Benchmarking Human Activity Recognition

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Introduction & Motivation

- Need datasets to benchmark different aspects of algorithms
- Need a common ground for researchers to evaluate/compare the performances of their approaches
- Need datasets that are good representatives of the problem being solved (solving the dataset vs. solving the problem)
- Focus and introduce the state of the art benchmarking video datasets for activity recognition

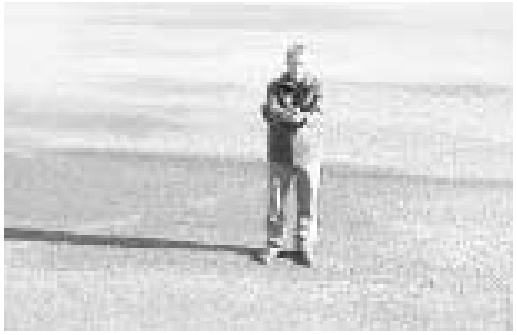
Outline

- Benchmark for Kinematic Activities
- Movie/Web Videos Benchmarks
- Benchmarks for Assisted Daily Life (ADL) Activities
- Video Surveillance Benchmarks
- Benchmarks for Group Activities
- Multi-Camera Benchmarks
- RGB-D Benchmarks
- Egocentric Benchmarks

Benchmarks for Kinematics Activities

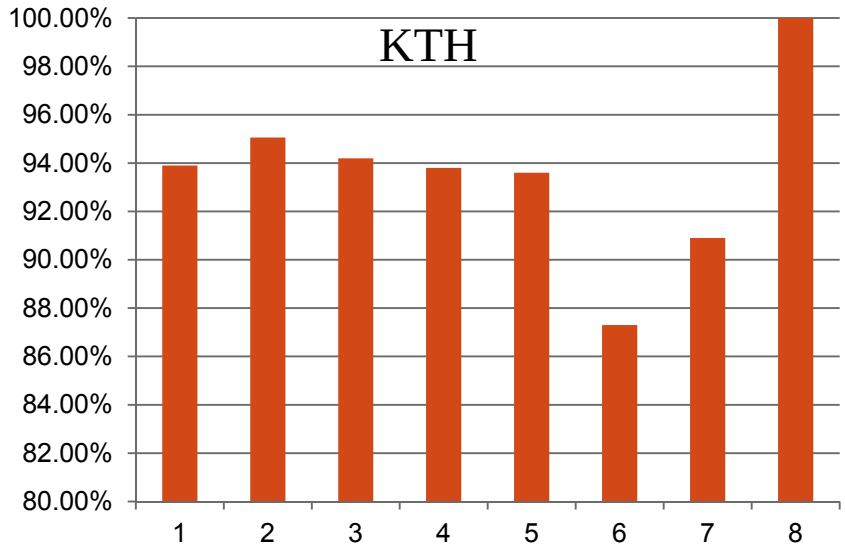
KTH* and Weizmann+

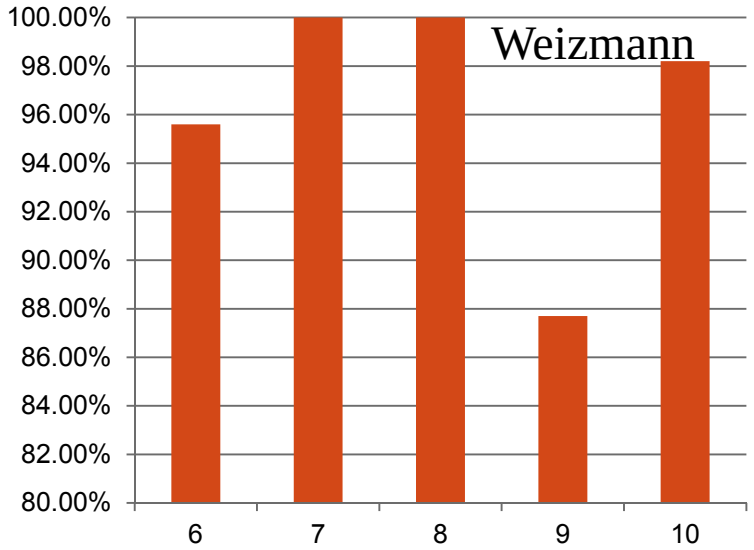
- Low resolution (<200x200)
- Few background clutters
- Mostly frontal and side-on camera viewing angles
- High accuracy reported by many papers already



