Unsupervised Co-Segmentation for Athlete Movements and Live Commentaries Using Crossmodal Temporal Proximity

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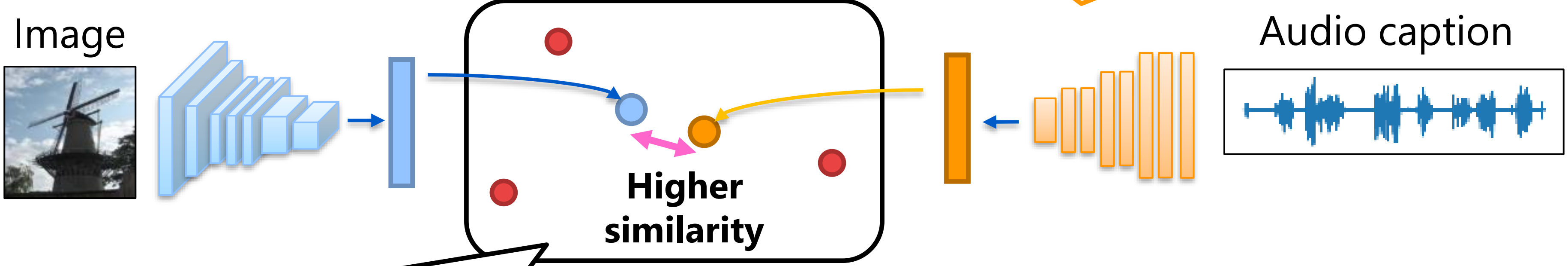
Related work

Embedding model (DAVEnet) that can directly associate visual objects with spoken words [Harwath+2016]

Image network (Pre-trained VGG16)

Speech network (CNN-based)

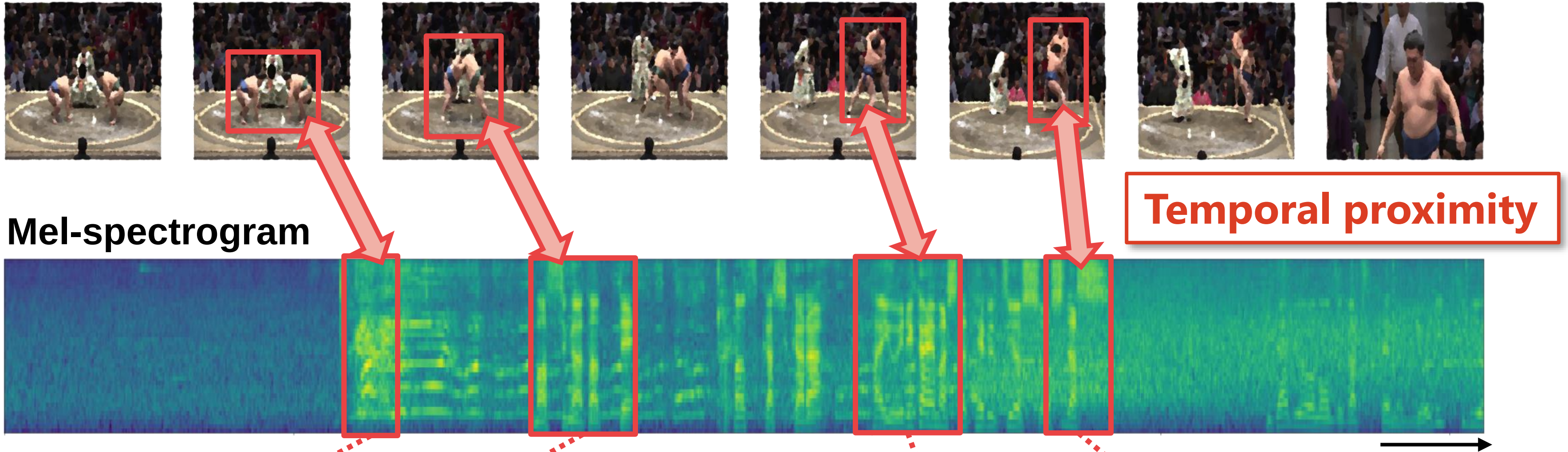


- Triplet loss function
- Margin softmax loss function
- Noise contrastive estimation

- 400K English captions [Harwath+2019]
- 100K Hindi captions [Harwath+2018]
- 100K Japanese captions [Ohishi+2020]

Our challenge

Co-segmentation of sports actions and live commentary



Video frames

Mel-spectrogram

Temporal proximity

Time axis

“はっけよいのこった”
(Ready go!)

