Raytheon
BBN Technologies

Video Indexing and Search with Event Recounting (VISER)

TRECVID 2013

Presented by

Shuang Wu

Scientist, Raytheon BBN Technologies

BBN VISER at TRECVID 2013

- Participated in both MED and MER tasks
- Made submissions for all event/training/system conditions
- Continue to build and improve upon core system work from previous years in TRECVID
  - Multi-modal feature extraction
  - Max-margin classification and multi-stage fusion
- One major area of focus in 2013: **semantics**

Semantics for MED and MER

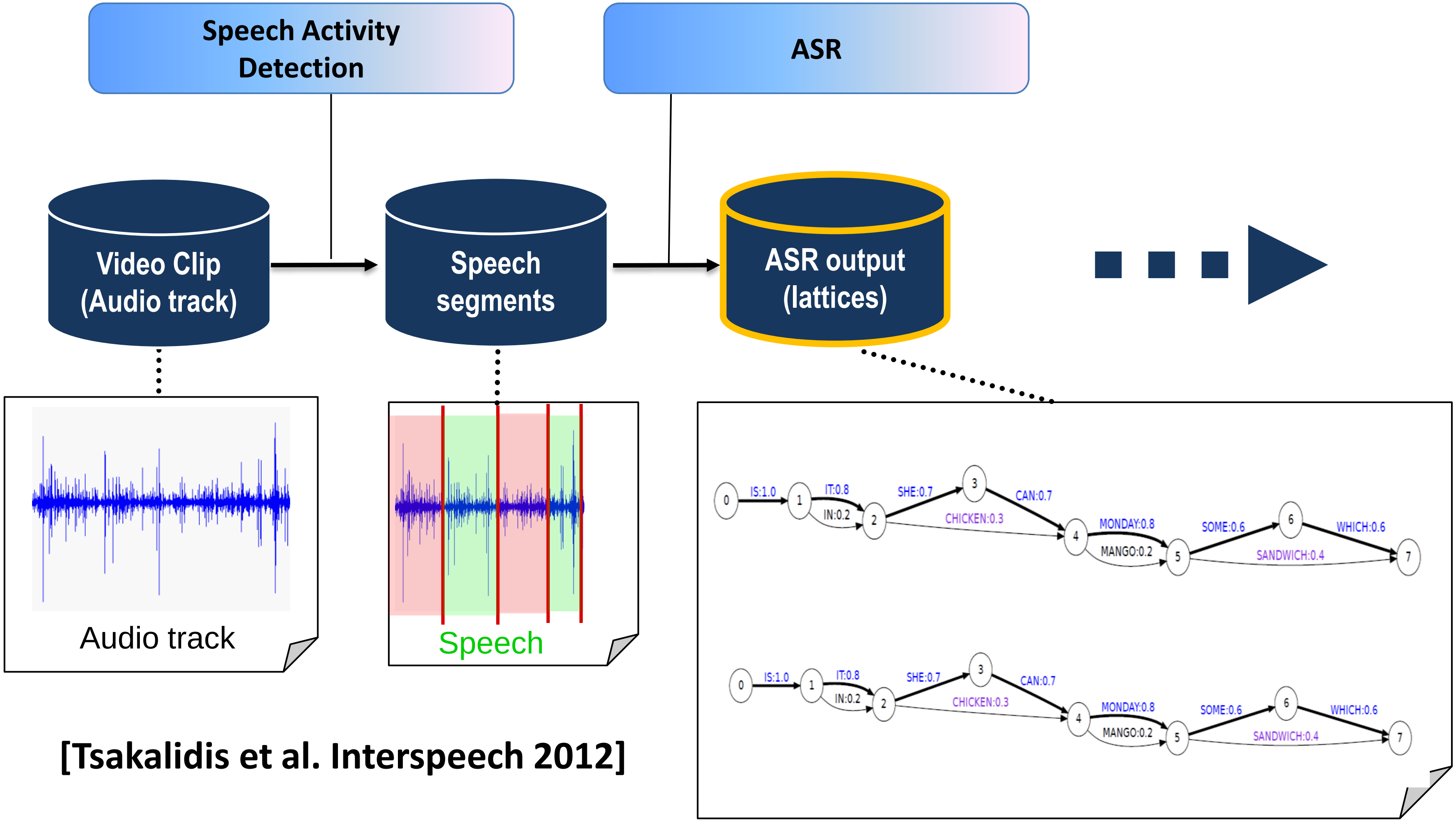
- Increasing necessity in TRECVID for semantic understanding of video
  - **MER**: semantic explanation of event detection
  - **MED 0Ex**: video event detection from text query only
- **Key building block for both problems**: reliable semantic extraction from video

Overview

- **Language extraction**:
  - Speech and video text
- **Audio-visual concepts**:
  - Off-the-shelf detectors
  - In-domain detectors
- **Experiments**:
  - 0Ex MED
  - Semantics in 10Ex/100Ex MED
- **TRECVID 13 results:**
  - MED
  - MER