KTH

Weizmann





*[SchuldtICPR2004Recognizing],+[GorelickICCV2005Action],[1][LeCVPR01Learning],[2][SubhabrataCVPR2011Probabilistic],[3][WangCVPR2011Action],[4][WangCVPR2011ActionST],[5][LiCVPR2011Activity],[6][XieCvpr11Unified],[7][ChenCVPR11Modeling],[8][SunICCV2011Action],[9][HoaiCVPR2011Joint],[10[BrendelICCV2011Learning]

Movie/Web Benchmarks

- Multiple camera viewing angles
- Camera motions
- Video qualities/ resolutions and clutters vary
- Multiple moving objects

HMDB51 Dataset*

- Large set (51) of activity categories
- High intra-category variations
- Drastic appearance, scale, position changes of actors. Variations in camera motion and viewpoints

*[KuehneICCV2011HMDB]

HMDB51 sample frames

Reported accuracy: 38.00% in [SadanandCVPR2012Action]

Movie/Web Benchmarks

Other datasets and reported results

	Classes	Clips	Resolution	Accuracy
UCF Youtube[1]	11	3185	240*320	84.2%[9]
UCF 50[3]	50	>5000	240*320	76.4%[12]
UCF Sports[2]	9	182	480*720	95.0%[12]
Coffee/Cigarette[4]	2	264	240*500	57%[8]
Hollywood1[5]	8	400	240*500	56.8%[11]
Hollywood2[6]	12	1707	240*500	58.3%[9]
Olympics[7]	16	800	360*450	77.3%[10]
TRECVID MED[14]	15	32061	vary	38%~54% [14]

[1][LiuCVPR09Recognizing],[2][RodriguezCVPR2008Action],[3][UCF50],
[4][LaptevICCV07Retrieve],[5][LaptevCVPR2008Learning],[6][MarszalekCVPR2009Actions]
,[7][NieblesECCV2010Modeling],[8][GaidonCVPR2011Actom],[9][WangCVPR2011Action],[10]
[BrendelICCV2011Learning], [11][GilbertPAMI2010Action],[12][SadanandCVPR2012Action
], [13] [TangCVPR2012Learning], [14][TRECVID2011]

Benchmarks for Assisted Daily Living (ADL) Activities

ADL65 Dataset*

- Large set (65 categories) of high-resolution kitchen activities
- Fine-grained activities (low inter-class variability)
- Detailed annotations including time intervals and poses
- Provide classification & detection tasks
- Similar dataset: URADL+
  - high-res 10 kitchen activities.
  - reported accuracy: 96% in [WangCVPR2011ActionST]
- Scene and object info highly correlates with the activities

sample frames

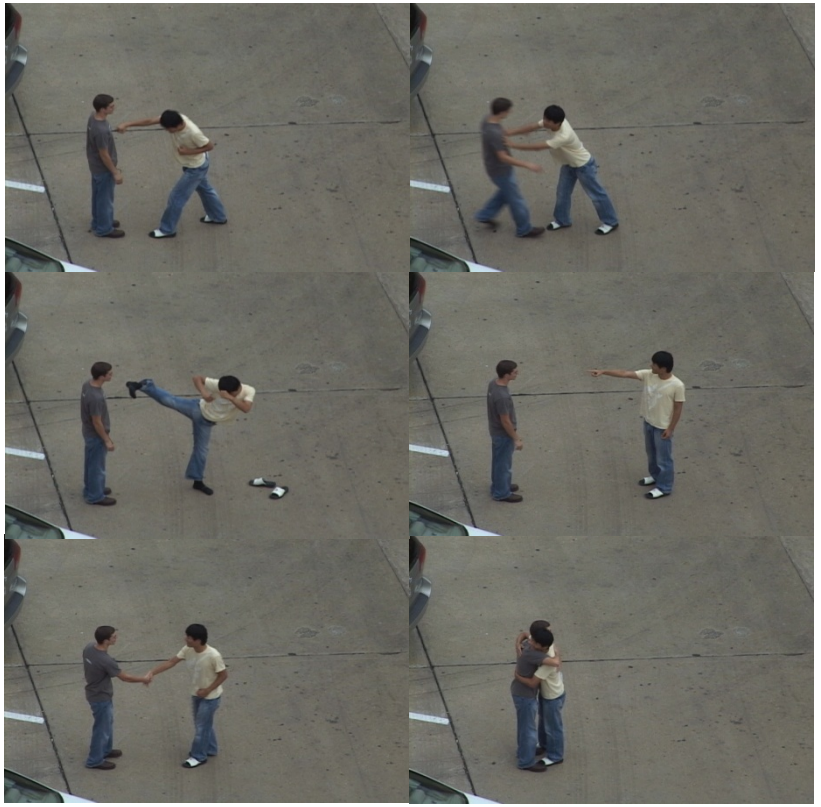
Reported average precision for
Classification: 59.2%
Detection: 45.0%
in [RohrbachCVPR2012Database]

