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# AUDIOVISUAL DISCRIMINATION BETWEEN LAUGHTER AND SPEECH

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# Motivation

- Powerful affective and social signal

- Most frequently annotated non-verbal behaviour in recorded natural speech
  - 8.6% of the time a person vocalizes is spent on laughing
  - 0.8% is spent on laughing while talking

# Previous work

- Audio-only Laughter Detection
  - Audio features only (MFCC, prosody)
  - Hidden Markov Models (HMMs) / SVM /GMM

- Audiovisual laughter Detection
  - Audio features (MFCC)
  - Visual features ( lip lengths, lip angles)
  - Improved performance
  - Tested on 3 sequences

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# Objective

- To use standard tools to discriminate laughter from speech using an audiovisual approach

# Audiovisual Recognition

- Audiovisual speech recognition
  - Audio + Visual features (e.g. lip contours)
  - Hidden Markov Models (HMMs) + Variants of HMMs
  - Feature level
  - Enhanced performance

- Audiovisual affect recognition
  - Recognition of six basic + non basic emotions
  - HMMs, GMMs, RNN, Bayesian Networks
  - Decision level, model-based fusion

# Dataset

- AMI Meeting Corpus
- 10 subjects – spontaneous expressions
- 67 voiced laughters (100.88 sec)
- 48 unvoiced laughters (60.76 sec)
- 93 speech segments (177.86 sec)
- 720 x 576 pixels, 25 FPS

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# Audio Features

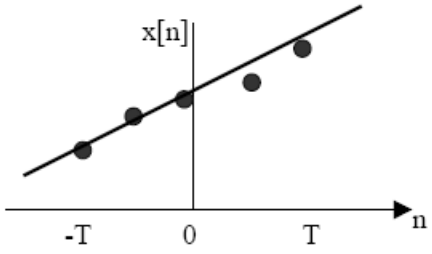
- Spectral Features

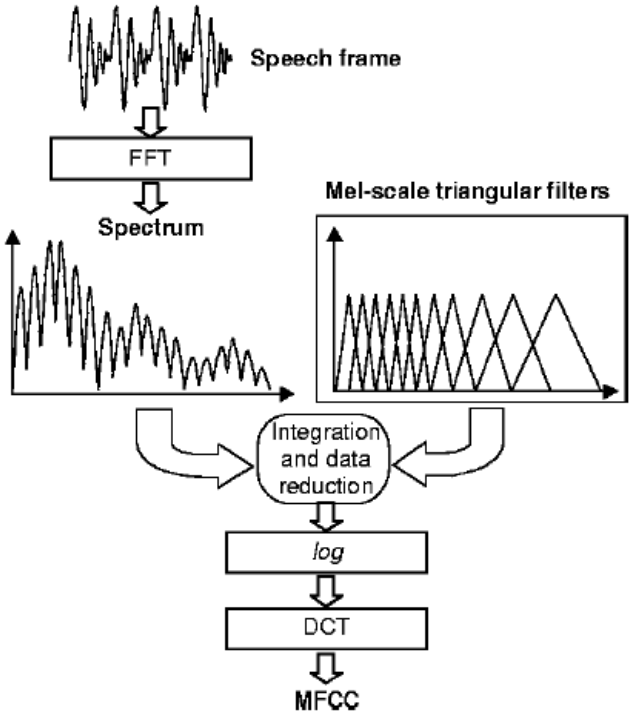
  - MFCC
  - PLP

- Non Spectral Features (Prosodic)

  - Pitch
  - Energy

- Delta Features



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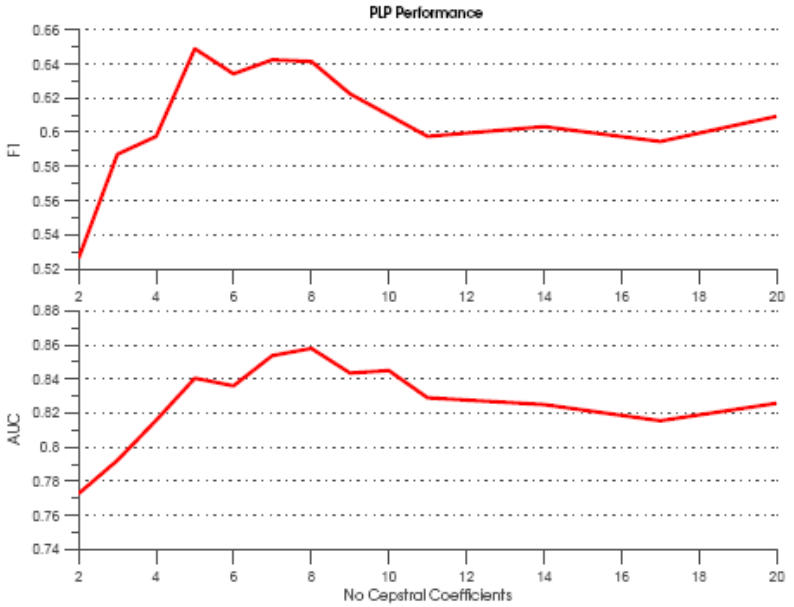
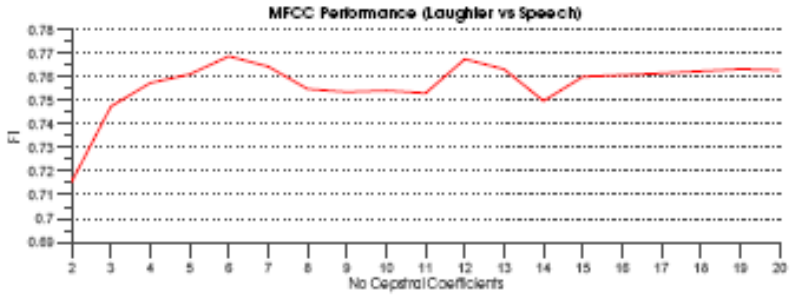
# AUDIO FEATURES