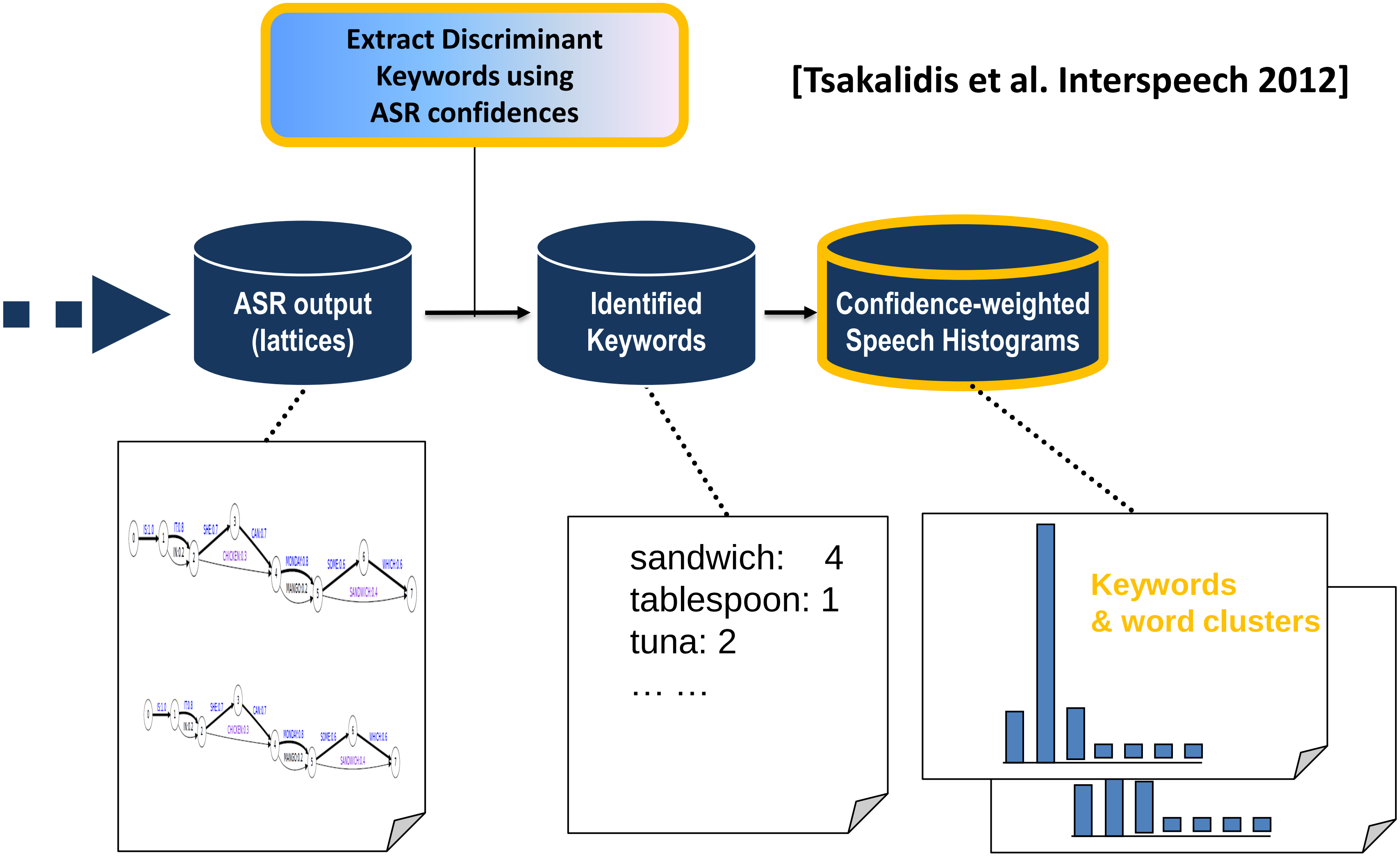
Language Extraction

Speech



[Tsakalidis et al. Interspeech 2012]

Speech (cont'd)



Extract Discriminant Keywords using ASR confidences

[Tsakalidis et al. Interspeech 2012]

ASR output (lattices)