*[RohrbachCVPR2012Database]
+[MessingICCV2009Activity]

Benchmarks for Group Activities

UT-Interaction*

- 6 classes of 2-person interaction activities
- Detailed annotation with time intervals/bounding boxes
- Camera jittering
- Pedestrians in the background
- Concurrent activities
- Similar datasets: Collective Dataset[1], BEHAVE[2]



UT-Interaction sample frames

	Accuracy
AmerICCV2011Chain	75.75%
BrendelICCV2011Learning	78%
RyooICCV2011Early	85%
GaurICCV2011SFG	72%

*[RyooICPR2010Overview]
[1][ChoiICCV2009Collective]
[2][BlunsdenBMVA2010Behave]

Benchmarks for Long Term Surveillance

Virat Ground Video Dataset*

- Realistic scenarios (non-actors)
- Multi spatial-temporal resolutions
- Diverse scenes (16 scenes) and event types (23)
- Multiple objects and concurrent activities
- Different camera perspectives
- Detailed annotations including time intervals, bounding boxes, and tracks
- People/facility, people/vehicle interaction

sample frames

sample annotations

* [OhCVPR2011Virat]

Benchmarks for Long Term Surveillance

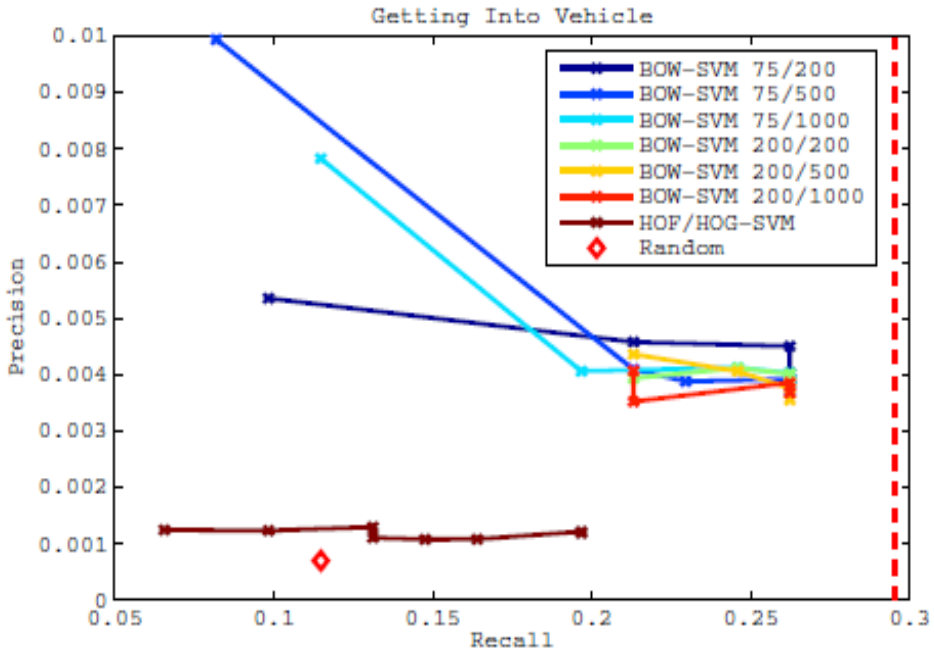
Virat Aerial Video Dataset

- Camera motion
- Low resolution of human figures
- Similarity across actions from high altitude
- Time-varying viewpoints and scales
- Shadows and interrupted tracking