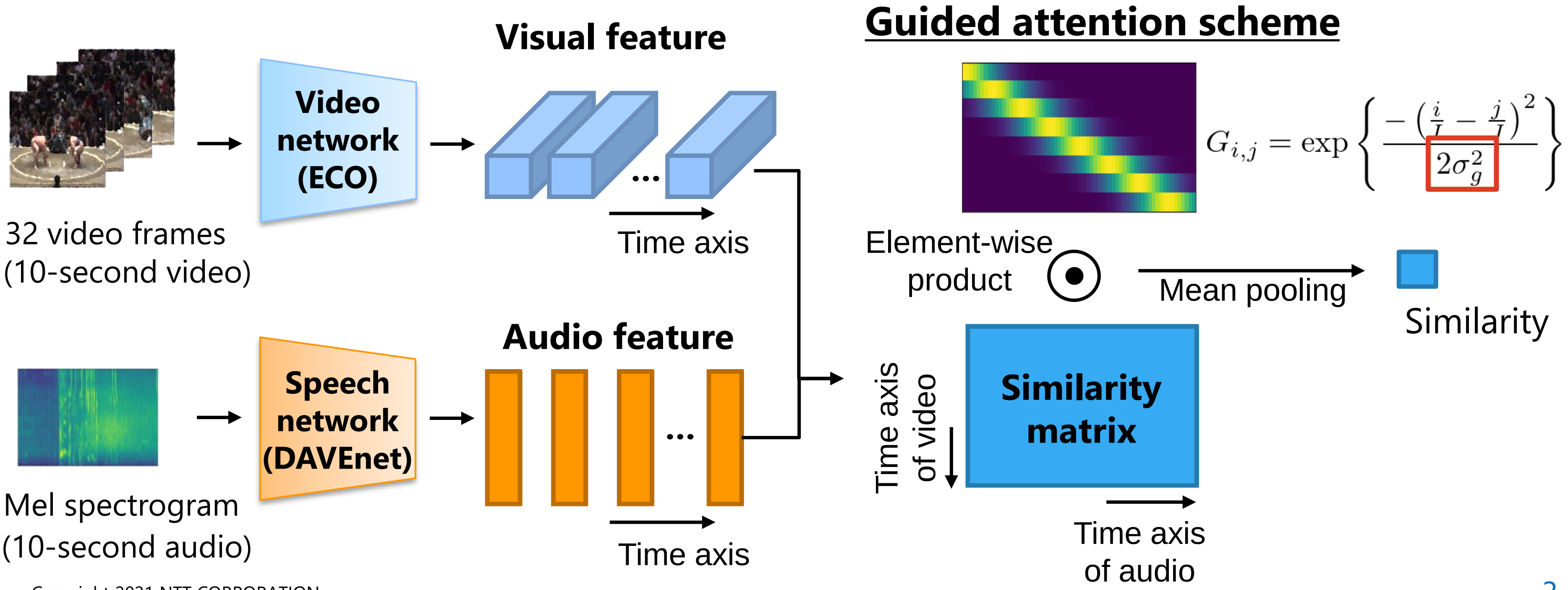
“正面からあたって” (Frontal attack)

“相手の上半身を強く押し、土俵の外へ出しました”
(Push hard against the opponents upper body to force him out of the ring)

“押し出し” (Oshi-dashi)

Model

Guided attention scheme to efficiently detect and utilize temporal co-occurrences of audio and video information



Visual feature

Video network (ECO)

32 video frames
(10-second video)

Time axis

Audio feature

Speech network (DAVEnet)

Mel spectrogram
(10-second audio)

Time axis

Guided attention scheme

$$G_{i,j} = \exp\left\{ \frac{-\left(\frac{i}{I} - \frac{j}{J}\right)^2}{\boxed{2\sigma_g^2}} \right\}$$

