

Multimedia Event Detection Using Segment-Based Representation

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Multimedia Event Detection

Motivation



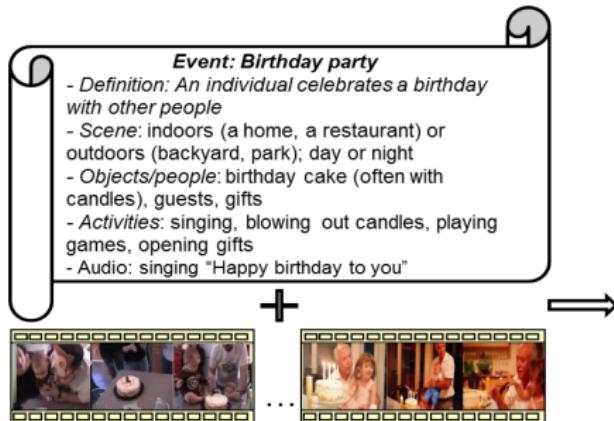
- Massive number of videos are produced every day.
 - ▶ YouTube: 72 hours uploaded per minute, with 3 billion viewers a day.
- Video need to be indexed, searched based on its content.
- Many applications:
 - ▶ User demands: tutorial videos such as "**how to make a cake**", "**how to repair an appliance**".
 - ▶ Security purposes: filter out irrelevant content such as "**how to make a bomb**".

Multimedia Event Detection

Task defined by TRECVID since 2010

Definition

- Given: An event kit which consists of an event name, definition, explication + video example.
- Wanted: A system that can search for this event through the large set of videos with reasonable accuracy and speed.



Challenges of Multimedia Event Detection



- Large content variation: Large number of events and large number of background videos.
- Uncontrolled capturing conditions: different time, location, clutter in the environment, camera motion.

Challenges of Multimedia Event Detection

- Evaluation datasets:

Dataset	MED 2010	MED 2011	MED 2012
Number of test events	3 (Assembling a shelter, Battling a run, Making a cake)	10 (Birthday party, Changing a vehicle tire, Flashmob gathering, etc)	20 (Cleaning an appliance, Dog show, Marriage proposal, etc)
Number of videos	3,468 (1,744 dev videos and 1,724 test videos)	45,000 (13,200 dev videos and 31,800 test videos)	156,000 videos (58,000 dev videos and 98,000 test videos)
Number of background videos	1,500 for dev and 1,500 for test	10,000 for dev and 28,000 for test	10,000 for dev and 95,000 for test
Hours of video	110	1,400	4,850

Challenges of Multimedia Event Detection

- **Specific challenge:** Data often contain irrelevant information



(a)



(b)

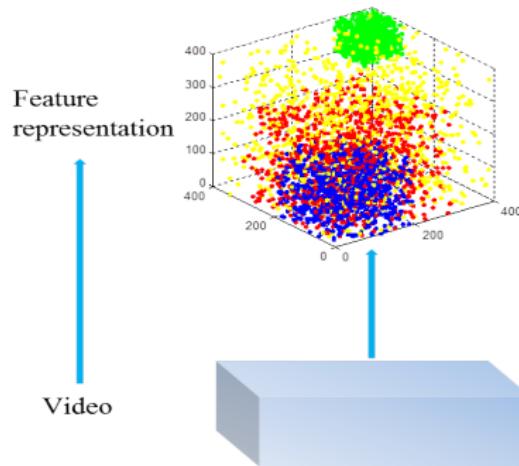
(a) Example video for "making a sandwich" event: the related segment appears after a self-cam segment (unrelated); (b) example video for "grooming an animal" event: related segment is sandwiched between two unrelated segments. This kind of video is popular in realistic dataset.

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Video-based Approach

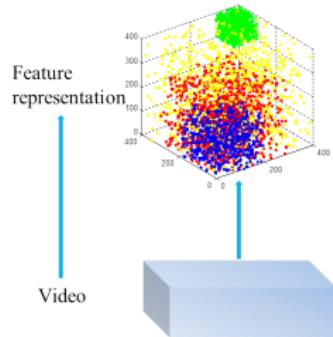
- Features are computed over the whole video
- One representation for each video