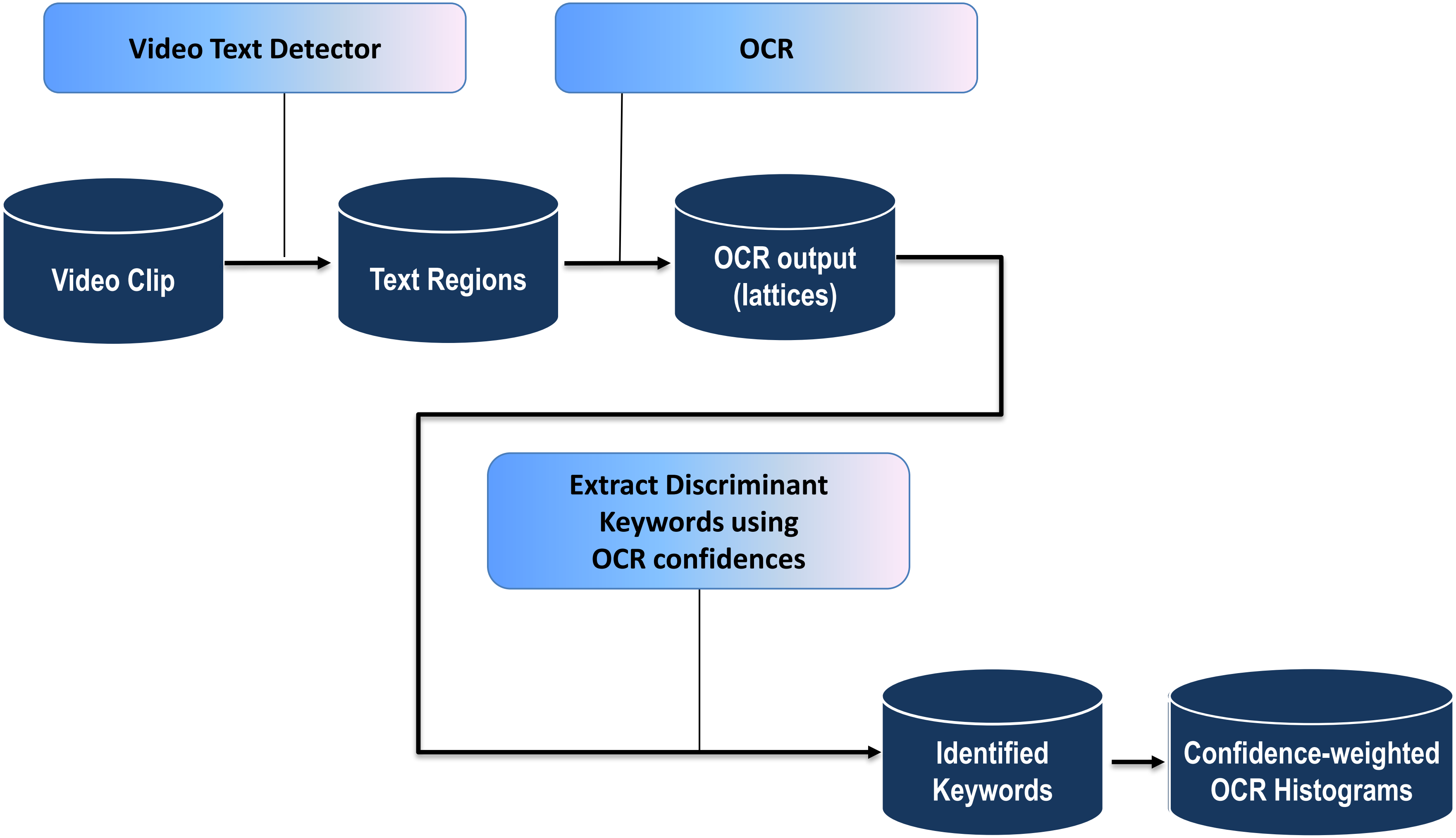
Identified Keywords

Confidence-weighted Speech Histograms

sandwich: 4
tablespoon: 1
tuna: 2
… …

Keywords & word clusters

Video Text


Video Text Detector
OCR
Video Clip
Text Regions
OCR output (lattices)
Extract Discriminant Keywords using OCR confidences
Identified Keywords
Confidence-weighted OCR Histograms

Language Content Frequency

- Keyword detections are usually precise
- Only a third of the data has relevant speech, and even less has video text
- Relevant speech and text content in web video is too sparse…

