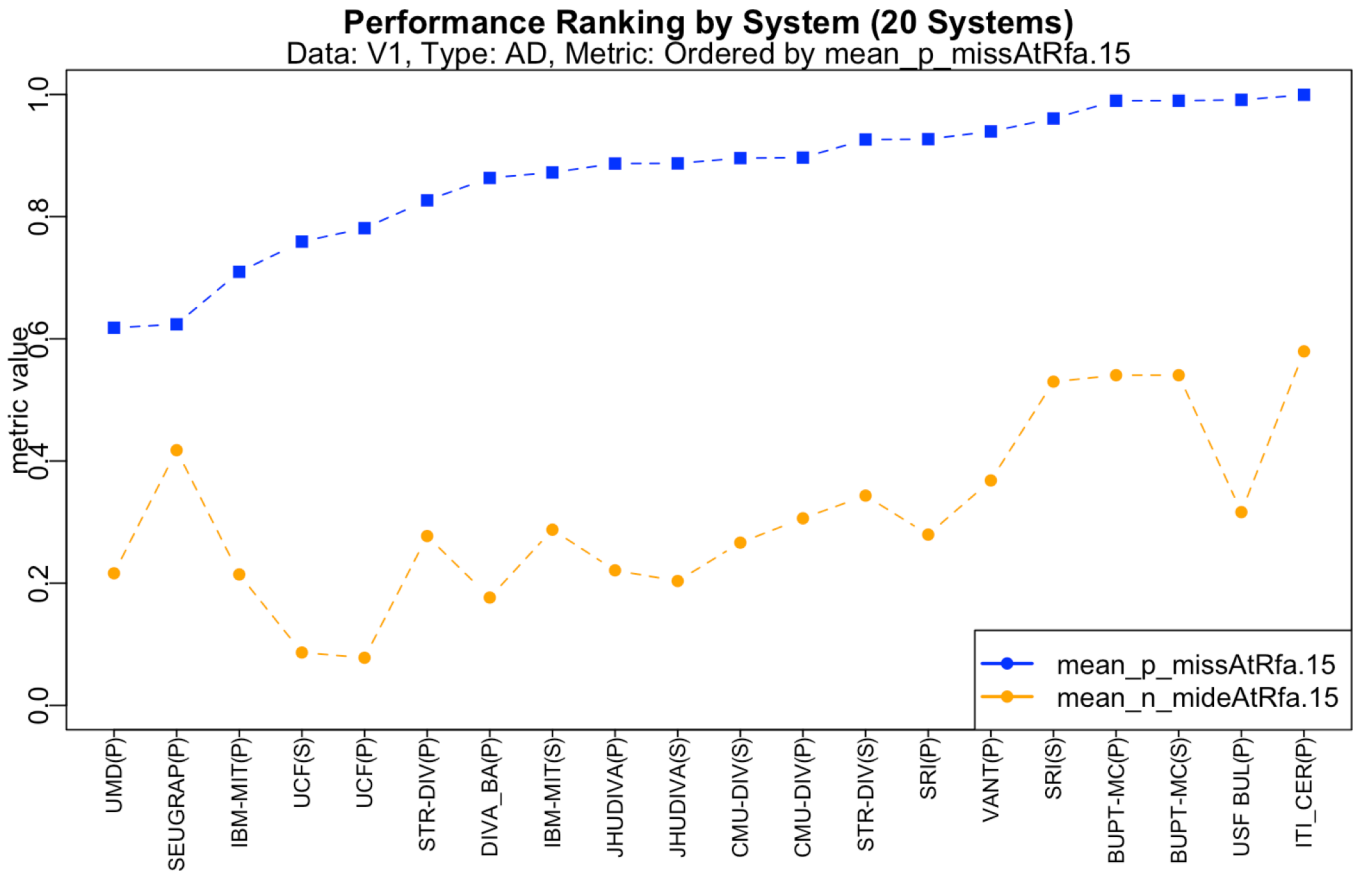
P: Primary, S: Secondary, PR.15: μP_{miss} at $R_{FA} = 0.15$, NR.15: μN_{MIDE} at $R_{FA} = 0.15$,
PR1: μP_{miss} at $R_{FA} = 1$, NR1: μN_{MIDE} at $R_{FA} = 1$, OPR.5: $\mu ObjectP_{miss}$ at $R_{FA} = 0.5$