- Spectral Features
  - 6 MFCC coeff. + 6 delta
  - Same results with PLP
  - Frame rate: 50 FPS, 50% overlap

- Prosodic Features
  - Pitch
  - Energy



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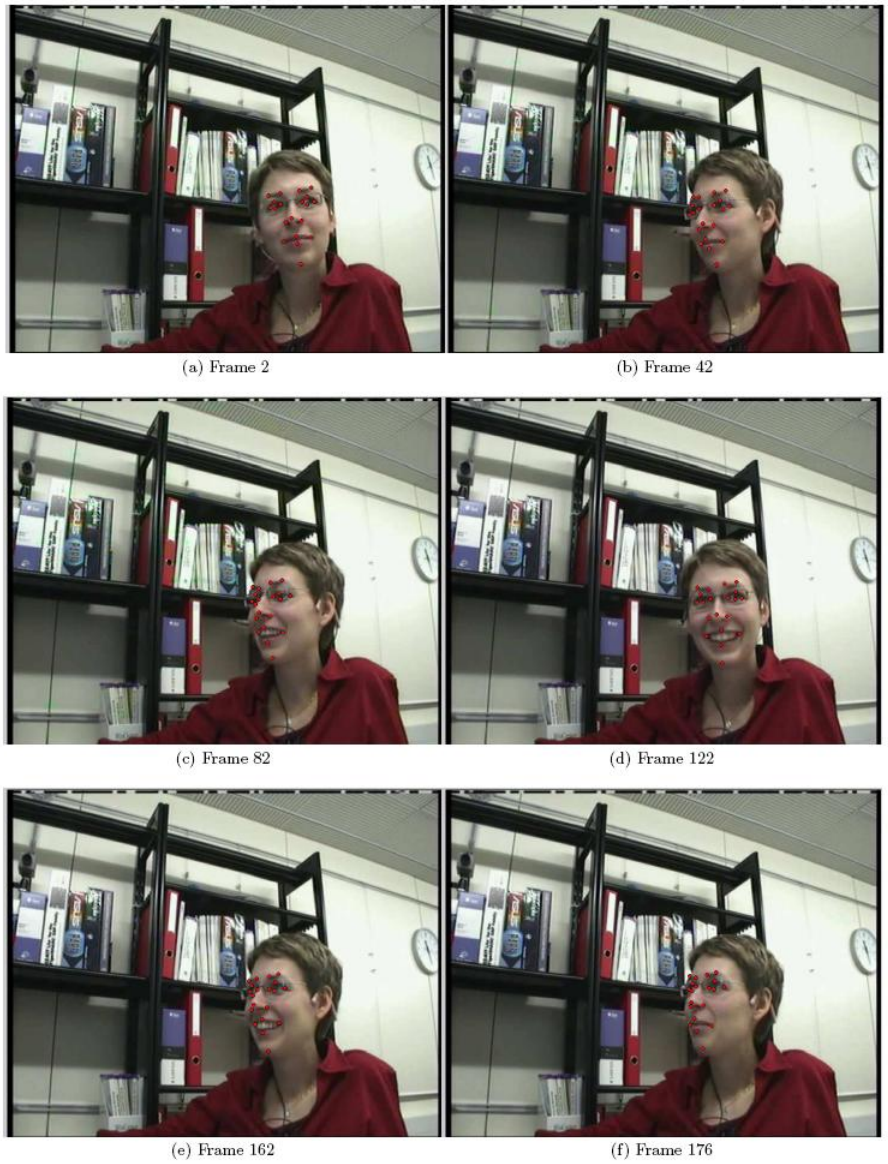
# VISUAL FEATURES - TRACKING