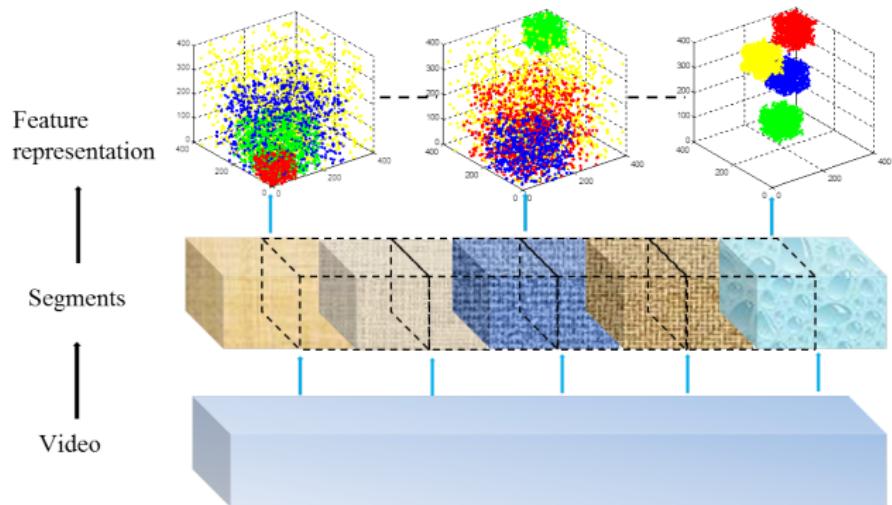
- Used by best MED'10 system (Columbia University)
- Used by best MED'11 system (BBN VISER)

Specific problem: The clues to determine an event can reside within a small segment.

Our Segment-based Approach



(b) The video-based approach



(b) **Our proposed segment-based approach:** the basic idea is to examine shorter segments instead of using the entire video

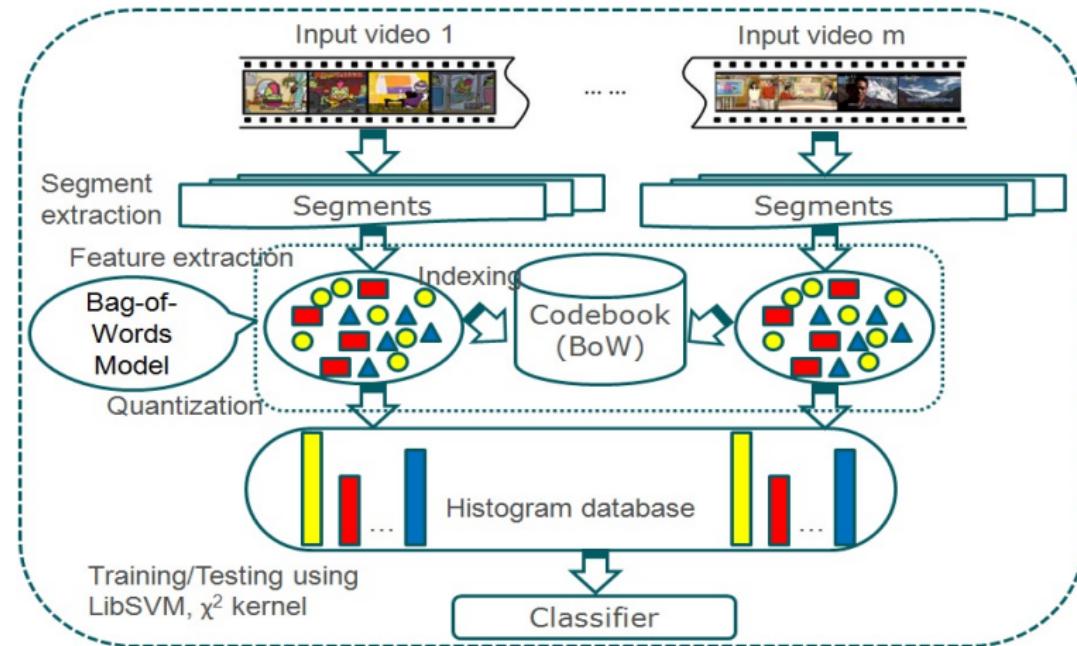
Our Segment-based Approach

How to select the segment length?

- Non-overlapping
 - ▶ Uniform sampling
 - ▶ Segment length: 30, 60, 90, 120, 200, 400 seconds
 - ▶ Compare with the video-based approach (using the whole video)
- Overlapping sampling
 - ▶ Uniform sampling, 50% overlapping
 - ▶ Segment length: 30, 60, 90, 120, 200, 400 seconds
 - ▶ Compare with the video-based approach (using the whole video)
- Segment sampling based on shot boundary detection
 - ▶ Take into account the boundary information of each segment
 - ▶ Employ the technique proposed by [Guimaraes et al. - 2003]

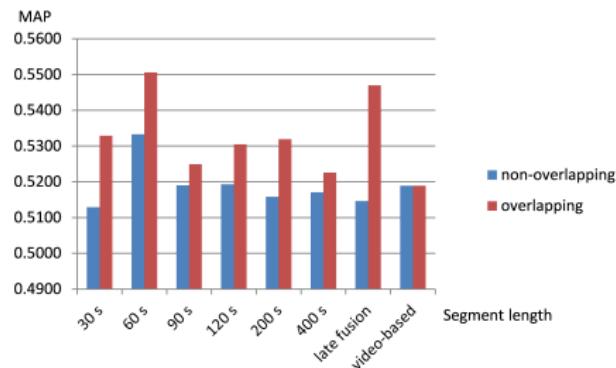
Guimaraes, S.J.F., Couprie, M., Araujo, A.d.A., Leite, N.J: Video segmentation based on 2d image analysis. Pattern Recognition Letters, 2003, 24(7), 947-957.