Element-wise product ⊙

Mean pooling

Similarity

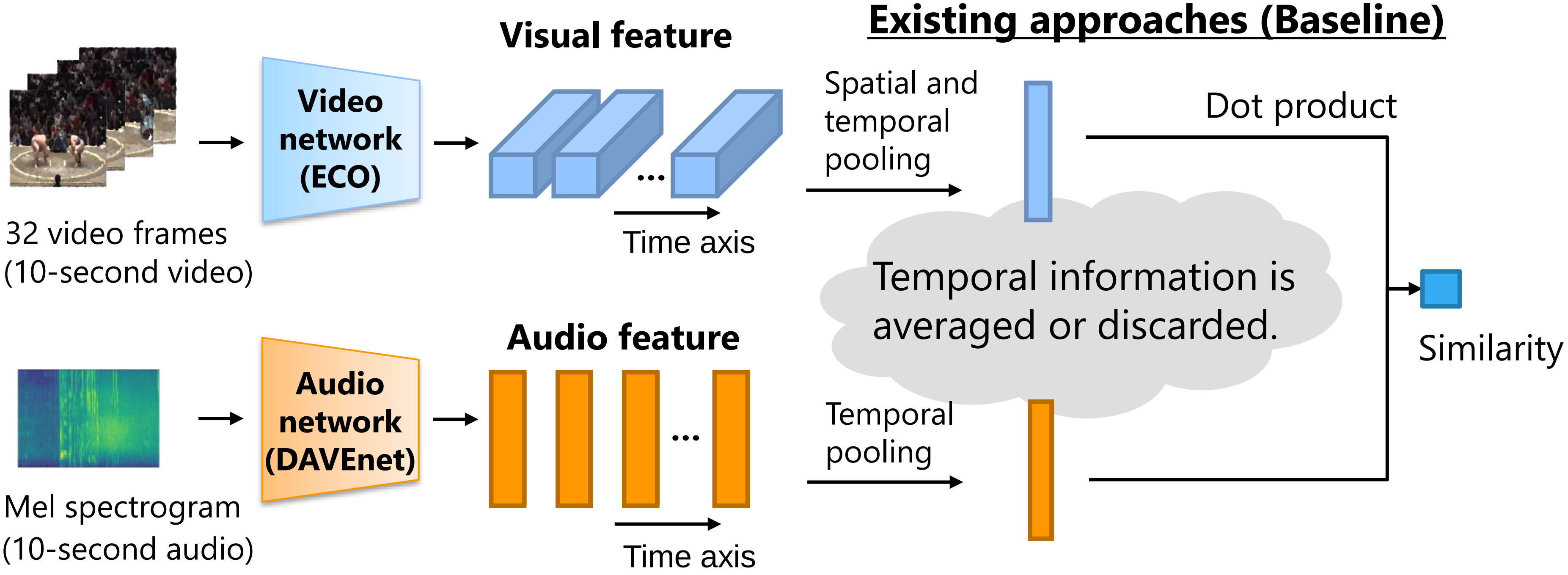
Similarity matrix

Time axis of video

Time axis of audio

Model

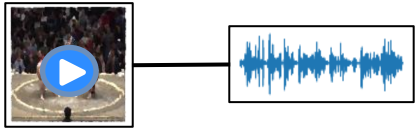
Guided attention scheme to efficiently detect and utilize temporal co-occurrences of audio and video information



Visual feature
Existing approaches (Baseline)
Video network (ECO)
Spatial and temporal pooling
Dot product
…
Time axis
32 video frames (10-second video)
Temporal information is averaged or discarded.
Similarity
Audio feature
Audio network (DAVEnet)
…
Temporal pooling
Mel spectrogram (10-second audio)
Time axis

Dataset

- 170 hours of NHK broadcast of grand sumo tournaments
- 1,218 matches of nine frequent winning techniques
- 10-second video clips and their raw audio waveforms centered around labeled times as audio-visual pairs



10-second video 10-second audio

Winning techniques	Training	Validation
Frontal push out	365	10
Frontal force out	362	10
Slap down	141	10
Thrust down	77	10
Over arm throw	45	10
Frontal thrust out	42	10
Frontal crush out	34	10
Rear push out	34	10
Frontal push down	28	10
	1,128	90