System and Version		AD				AOD		
						AOD_AD	AOD_AOD	
		PR.15↓	PR1↓	NR.15↓	NR1↓	PR.15↓	PR.15↓	OPR.5↓
UMD	P	0.618	0.441	0.216	0.223	0.618	0.680	0.306
SeuGraph	P	0.624	0.621	0.418	0.416	0.624	0.664	0.362
IBM-MIT-Purdue	P	0.710	0.603	0.214	0.230	0.710	0.726	0.110
UCF	S	0.759	0.624	0.086	0.129	n/a	n/a	n/a
UCF	P	0.781	0.654	0.078	0.112	n/a	n/a	n/a
STR-DIVA Team	P	0.827	0.722	0.277	0.321	0.827	0.838	0.443
DIVA_Baseline	P	0.863	0.720	0.176	0.196	n/a	n/a	n/a
IBM-MIT-Purdue	S	0.872	0.704	0.288	0.282	0.872	0.878	0.329
JHUDIVATeam	P	0.887	0.829	0.221	0.219	0.887	0.933	0.266
JHUDIVATeam	S	0.887	0.813	0.203	0.240	0.887	0.926	0.332
CMU-DIVA	S	0.896	0.831	0.266	0.317	0.896	0.904	0.421
CMU-DIVA	P	0.897	0.766	0.306	0.349	0.897	0.908	0.244
STR-DIVA Team	S	0.926	0.905	0.343	0.355	n/a	n/a	n/a
SRI	P	0.927	0.856	0.279	0.282	0.927	0.936	0.406
VANT	P	0.940	0.918	0.368	0.385	0.940	0.945	0.837
SRI	S	0.961	0.885	0.530	0.490	0.961	0.963	0.446
BUPT-MCPRL	P	0.990	0.839	0.540	0.248	0.990	1.000	0.669
BUPT-MCPRL	S	0.990	0.839	0.540	0.248	0.990	1.000	0.669
USF Bulls	P	0.991	0.949	0.316	0.375	n/a	n/a	n/a
ITI_CERTH	P	0.999	0.998	0.579	0.667	0.999	0.999	0.955
HSMW_TUC	P	n/a	n/a	n/a	n/a	0.961	0.968	0.502

Performance Ranking (AD)

What is the general trend on performance between activity detection and temporal localization?