Evaluation Framework

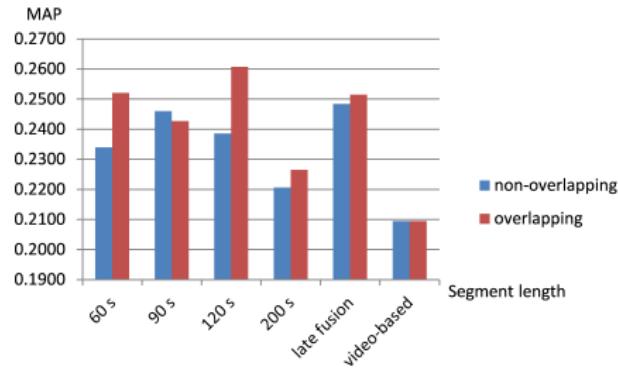


Evaluation framework for our baseline MED system

Result: Non-Overlapping vs. Overlapping Sampling



(b) On the MED 2010 dataset



(b) On the MED 2011 dataset

In most cases, the overlapping sampling performs the best.

Result: Comparison

Table: Comparison of different segment-based approaches with the video-based approach on the MED 2010 dataset.

Event/MAP	Best non-overlapping	Best overlapping	SBD segments	Video-based
Assembling shelter	0.4511	0.4781	0.4284	0.4911
Batting in a run	0.7852	0.7918	0.7866	0.7902
Making a cake	0.3636	0.3819	0.1918	0.2755
All	0.5333	0.5506	0.4689	0.5189

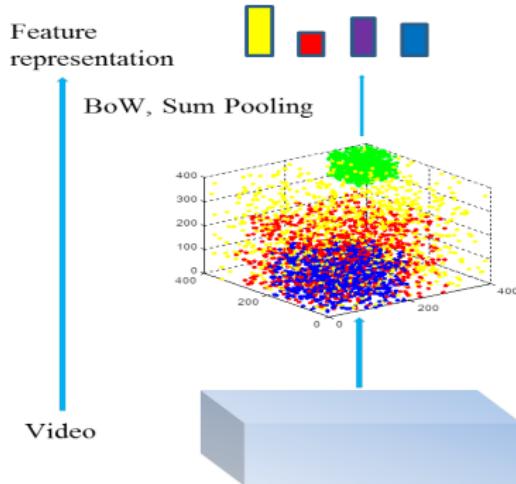
Segment-based approach outperforms the traditional video-based approach.

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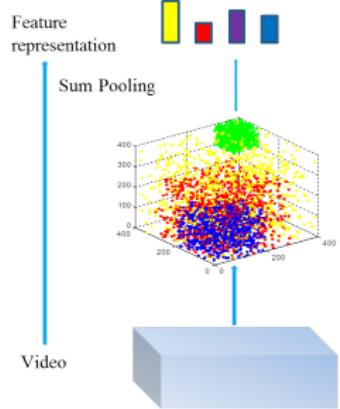
Video-based Approach

Bag-of-visual-words model: Video level features are aggregated over the entire videos