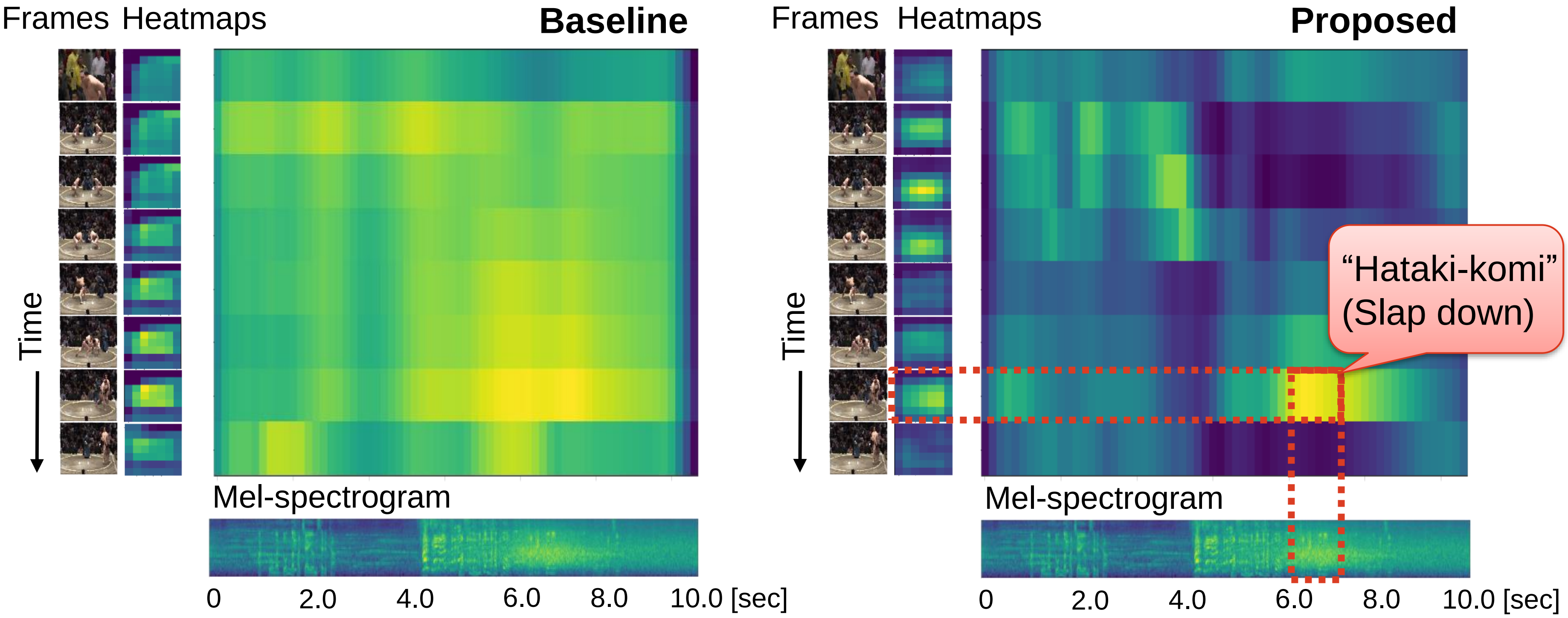
Crossmodal search results

Audio-visual retrieval recall scores when the correct result was defined as the clips with the same winning techniques as the query

	Audio to Video			Video to Audio		
σ_g	R@1	R@3	R@5	R@1	R@3	R@5
0.001	.289	.600	.739	.294	**.611**	.717
0.01	**.348**	**.656**	**.770**	.304	.604	**.785**
0.1	.304	.648	.763	**.307**	.581	.733
1	.289	.600	.711	.211	.511	.622
10	.211	.461	.611	.144	.389	.561
100	.122	.389	.511	.056	.211	.411
Baseline	.256	.422	.589	.233	.511	.633

Co-segmentation results

Our method better captures the correspondence between audio and visual information and the edges of the segments.


Frames
Heatmaps
Baseline
Time
Mel-spectrogram
10.0 [sec]
Frames
Heatmaps
Proposed
Time
“Hataki-komi”
(Slap down)
Mel-spectrogram
10.0 [sec]