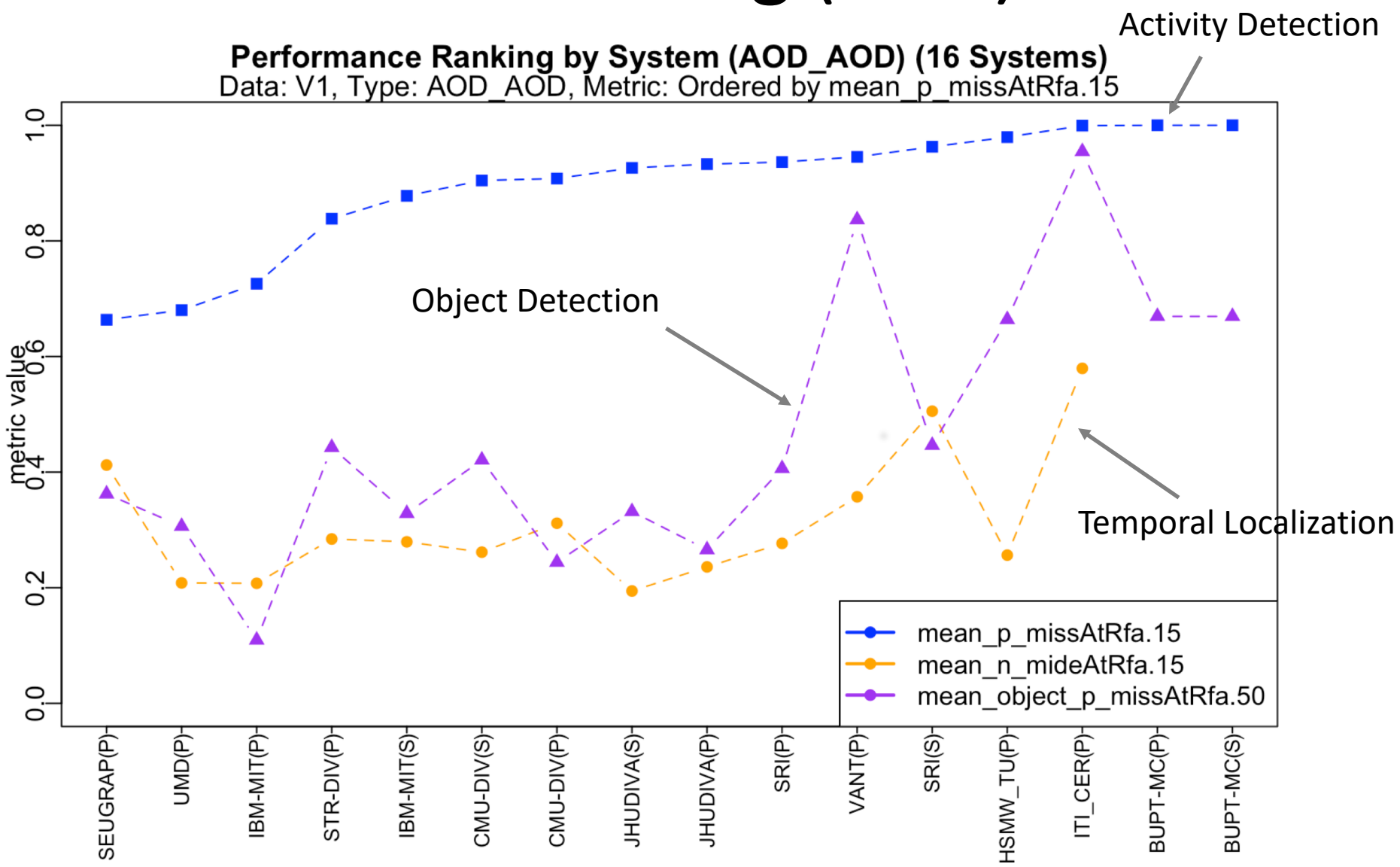


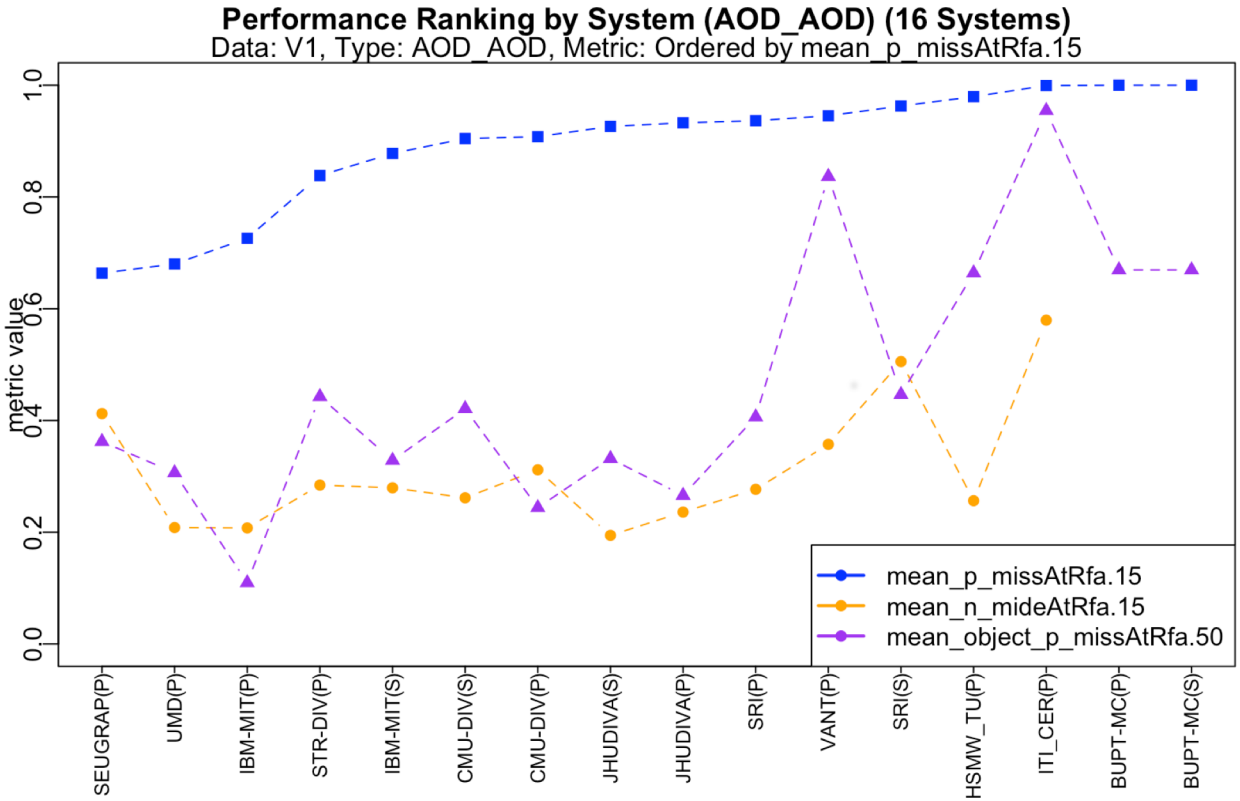


Observation

- Highest performance on activity detection:
  - UMD (PR.15: 61.8%) followed by SeuGraph (PR.15: 62.4%)
- Highest performance on temporal localization
  - UCF (NR.15: 7.8%)
- Different trend between activity detection and temporal localization

Performance Ranking (AOD)