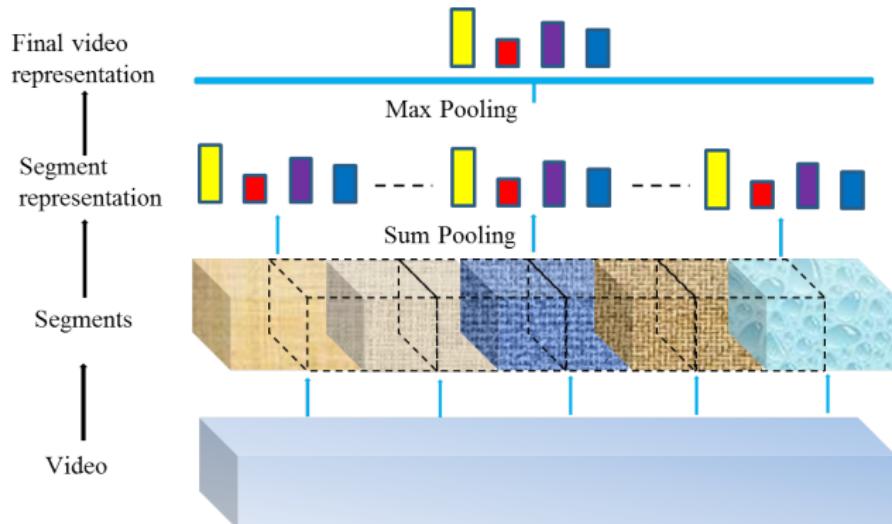


- The proposed segment-based approach: increasing the number of segment representation is not scalable.
- **Specific problem:** How to generate one representation per each video from its segment-level representations?

Sum-max Video Pooling



(b) The video-based approach



(b) **Our proposed Sum-max Video Pooling:** the basic idea is to retrieve the most relevant features at the high layer, therefore it can discard irrelevant features in the final video representation

Sum-max Video Pooling

- N local descriptors $x_n \in R^D$, where $n = 1, \dots, N$ and D is the feature dimension
- K visual words $m_k \in R^D$, where $k = 1, \dots, K$
- $M = \{m_k\}$ is the set of visual words
- Coding step: $\phi_n = [\Phi_{1n}, \dots, \Phi_{Kn}]$
- S is number of segments
- N_s is the number of local descriptors in segment s
- The sum-max and max-sum video pooling at each visual word can be defined as follows:

$$\psi_{k_{\text{sum-max}}} = \text{Max}_{s \in S} \left(\sum_{n \in N_s} \Phi_{kn} \right) \quad (1)$$

$$\psi_{k_{\text{max-sum}}} = \sum_{s \in S} \left(\text{Max}_{n \in N_s} \Phi_{kn} \right) \quad (2)$$

Experimental Results

Table: Performance comparison of different video pooling strategies on the MED 2010 dataset.

Event/MAP	Max pooling (Video-based)	Sum pooling (Video-based)	Max-sum pooling (at 60 s)	Sum-max pooling (at 60 s)
E001	0.4365	0.4468	0.4646	0.5072
E002	0.6434	0.7988	0.7103	0.7900
E003	0.3144	0.3053	0.2806	0.3100
All	0.4648	0.5170	0.4852	0.5357

- Pooling over segments is more effective.
- Sum-max video pooling outperforms the traditional video-based sum pooling.**

Where am I now?