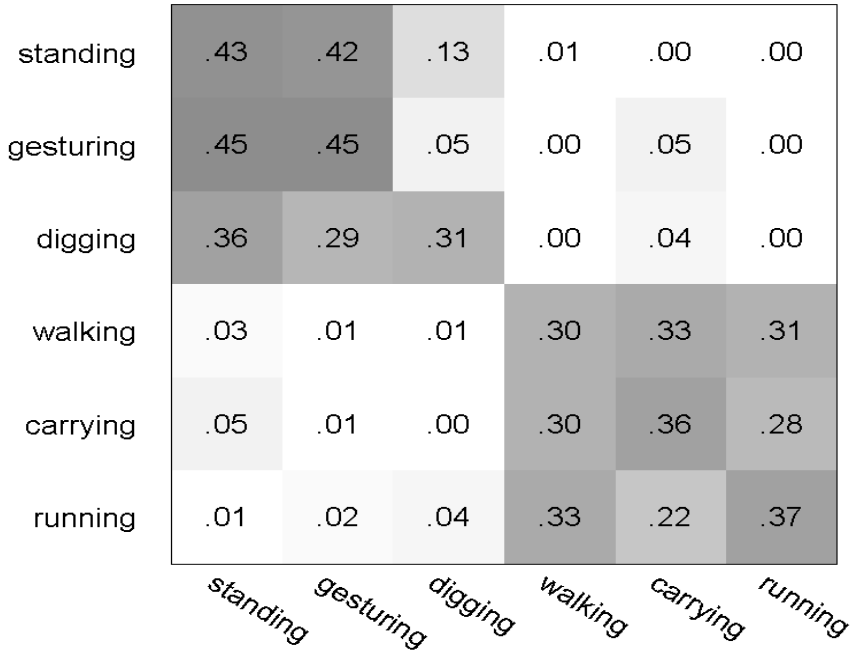
sample frames for different scenes and viewpoints

Benchmarks for Long Term Surveillance Evaluations

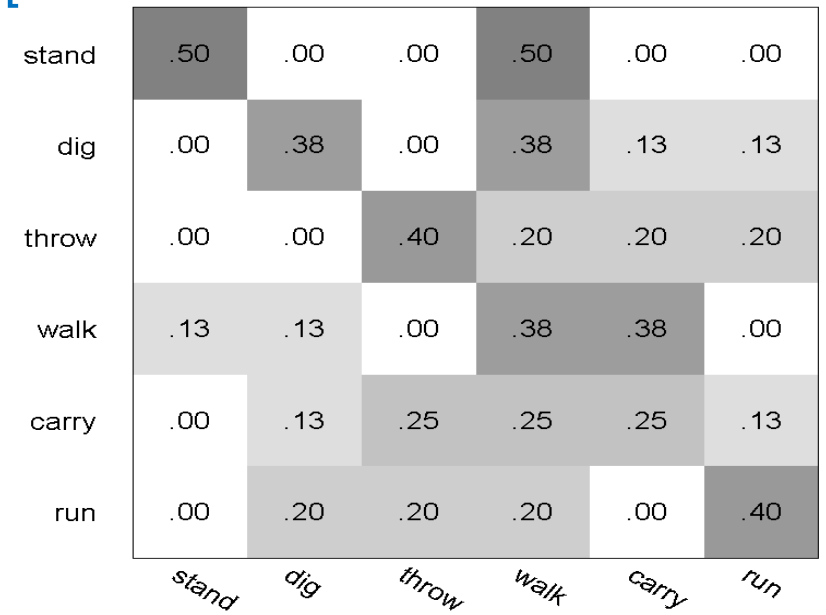


[OhCVPR2011Virat]

Average hit rate on ground dataset:
33% in [OhCVPR2011Virat]
Average accuracy on aerial dataset:
38% in [ChenCVPR11Modeling]