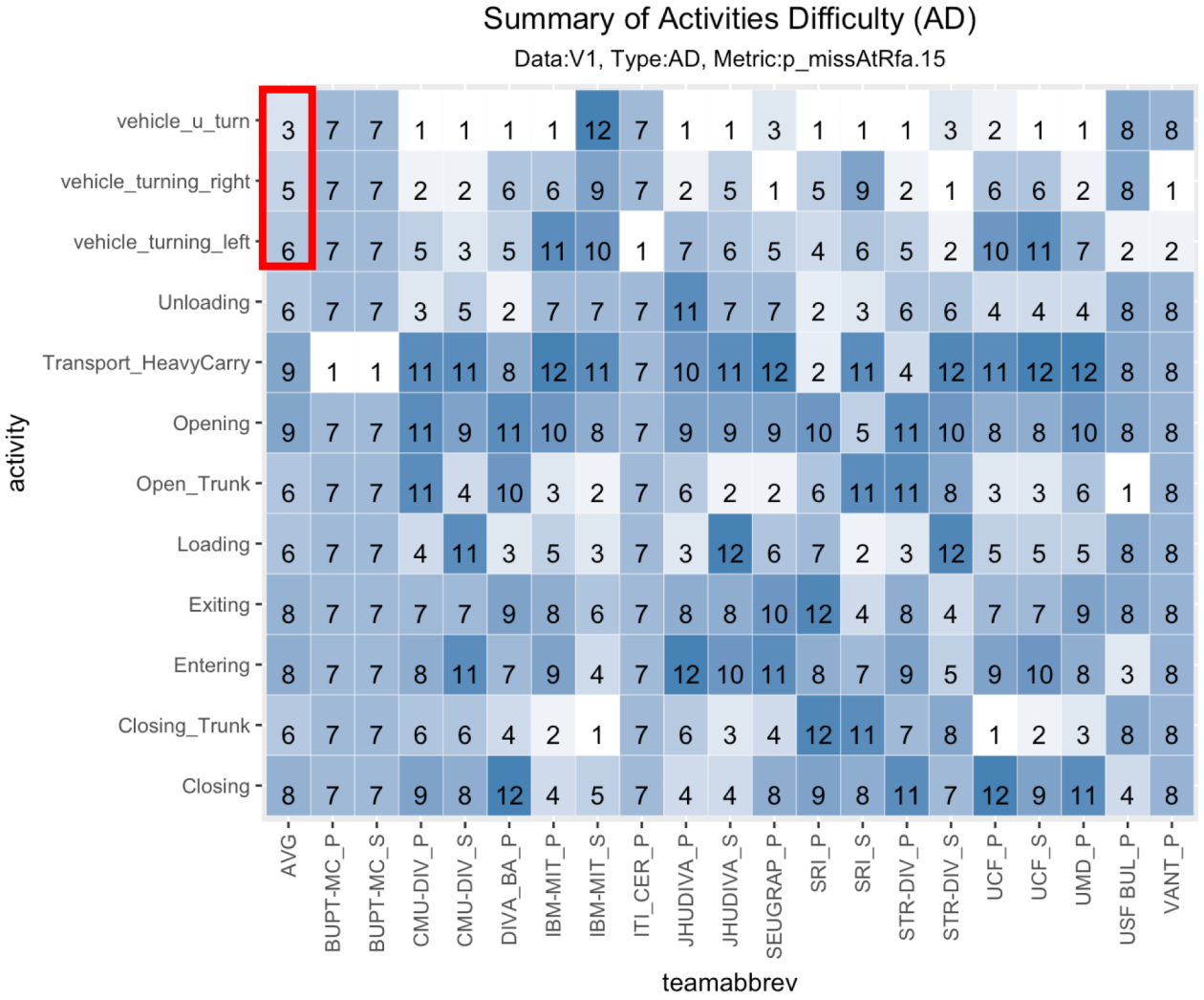




Observation

- Highest performance on activity detection:
  - SeuGraph (PR.15: 66.4%), UMD (PR.15: 68%)
- Highest performance on temporal localization
  - JHU (NR.15: 19.4%), IBM_MIT_PURDUE (20.7%) , UMD (20.8%)
- Highest performance on object detection
  - IBM_MIT_PURDUE (OPR.5: 11%)
- Different trend among activity detection, temporal localization, and object detection

Which activities are easier or more difficult to detect?