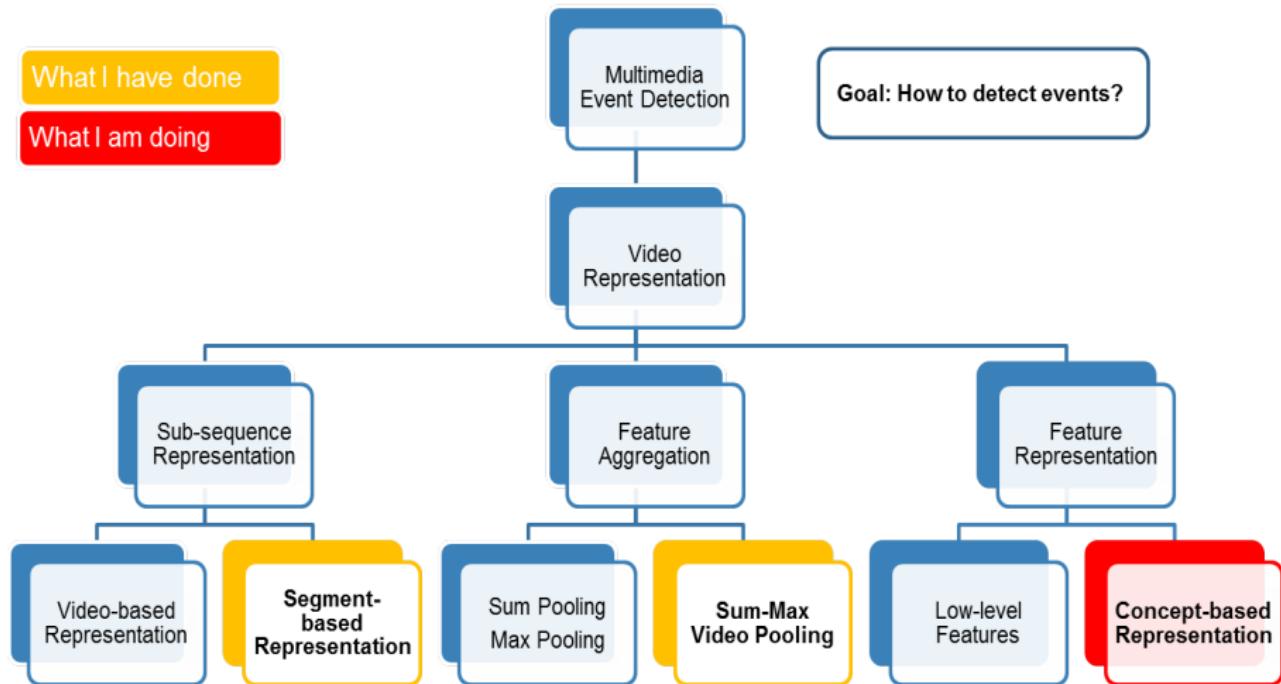
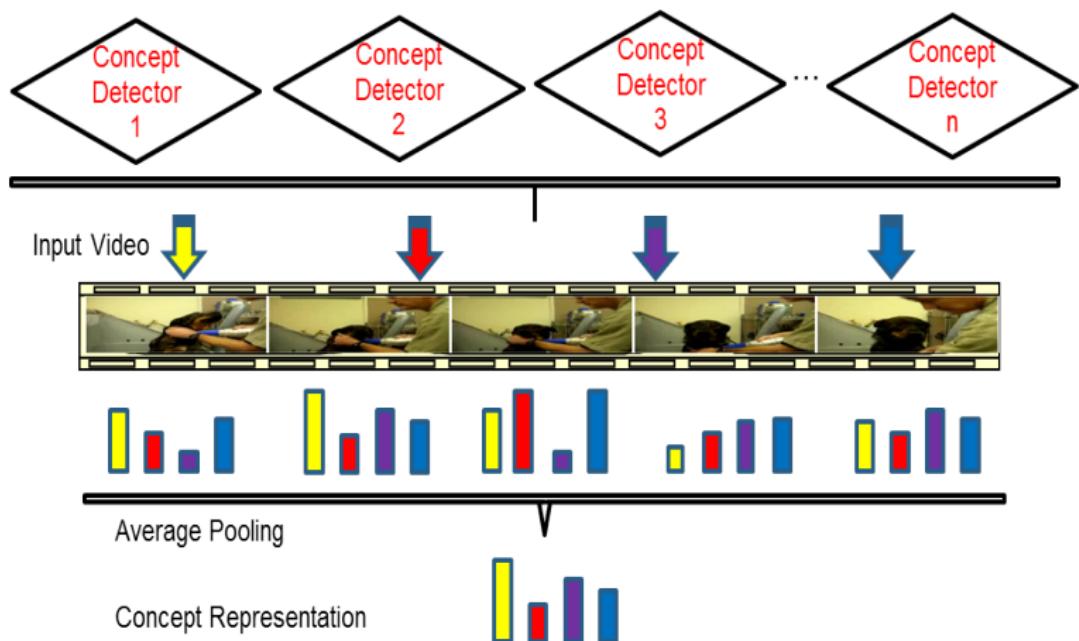


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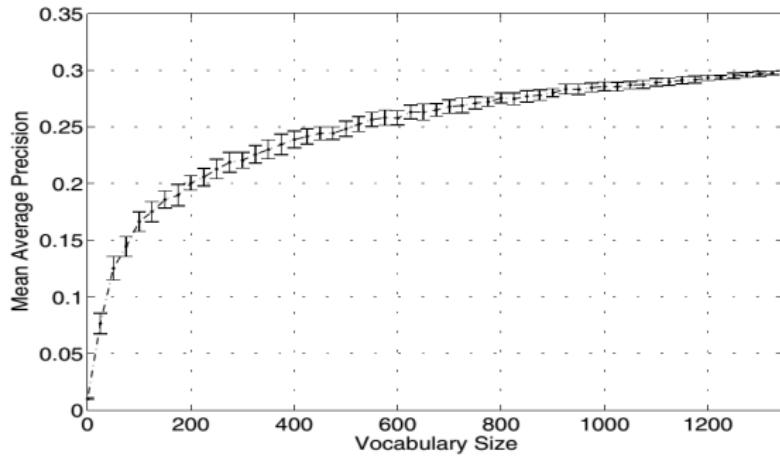
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Concept-based Representation

A complex event can involve multiple objects → **A video can be represented by concept vectors.**