- 20 facial points
- Eyes: 4 points each
- Eyebrows: 2 points each
- Nose: 3 points
- Mouth: 4 points
- Chin: 1 point



(a) Frame 2 (b) Frame 42

(c) Frame 82 (d) Frame 122

(e) Frame 162 (f) Frame 176

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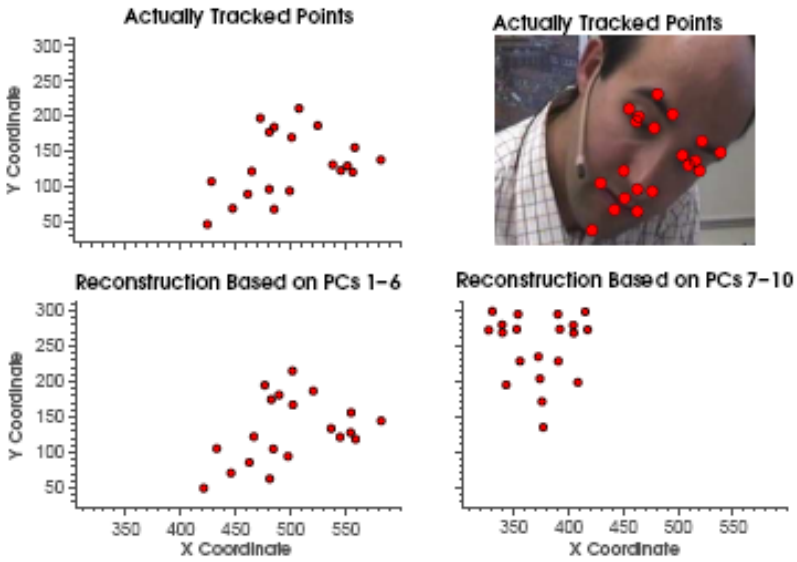
# VISUAL FEATURES – DECOUPLING OF HEAD AND FACE

- Concatenate the (x,y) coord.
  → 40-dim vector
- k frames → k x 40 data matrix
- Find the PCs of the data matrix (PCA)
- Point Distribution Model with no alignment



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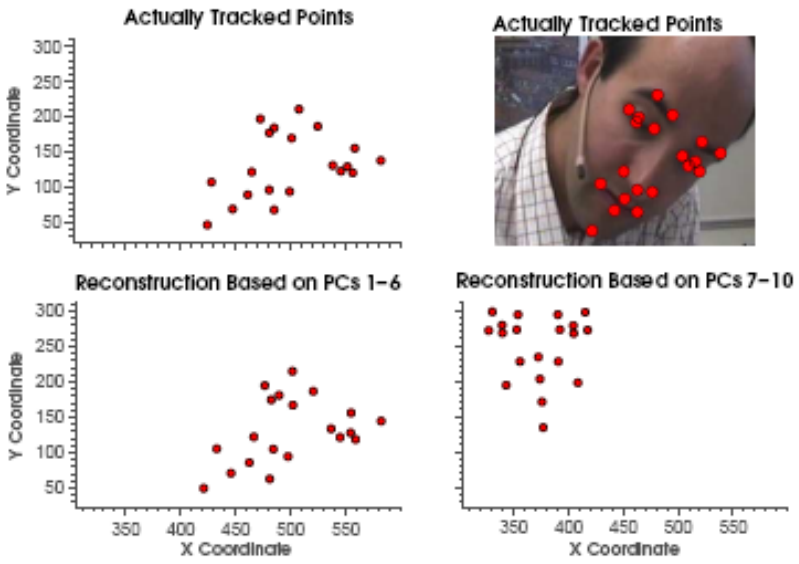
# VISUAL FEATURES – DECOUPLING OF HEAD AND FACE