[SubhabrataCVPR2011Probabilistic]



[ChenCVPR11Modeling]

Benchmarks for Long Term Surveillance

TRECVID 2011 Surveillance Event Detection (SED) Dataset

- ~100 hours indoor airport surveillance videos
- 7 events including 2 single person events, 2 person-object interaction events and 3 multi-person events
- Different background clutters and traffic due to different camera placements
- Best Normalized Detection Cost Rate (NDCR): 0.8~2

$$NDCR = P_{miss} + \frac{Rate_{FA}}{Rate_{event}}$$

Perfect NDCR: 0




camera placements: controlled access door, waiting area, debarkation area, elevator door, transit area

Multi-Camera Benchmarks

IXMAS Dataset*

- Provide 5-view videos of 13 kinematic activities
- Provide silhouette, reconstructed volumes, and calibration information
- 3D information is available
- Suitable to evaluate view dependent models

Wave

Pick up

sample frames

*[WeinlandICCV07Action]

Multi-Camera Benchmarks

IXMAS Dataset - Evaluations

- Accuracy by using multi-cameras*

1,2,3,4,5	1,2,3,4	1,2,3,5	1,2,3	1,3,5	1,3	2,4	3,5
88.20%	88.20%	89.40%	87.70%	88.40%	86.60%	82.40%	83.30%

Recognition using multi-view information (5~15% improvements over single view)

- View transfer evaluations+

Evaluating cross-view model effectiveness

%	1	2	3	4	5
1		81.8	88.1	87.5	81.4
2	87.5		82	92.3	74.2
3	85.3	82.6		82.6	76.5
4	82.1	81.5	80.2		70
5	78.8	73.8	77.7	78.7	

+[LiCVPR2012Discriminative]

*[WuCVPR2011Action]

RGB-D Benchmarks

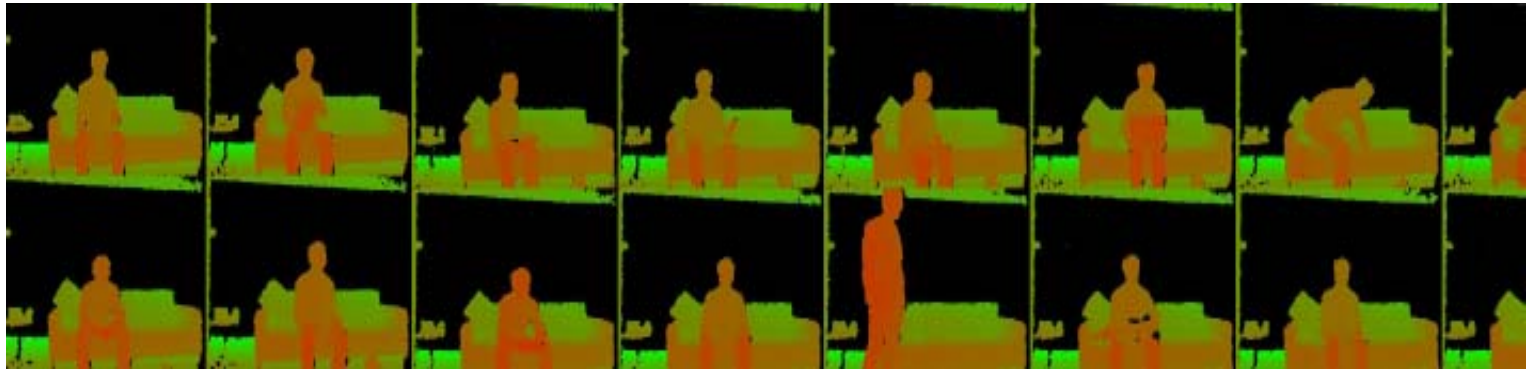
MSRAction3D and DailyActivity3D*

- Both recorded with commercially available depth sensor
- MSRAction3D consists of 20 kinematic activities
- DailyActiviy3D consists of 16 living room activities involving different objects e.g. writing on a paper, answering phone

Accuracy: 88.2% *

MSRAction3D sample frames

Accuracy: 85.7%*



DailyActivity3D sample frames

*[WangCVPR2012Mining]