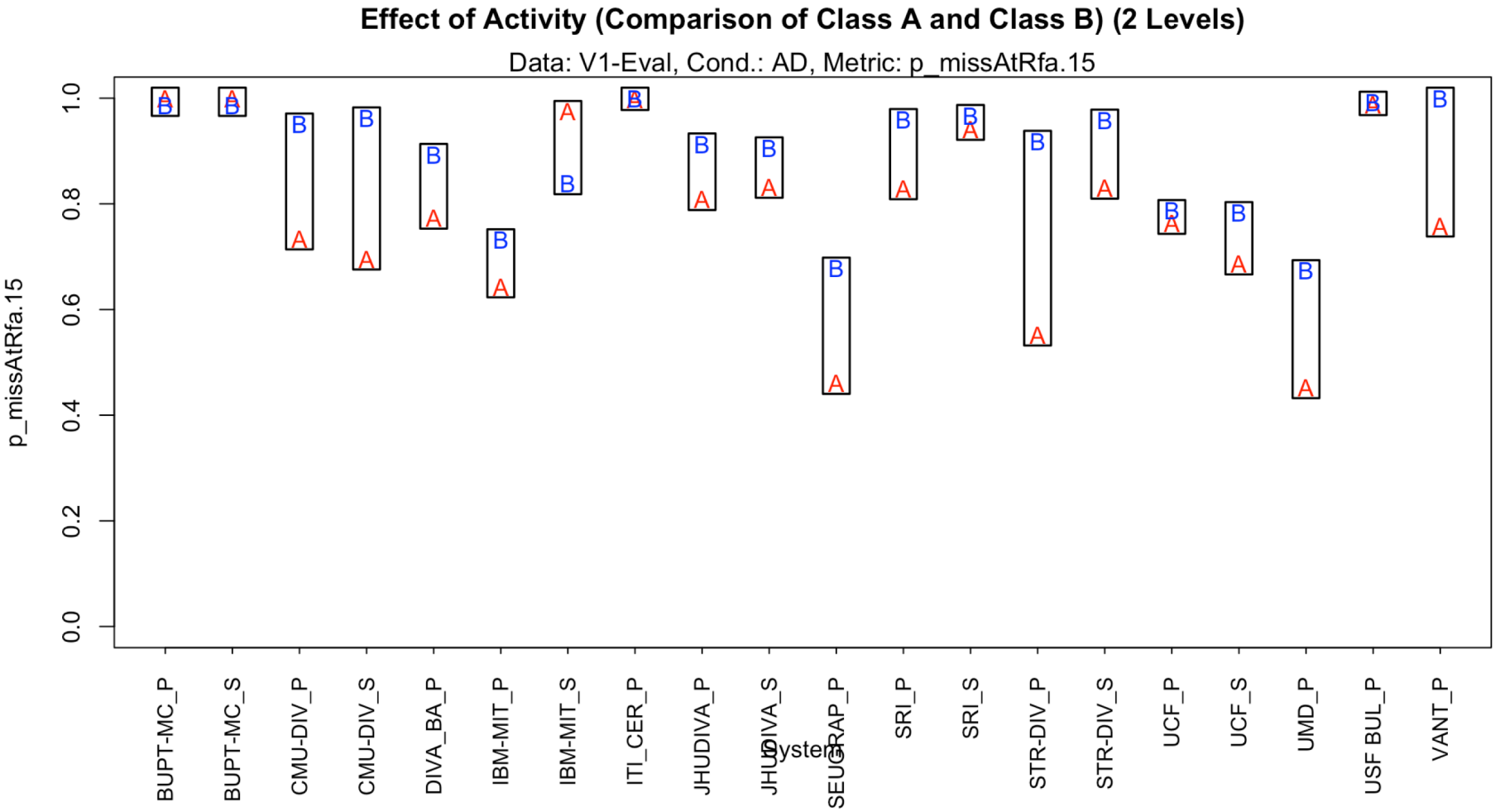
- X-axis: systems ordered by name
- Y-axis:12 activities and average activity ranking (AVG)
- Numbers in the matrix: the ranking of 12 activities per system

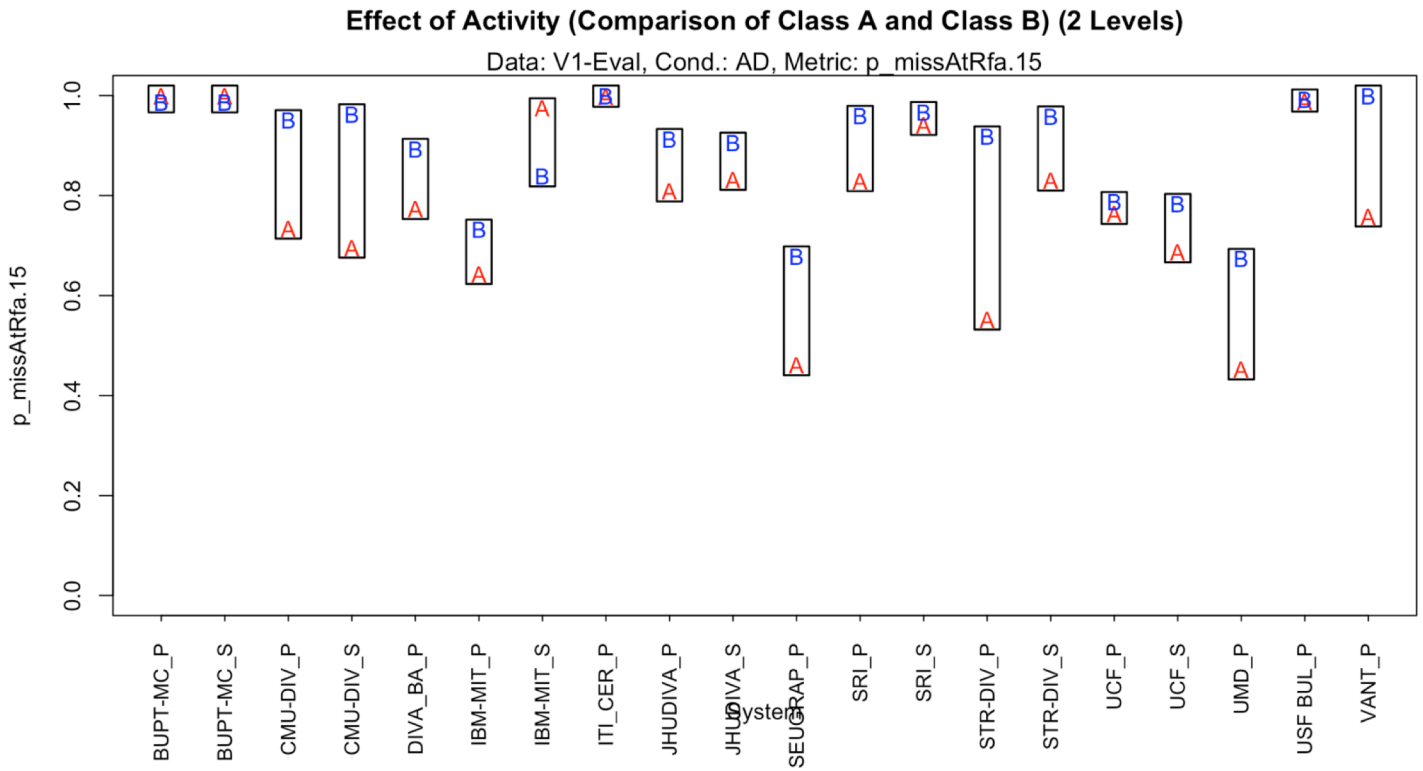
The activity class was characterized by systems and baseline performance