Audio-visual Concepts

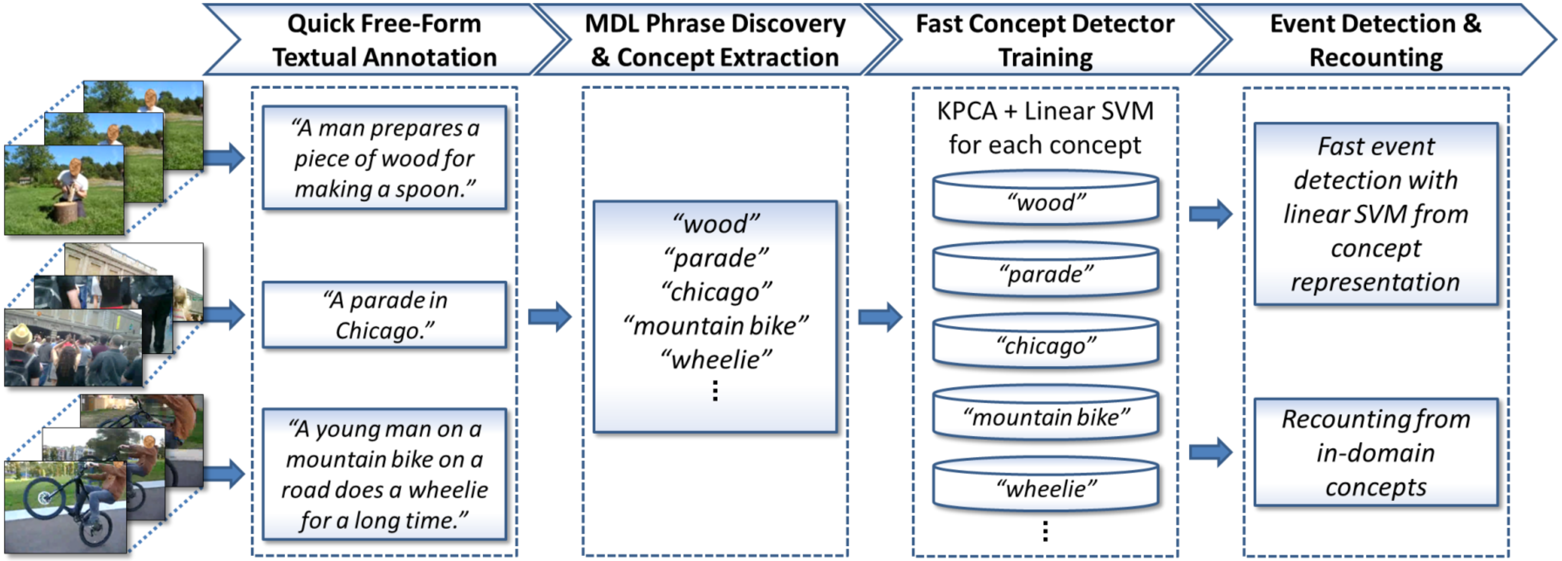
Off-the-shelf Concept Detectors

- Evaluated several off-the-shelf concept detector collections
  - Classemes [Torresani *et al.*, ECCV ‘10]
  - ObjectBank [Li *et al.*, NIPS ‘10]
  - Sun Scene [Patterson *et al.*, CVPR ‘12]
- Domain mismatch
  - Image vs. video; professional vs. user-contributed quality
  - Pre-defined concept ontology vs. MED/MER concepts
- Could address issues with adaptation, but…

In-domain Concept Discovery

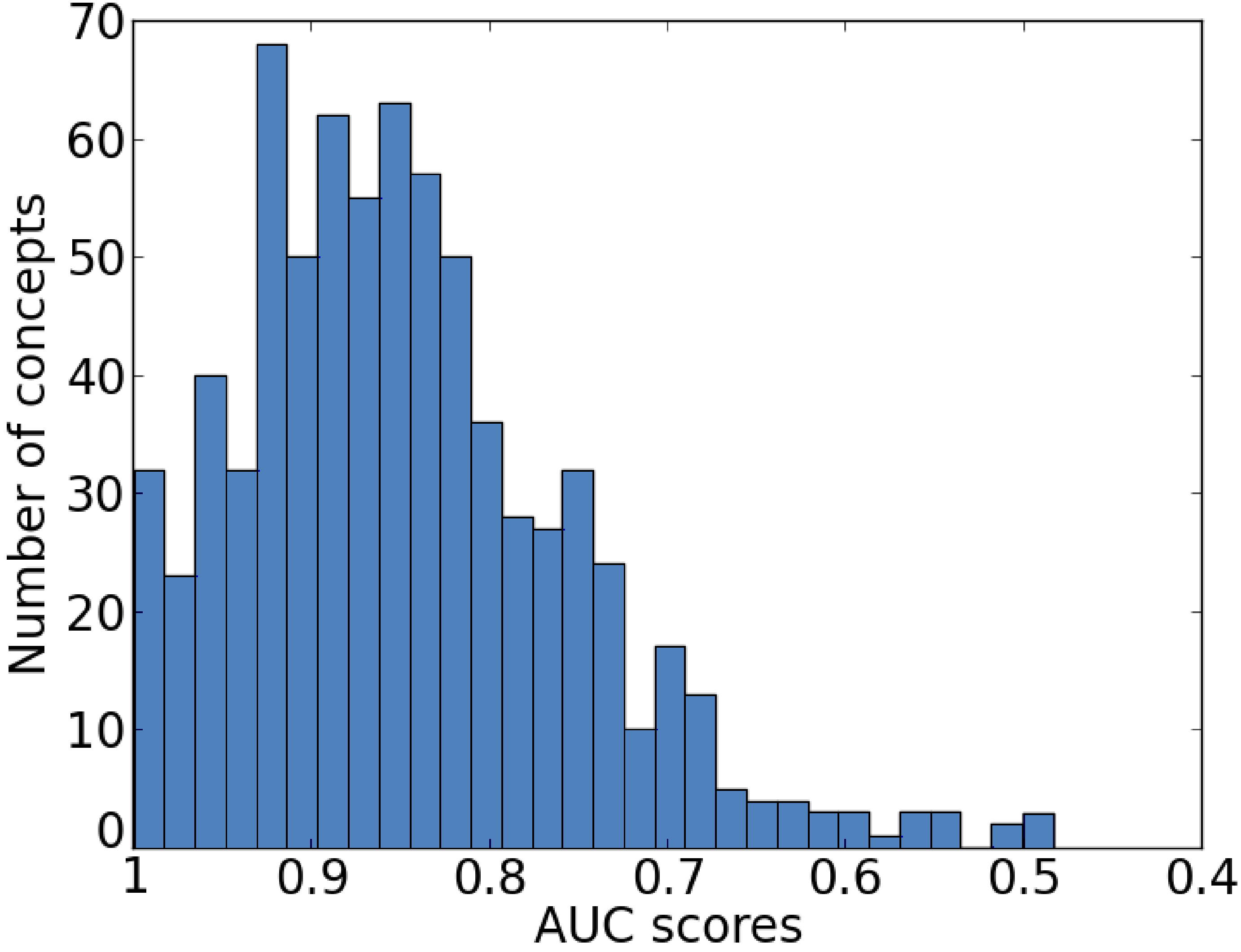
- Start with in-domain data: **MED research collection**
- Minimized domain mismatch but no concept annotation
- Available short text summaries in judgement files
- Discover concept labels from natural language snippets
  - Efficient to collect: **28x faster** than annotating fixed concept ontology
  - No predefined constraints on concept vocabulary