Egocentric Benchmarks

Egocentric ADL Datasets[1]

- Complex object interactions (42 objects)
- Large set of actions (18 actions), and sites (20 homes)
- Longer activities
- Large variations of object appearance
- Scene/Clutter variations
- Similar datasets: GTEA[2] (GeorgiaTech Egocentric) and Intel Egocentric Dataset[3]
- Strong priors for hand locations

appearance variations

scene variations

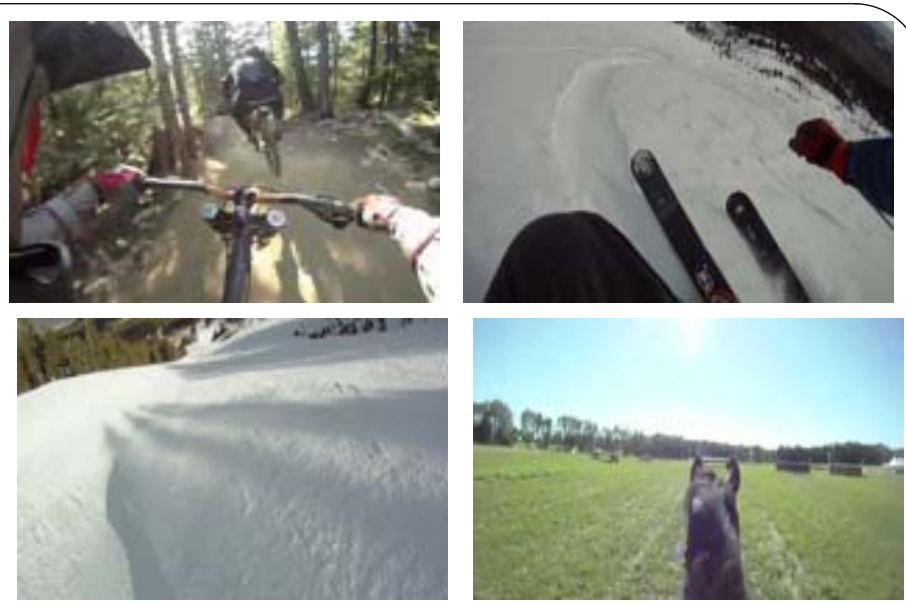
Reported classification accuracy: 40.6% in [PirsiavashCVPR2012 Detecting]

[1][PirsiavashCVPR2012Detecting]
[2][FathiICCV2011Understanding]
[3][RenEgo2009Ego]

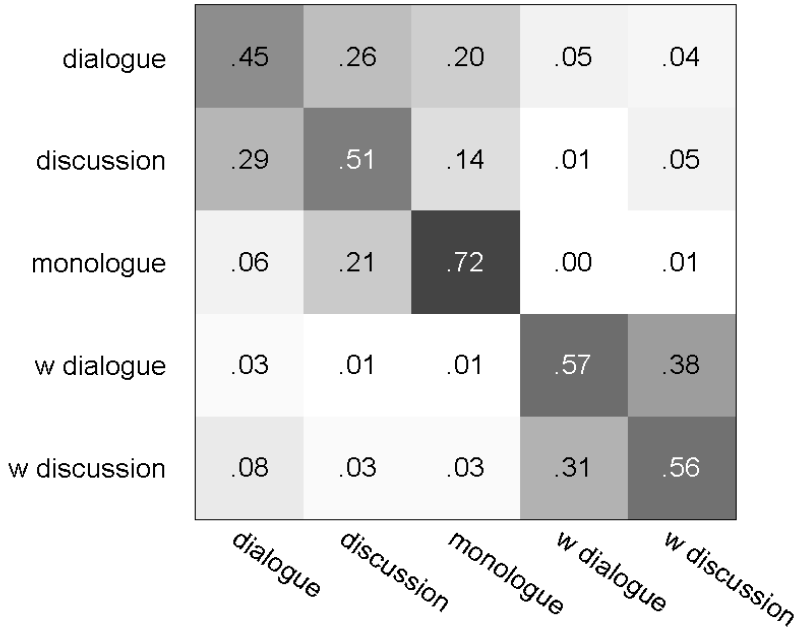
Egocentric Benchmarks

Other Egocentric Datasets

- UEC Sports[1]
  - Large set of outdoor activities
  - Large motion and blur
- GeorgiaTech[2] –
  - Egocentric social activity recognition
- Other datasets: Egocentric novelty detection[3], and egocentric video summary[4]