Observation: the vehicle-turn related activities are easier to detect compared to the rest of the other activities

How does the activity class behave per system?

Class A: Vehicle-turn related activities, **Class B**: the rest of the other activities





Observation

1. How does the activity class behave per system?

- In general, the class A activities are easier to detect

2. Robustness?

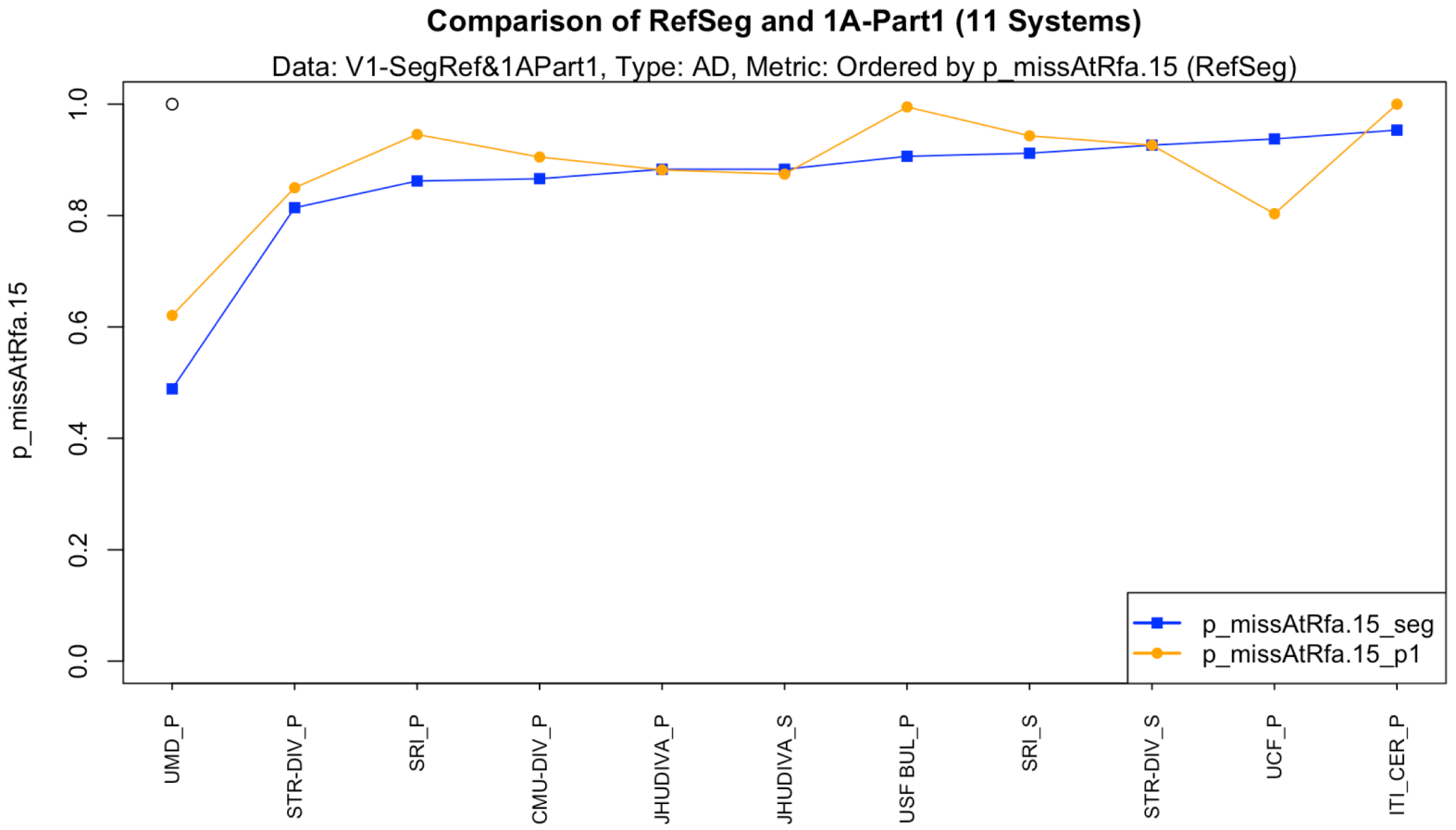
- The conclusion is consistent across systems with a few exception (e.g., IBM_MIT_Purdue)