Weakly Supervised Concepts (WSC)


Quick Free-Form Textual Annotation
MDL Phrase Discovery & Concept Extraction
Fast Concept Detector Training
Event Detection & Recounting
"A man prepares a piece of wood for making a spoon."
"A parade in Chicago."
"A young man on a mountain bike on a road does a wheelie for a long time."
"wood"
"parade"
"chicago"
"mountain bike"
"wheelie"
⋮
KPCA + Linear SVM for each concept
"wood"
"parade"
"chicago"
"mountain bike"
"wheelie"
⋮
Fast event detection with linear SVM from concept representation
Recounting from in-domain concepts

- Natural language pre-processing and phrase discovery
- Leverage existing MED infrastructure and extracted concept labels to train concept detectors
- Concept selection via cross-validation

Concept Performance Distribution



Examples of Top Concepts Detected

Event: birthday party (E006)
WSC recounting: piñata, people celebrate, gift, surprise party.
Classemes: chemical weapon, collection, display setting, backpacker

Event: changing a vehicle tire (E007)
WSC recounting: tire, change, replace, technique.
Classemes: chemical weapon, physical creation event, dangerous activity, movement translation process

Event: flash mob gathering (E008)
WSC recounting: dance flash mob, shopping, hong kong
Classemes: chemical weapon, collection display setting, small group, windsurfer

Event: getting a vehicle unstuck (E009)
WSC recounting: rocky, jeep, trail, car.
Classemes: collection display setting, anti-armor mine, mine, fighting hole

Event: grooming an animal (E010)
WSC recounting: dog, carve, bathe, pig.
Classemes: chemical weapon, collection display setting, single doer action, diplomat

WSC Concept Flexibility

- We can train WSC concepts using any of the existing features/modalities already present in the MED infrastructure
  - Can learn visual and audio features from the same discovered labels, as well as multi-modal detectors
- Initial exploration of web data download allowed in TRECVID 13:
  - Retrieved image data via Google Image Search and Youtube Search API (thumbnail only)
  - Train visual WSC features

Concept Distance (CD) Detectors

- SVM training is unreliable for concepts with few examples
  - e.g. 10Ex MED
- Alternative fast and simple concept detection approach
- Using discovered concepts *C*, V$_c$ videos for each concept *c* in *C*
- Compute Concept Distance (CD) model $\mathbf{y}_c$ (vector) by simple aggregation of feature vectors in V$_c$
- Concept detection score is computed as distance of test video to $\mathbf{y}_c$