UEC Dataset



FPSI Result in [FathiCVPR2012Social]

[1][KitaniCVPR2011Fast],
[2][FathiCVPR2012Social],
[3][AghazadehCVPR2011Novelty],
[4][LeeCVPR2012Discovering]

Summary Table

	classes	res.	seqs	frames	url	annotation
KTH	6	160*120	600	~500k	http://www.nada.kth.se/cvap/actions/	N.A
Weizmann	10	180*144	90	~8k	http://www.wisdom.weizmann.ac.il/~vision/SpaceTimeActions.html	extracted foreground mask
HMDB51	51	~240*480	7000	~800K	http://serre-lab.clps.brown.edu/resources/HMDB/	meta info regarding video quality, angle, and camera motion
UCF Youtube	11	240*320	1168	~80K	http://www.cs.ucf.edu/vision/public_html/data.html#UCF%20YouTube%20Action%20Dataset	N.A
UCF Sports	9	480*720	182	~6K	http://www.cs.ucf.edu/vision/public_html/data.html#UCF%20Sports%20Action%20Dataset	N.A
UCF 50	50	240*320	>500	>150K	http://www.cs.ucf.edu/vision/public_html/data.html#UCF50	N.A
Coffee/Cigarette	2	240*500	1	36K	http://www.di.ens.fr/~laptev/download.html	Space-time cuboid, key frame and head position
Hollywood1	8	240*500	~600	~400K	http://www.di.ens.fr/~laptev/download.html	Time interval
Hollywood2	12	240*500	~600	~600K	http://www.di.ens.fr/~laptev/download.html	Time interval

Summary Table

	classes	res.	seqs	frames	url	annotation
MED11	10	N.A	10K	35M	http://www-nlpir.nist.gov/projects/tv2011	event intervals
ADL65	65	1624x1224	44	~881K	N.A	time-interval and body pose
URADL	10	1280x720	50	~75K	http://www.cs.rochester.edu/~rmessing/uradl/	N.A
Ut-interaction	6	480*720	20	~36K	http://cvrc.ece.utexas.edu/SDHA2010/Human Interaction.html	time-interval and bounding boxes of subjects
Collective	5	480*720	44	~13K	http://www.eecs.umich.edu/vision/activity-dataset.html	locations of the subjects, bounding box, and pose info
BEHAVE	10	480*640	4	~300K	http://groups.inf.ed.ac.uk/vision/BEHAVEDATA/INTERACTIONS/	Interval, group id, bounding box
IXMAS	13	390x291	36	~40K*	http://4drepository.inrialpes.fr/	silhouettes, reconstructed volume
VIRAT	23	1920 x 1080	N.A	~1620K	http://www.viratdata.org/	object tracks, subject bounding boxes, event interval
SED11	7	720x576	N.A	~9M	http://www-nlpir.nist.gov/projects/tv2011	event intervals, bounding boxes

Summary Table

	classes	res.	seqs	frames	url	annotation
MSRAction3D	20	320*240	320	9.6K	http://research.microsoft.com/en-us/um/people/zliu/actionrecorsrc/default.htm	joints
DailyAvtivity 3D	16	320*240	567	~15K	http://research.microsoft.com/en-us/um/people/zliu/actionrecorsrc/default.htm	joints
EgoADL	18	N.A	N.A	1M	N.A	object bounding box, tracks and labels, hand positions

Conclusions and Challenges

- We covered most of the major benchmarking datasets – good starting points for people new to the field
- Creating a benchmark that captures the level of complexity of real world problems is still hard
- Few reported cross dataset performance or model generality evaluation
- The trend is to create large scale benchmarking datasets with detailed annotations - need better tools (e.g. LabelMe Video) or technology (e.g. Machine-aided Mechanical Turk) for good quality and large annotation tasks

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