Concept-based Representation



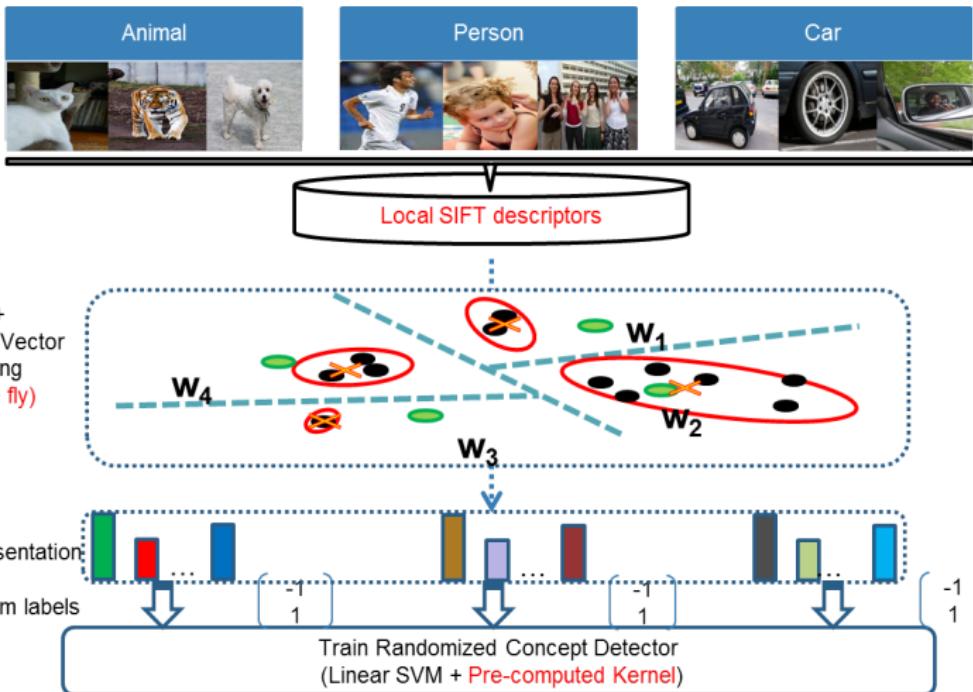
- Increasing the concept vocabularies can improve the event recognition performance. [Habibian - ICMR2013]
- Limitation: Annotation requires a lot of human effort!

AmirHossein Habibian, Koen E. A. van de Sande, Cees G. M. Snoek: Recommendations for video event recognition using concept vocabularies. ICMR 2013: 89-96

How About an Effortless Approach?

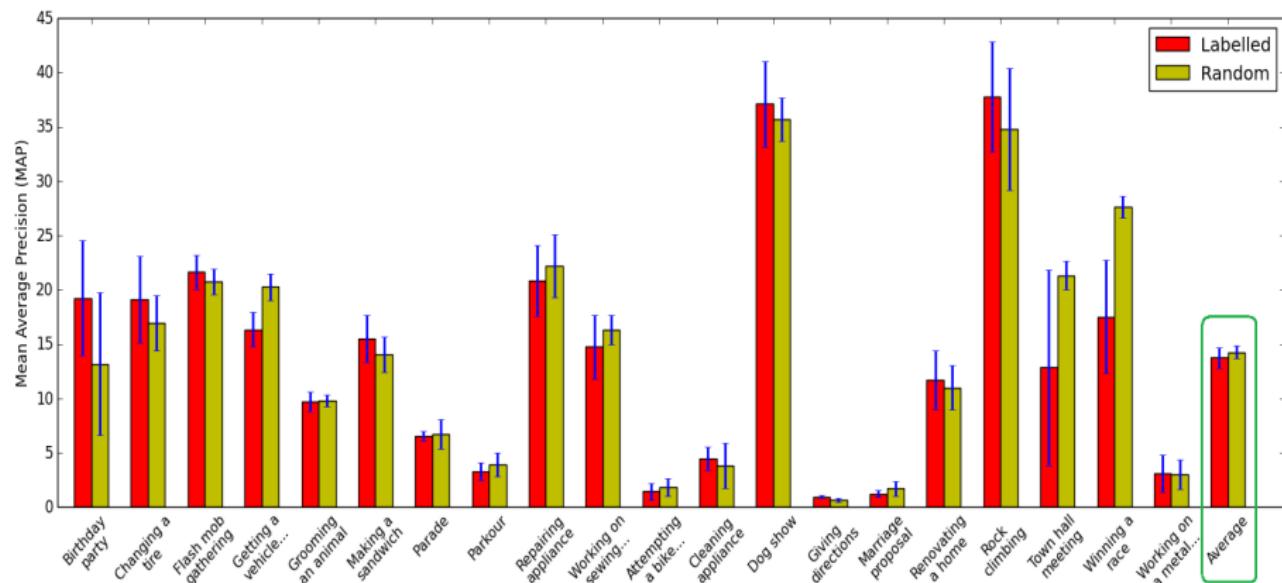
- We introduce a new approach in order to get labels for training data efficiently.
- **Random Concepts:** Given a set of images used to train a concept classifier, positive and negative labels are generated randomly.
 - ▶ In most of cases, the presence of a concept is null
 - ▶ The performance of concept detection is usually poor
 - ▶ Different domain problem