Experiments

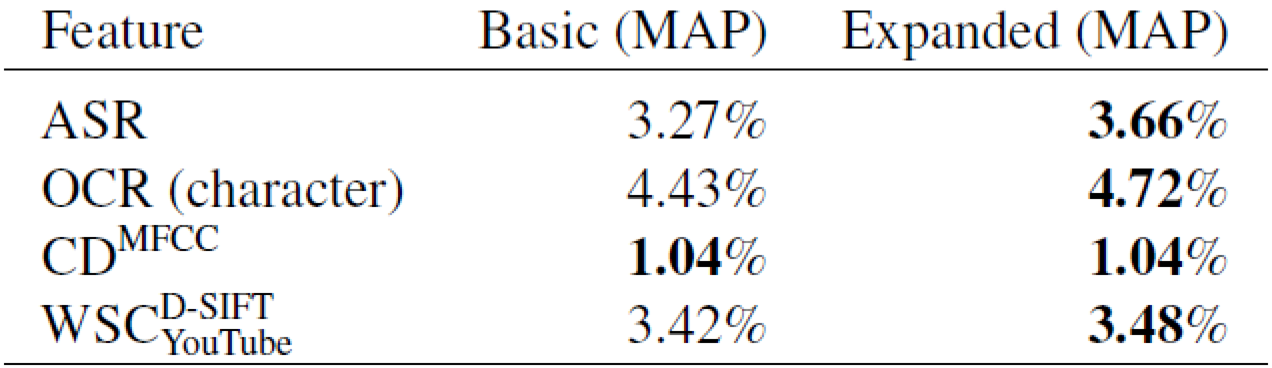
0Ex MED

- Convert test video to semantic concepts
  - Off-the-shelf detectors
  - WSC
  - CD
  - ASR/OCR keyword spotting
- Convert event-kit description (query) to concept list
- Improve query-video concept matching with text expansion
- Compute query-video similarity scores

Experimental Setup

- Tested on 20 events in MEDTest collection (~27k videos)
- WSC/CD learning on Research set (~10k videos)
- Use Event Kit descriptions (~250 words length) as queries

Text Expansion

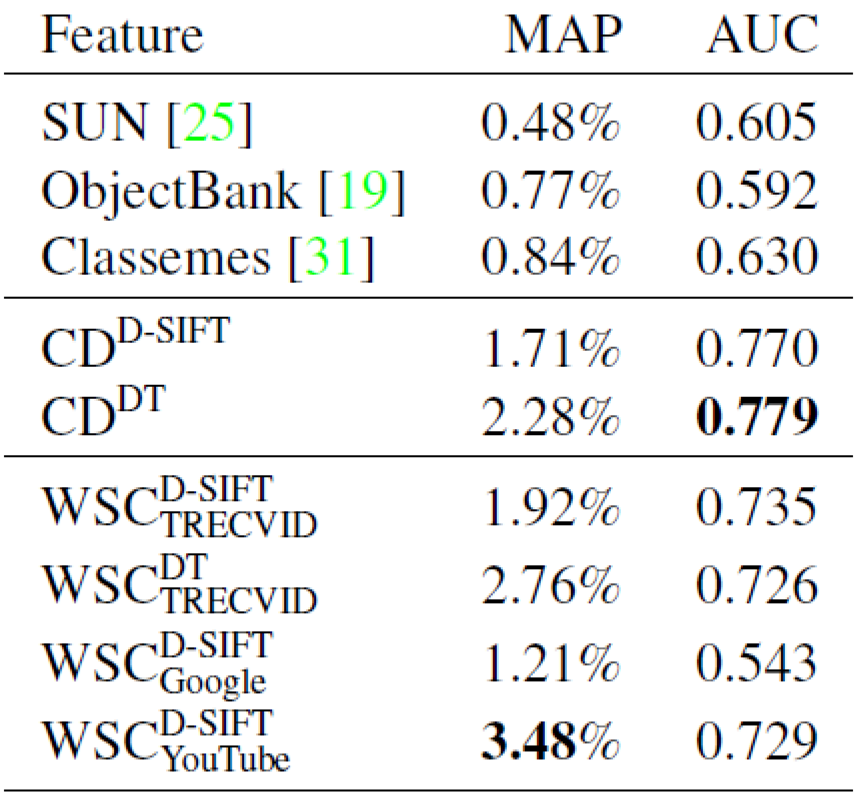


Feature	Basic (MAP)	Expanded (MAP)
ASR	3.27%	**3.66%**
OCR (character)	4.43%	**4.72%**
CD^{MFCC}	**1.04%**	**1.04%**
$\text{WSC}^{\text{D-SIFT}}_{\text{YouTube}}$	3.42%	**3.48%**

- Small but consistent gains with text expansion

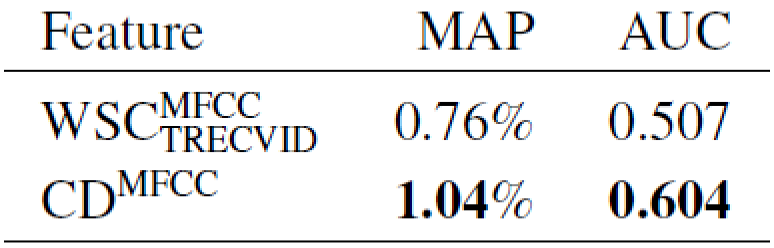
Visual Concepts

- Off-the-shelf detectors have poor performance
- CD features strong despite simplicity
- $\text{WSC}_{\text{YouTube}}$ has best performance