3. Effect comparison?

- STR and CMU have larger effect on the activity class

Comparison of RefSeg and EvalPart1 (AD)

RefSeg: the systems were scored on the reference temporal segment test set
EvalPart1: the systems submitted for the activity-level evaluation were scored on the same test set

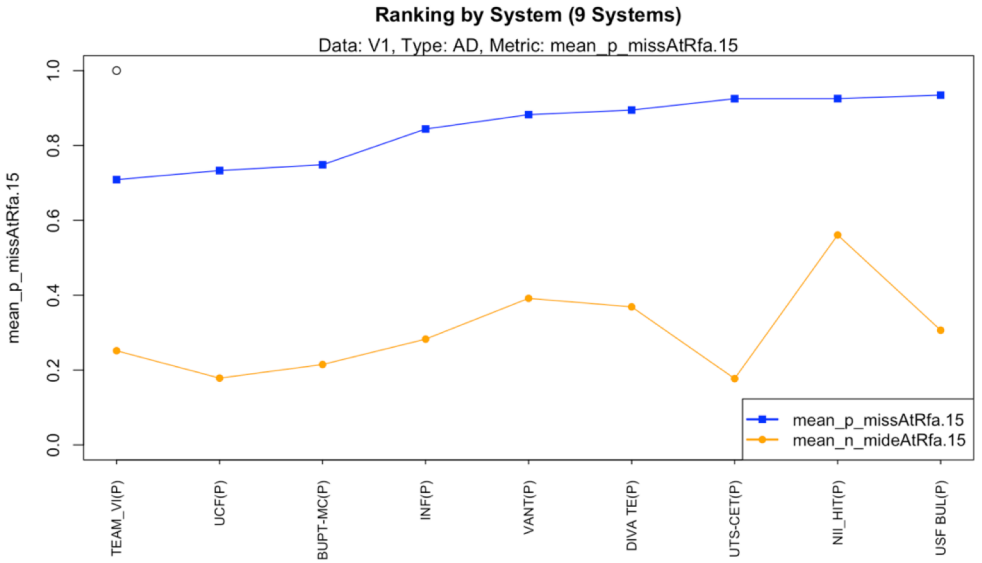


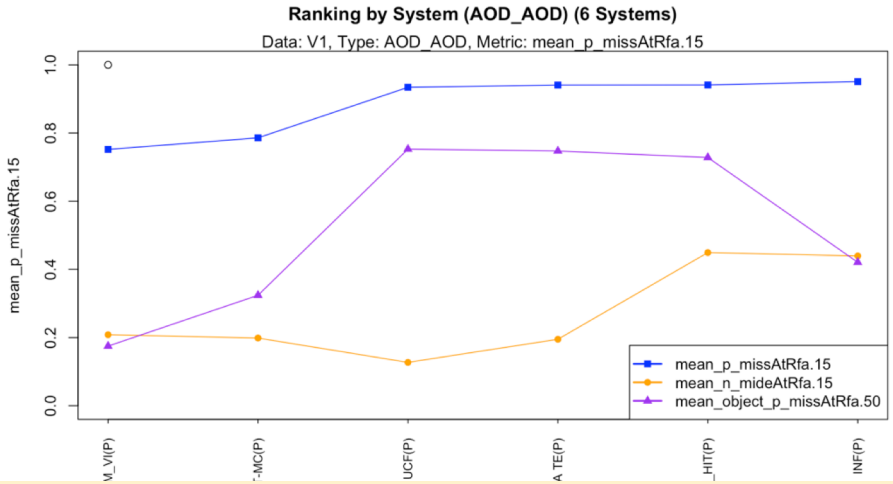
Observation: with a few exceptions, system performance with reference segment info is better than system performance without

Leaderboard (as of 11/08/18)

Teams	AD	
	PR.15	NR.15
Team_Vision	0.709	0.252
UCF	0.733	0.179
BUPT-MCPRL	0.749	0.215
INF	0.844	0.283
VANT	0.882	0.392
DIVA Baseline	0.895	0.369
UTS-CETC	0.925	0.177
NII_Hitachi_UIT	0.925	0.561
USF Bulls	0.934	0.306