Randomized Concept Detector Framework



Framework for building randomized concept detectors from ImageNet dataset

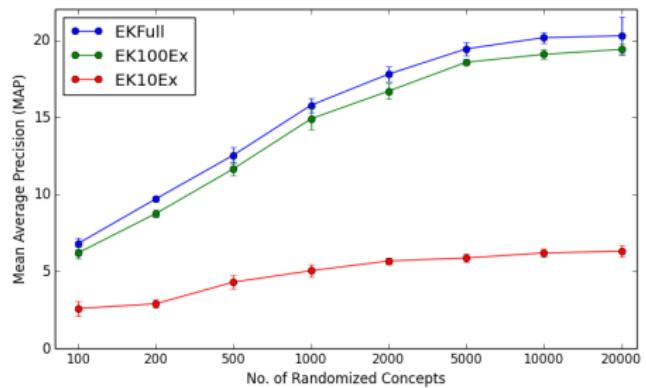
Labelled vs. Random Concept Detector?



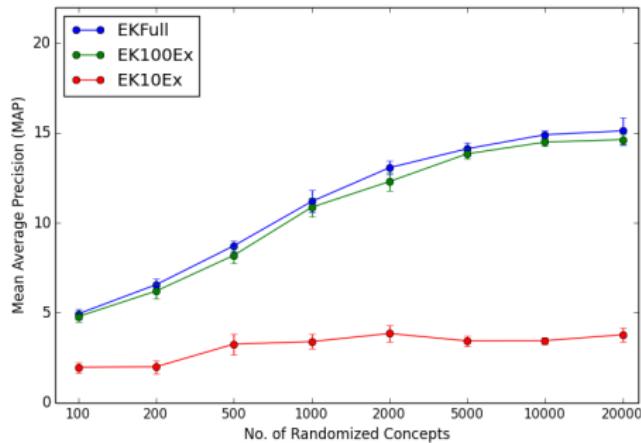
Performance of 1000 labelled concept detectors vs. Performance of 1000 random concept detectors.

We can obtain comparable performance with labelled concepts!

How Many Random Concepts?



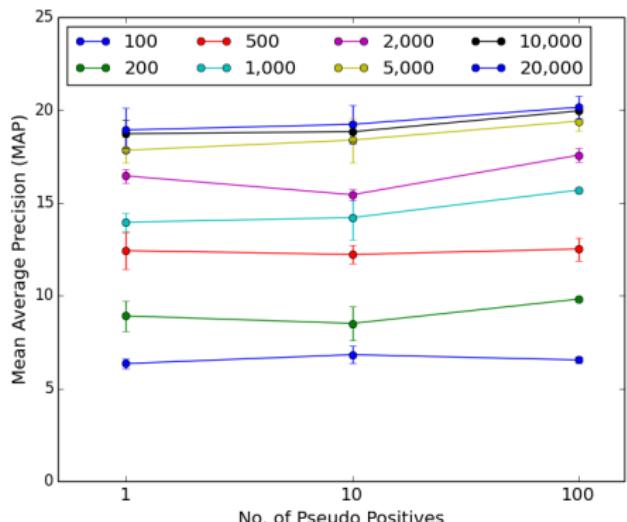
(a) On the MED 2012
KINDREDTEST dataset



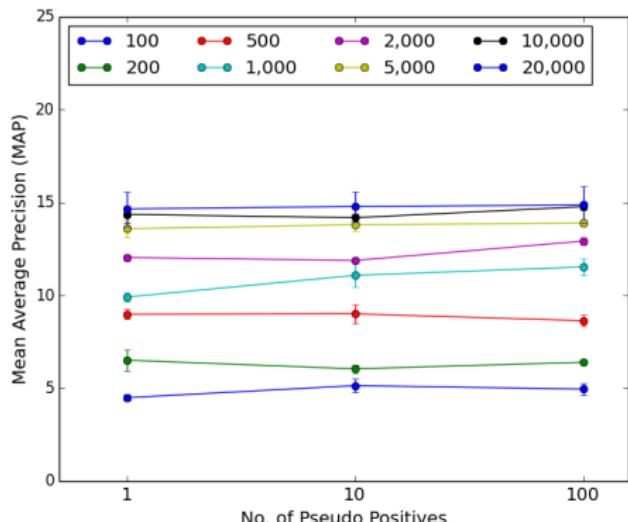
(b) On the MED 2012 MEDTEST
dataset

The best performance can be obtained using around **ten thousands** of totally random labelled concept detectors!