Feature	MAP	AUC
SUN [25]	0.48%	0.605
ObjectBank [19]	0.77%	0.592
Classemes [31]	0.84%	0.630
$\text{CD}^{\text{D-SIFT}}$	1.71%	0.770
CD^{DT}	2.28%	**0.779**
$\text{WSC}^{\text{D-SIFT}}_{\text{TRECVID}}$	1.92%	0.735
$\text{WSC}^{\text{DT}}_{\text{TRECVID}}$	2.76%	0.726
$\text{WSC}^{\text{D-SIFT}}_{\text{Google}}$	1.21%	0.543
$\text{WSC}^{\text{D-SIFT}}_{\text{YouTube}}$	**3.48%**	0.729

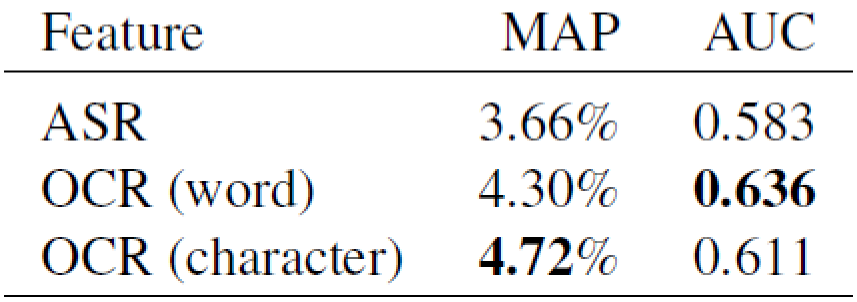
Audio Concepts



Feature	MAP	AUC
WSC$^{\text{MFCC}}_{\text{TRECVID}}$	0.76%	0.507
CD$^{\text{MFCC}}$	**1.04%**	**0.604**

- Suffers from sparse content and unrelated audio content

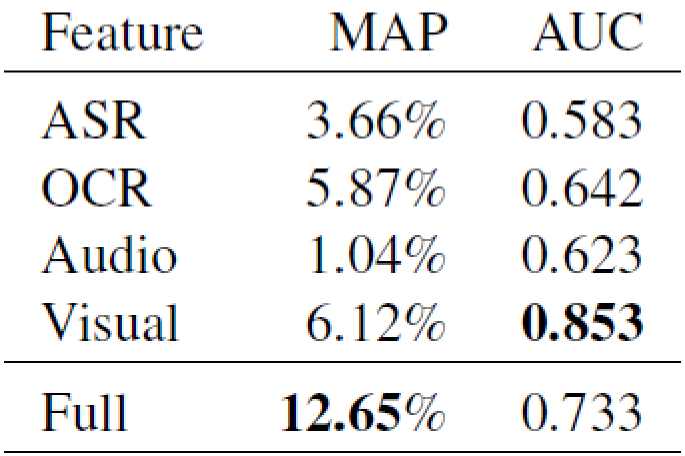
Language Keywords



Feature	MAP	AUC
ASR	3.66%	0.583
OCR (word)	4.30%	**0.636**
OCR (character)	**4.72%**	0.611

- All systems have higher MAP than audio-visual concepts
- Lower AUC: sparse language content

Fusion



Feature	MAP	AUC
ASR	3.66%	0.583
OCR	5.87%	0.642
Audio	1.04%	0.623
Visual	6.12%	**0.853**
Full	**12.65%**	0.733

- WSC/CD concepts are complementary
  - Off-the-shelf detectors discarded due to negative performance impact
- Fusion across modalities more than doubles individual performance