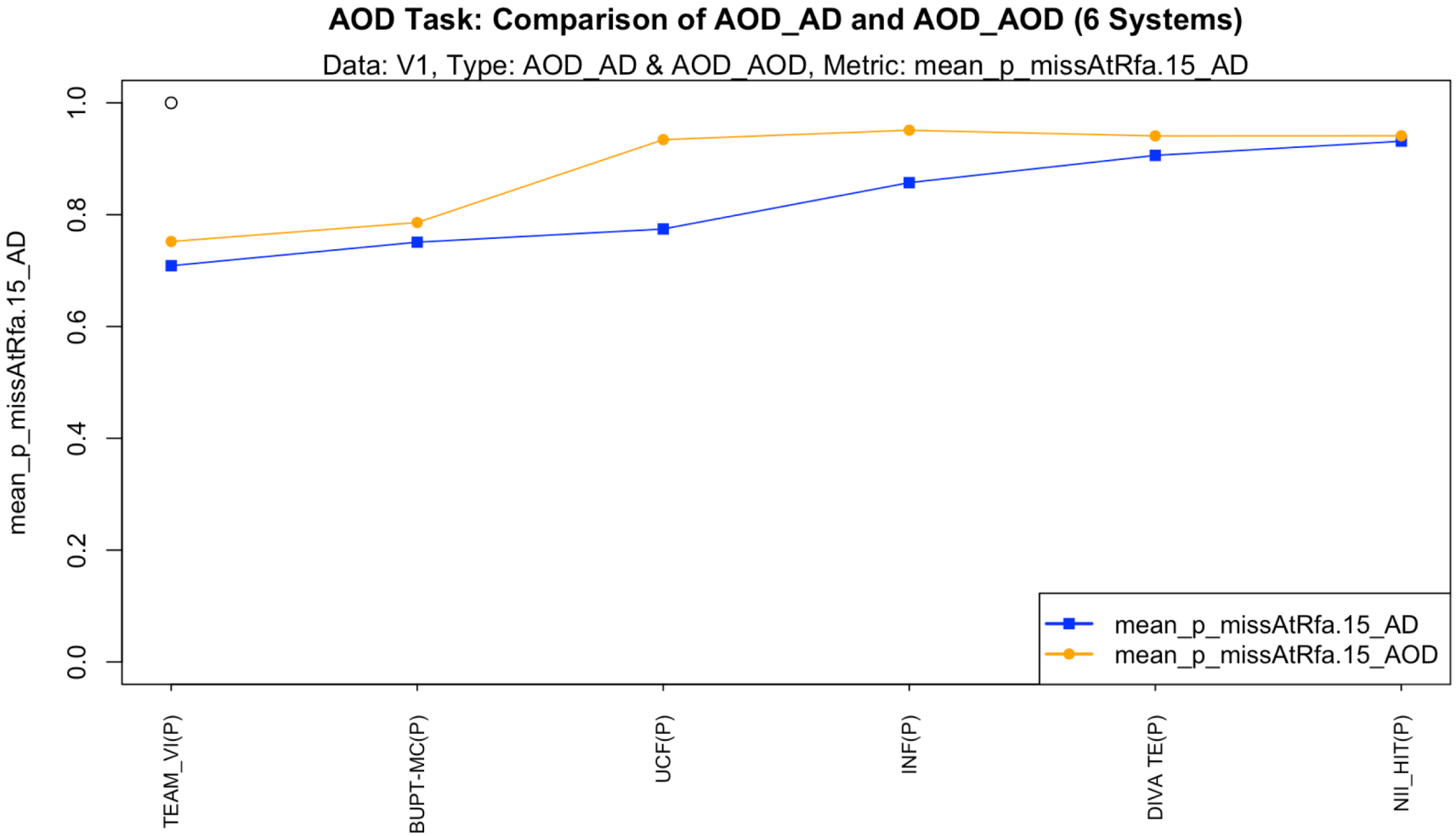
Teams	AOD		
	AOD_AD	AOD_AOD	
	PR.15	PR.15	OPR.5
Team_Vision	0.709	0.752	0.175
BUPT-MCPRL	0.751	0.786	0.324
UCF	0.774	0.934	0.753
DIVA Baseline	0.906	0.941	0.747
NII_Hitachi_UIT	0.931	0.941	0.728
INF	0.857	0.951	0.421





Observation: Team-Vision (IBM-MIT-Purdue) team achieved the highest performance on AD and AOD

How does activity detection behave when object detection was taken into account?



Observation: when the object detection was taken into account, the AOD_AOD performance under-performs compared to AOD_AD

Next Steps

Next Steps

- ActEV18 next phase evaluation incudes AODT (on VIRAT V1/V2 dataset)—ongoing
- 50K ActEV-PC (IARPA Activity in Extended Videos Prize Challenge)--ongoing https://actev.nist.gov/prizechallenge
- ActivityNet workshop under CVPR19
- New datasets (M1/M2) are coming soon

Questions?

https://actev.nist.gov/

Contact: actev-nist@nist.gov