Influence of Number of Pseudo Positives?



(a) On the MED 2012
KINDREDTEST dataset



(b) On the MED 2012 MEDTEST
dataset

The detection performance **does not depend on the number of pseudo positives!**

Discussions

- Current results show the limitation of concept-based representation!
- Using totally random 'concept' detectors does not capture any semantic features!
- How to improve?
 - ▶ Build more concept detectors for each labelled image class?
 - ▶ How about random projection of classifiers?

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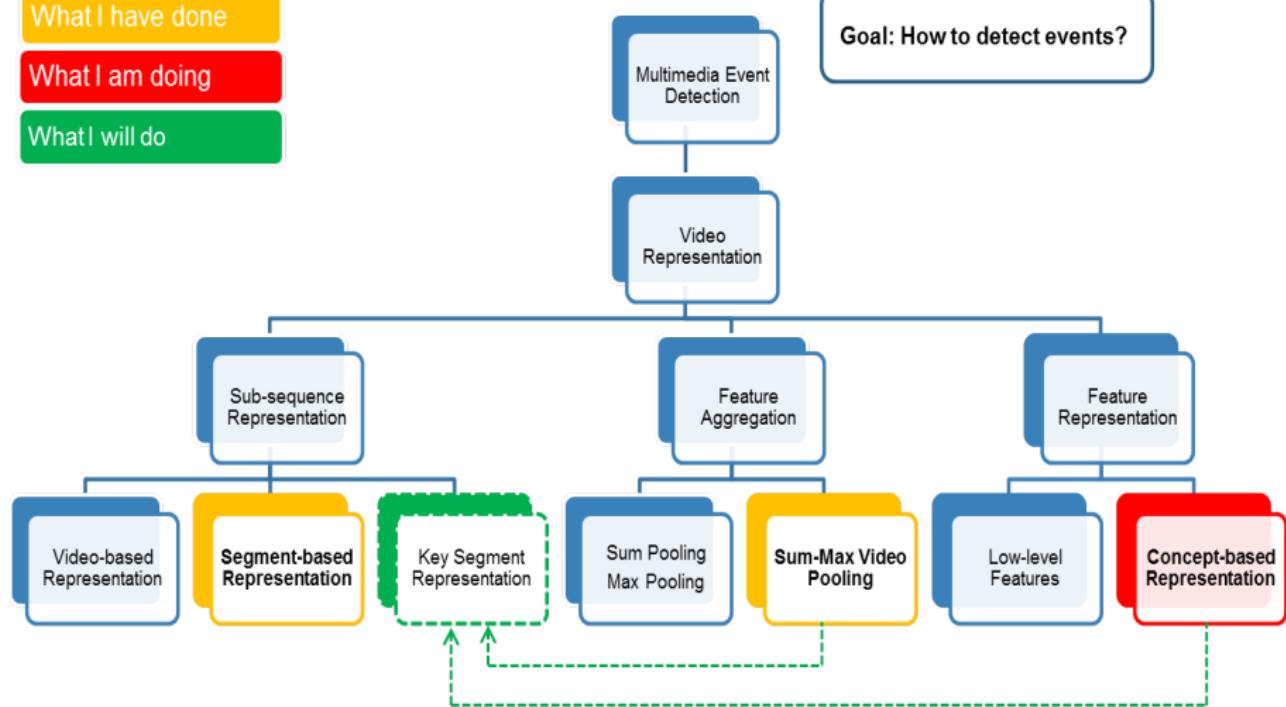
Next Study

What I have done

What I am doing

What I will do

Goal: How to detect events?



Motivation

Definition

Key segments: segments that contain positive evidence for a specific event

- Existing work addresses the problem without identification of key segments.
- Video level features are aggregated over the entire videos.

Drawback: Each part of the video contributes equally to the final representation → making it prone to noise.

For our segment-based approach: features are aggregated over the uniform sampled segments → might not contain key segments

Research Problem: How about automatically finding the key segments that contain positive evidence for a specific event?

First Approach

- We first analyze videos of specific event kit and manually identify key video segments to well represent that event type ()
 - ▶ E.g., "no dance" segment followed by "dance by group of people" segment for "flash mob gathering" event
- Train classifiers for each types of video segments (using current state of the art event detection method)
- Combine the results

Issues

- How to identify key video segments?
- How about classes of video segments?
 - ▶ Can be a set of generic classes (generic sub events)?
 - ▶ Depending of each event (sub events specific to each event)?
- How to combine the analysis results of video segment?

Summary

- What I have done
- What I am doing
- What I will do