10Ex/100Ex MED

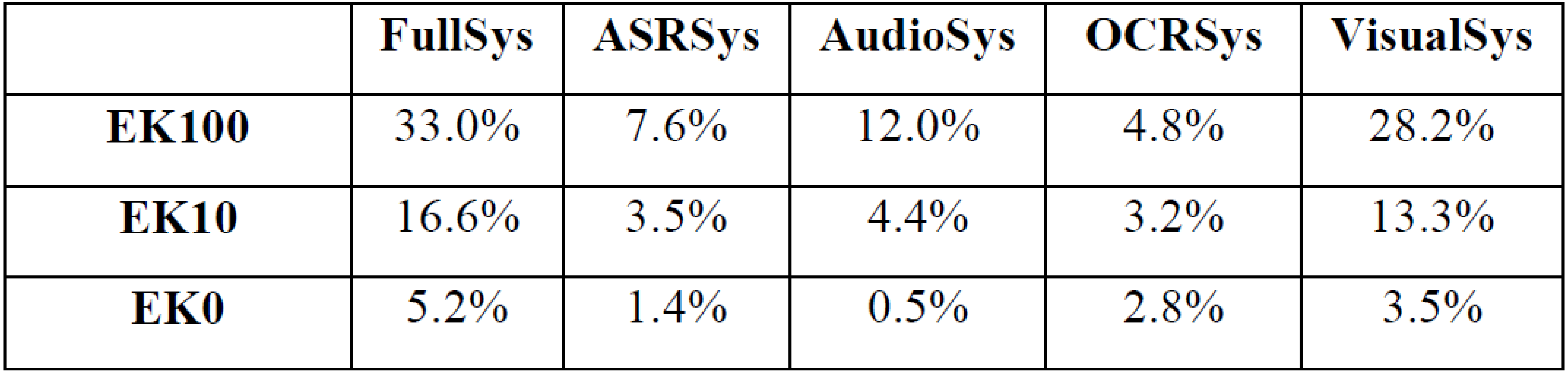
- Measure usefulness of visual semantic information on top of low-level visual information
- Treat concept scores as feature vector in standard 10Ex/100Ex MED framework
- Semantics particularly helpful in 10Ex

Training/Features	MAP	R0
10Ex/LLFeat	0.1459	0.1885
10Ex/LLFeat+WSC	**0.1785**	**0.2190**
100Ex/LLFeat	0.3810	0.4771
100Ex/LLFeat+WSC	**0.3852**	**0.4830**

TRECVID 13 Results

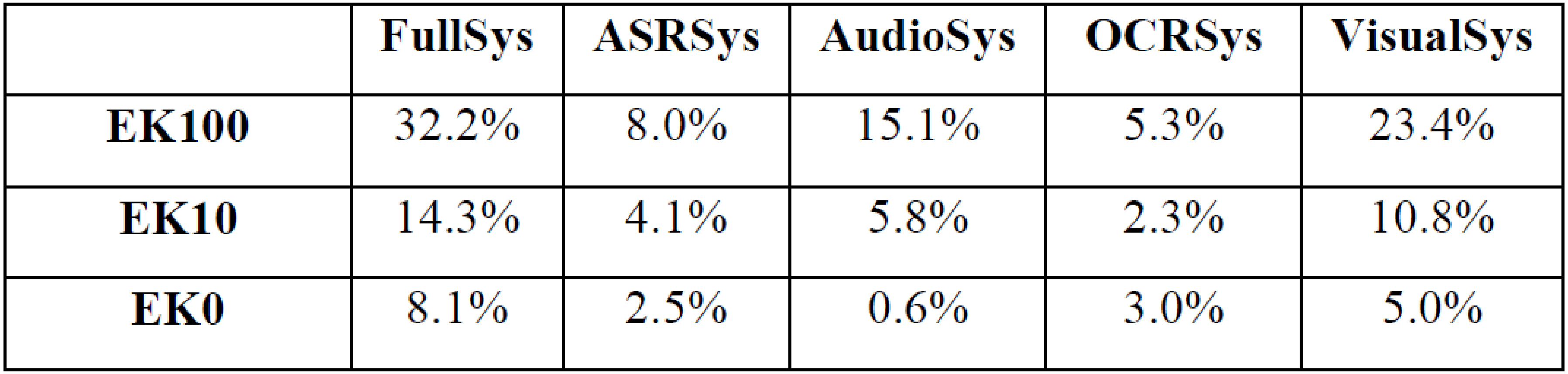
MED

Prespecified



	FullSys	ASRSys	AudioSys	OCRSys	VisualSys
EK100	33.0%	7.6%	12.0%	4.8%	28.2%
EK10	16.6%	3.5%	4.4%	3.2%	13.3%
EK0	5.2%	1.4%	0.5%	2.8%	3.5%

Ad Hoc



	FullSys	ASRSys	AudioSys	OCRSys	VisualSys
EK100	32.2%	8.0%	15.1%	5.3%	23.4%
EK10	14.3%	4.1%	5.8%	2.3%	10.8%
EK0	8.1%	2.5%	0.6%	3.0%	5.0%

MED

- Consistent prespecified and ad hoc performance
  - Our in-domain concepts are event-independent and generalize well to different event queries
- Strong overall performance in all system conditions

MER

- **Philosophy:** fine balance between presenting enough information, and keeping review times short enough
- Filter concept detections with low confidence or relevance to detected event
- Aggregate semantic information by modality, taking into account temporal overlap to merge evidences
- Generate short list of itemized evidences sorted by confidence and relevance

MER

- Overall accuracy: 64.96%
- Percent recounting review time: 50.59%
- Observation text precision: 1.78

Summary

- Reliable semantic extraction from video is key for many MED/MER tasks
- Leveraging in-domain data produces strong results even from simple methods
- Multi-modal combination of semantic information is especially important
- Semantics can contribute even to traditional 10Ex/100Ex MED

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