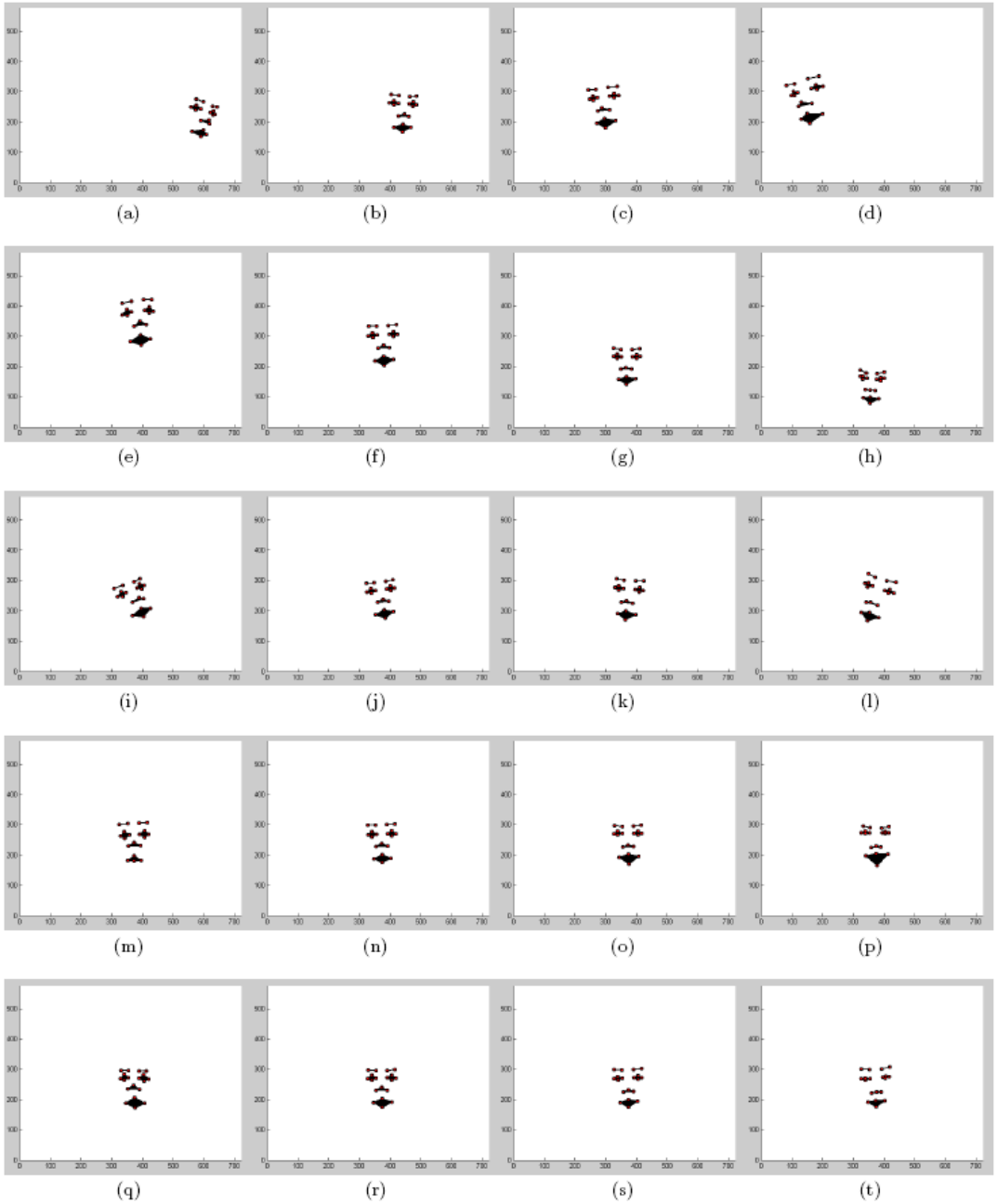
- Greatest variance of the data lies on the first PCs
- Greatest variance = head (rigid) movements
- First N(=5) PCs: reflect head movements (large variation)
- N+1...M(=6-10) PCs: reflect facial expressions (small variation)




$$b = (x - \overline{x})P$$

$$x \approx \hat{x} = \overline{x} + bP^T$$

- P: eigenvector matrix (40xN)
- b: shape parameters, (1xN)


(a)
(b)
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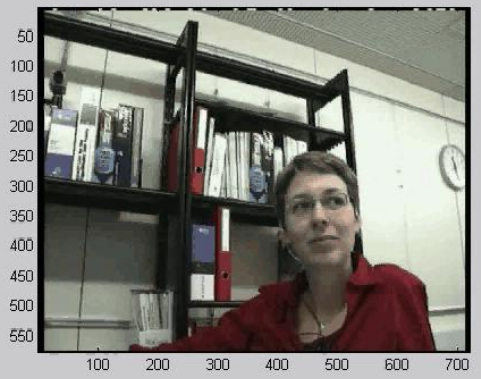
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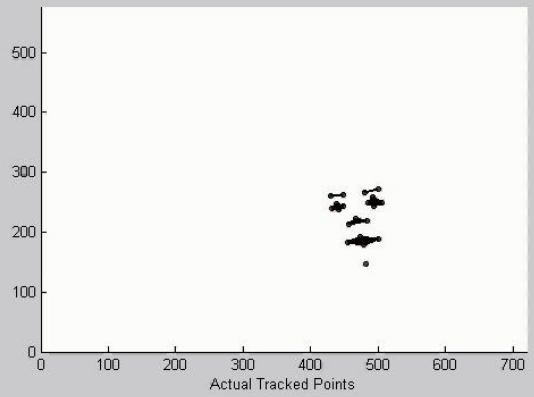
500
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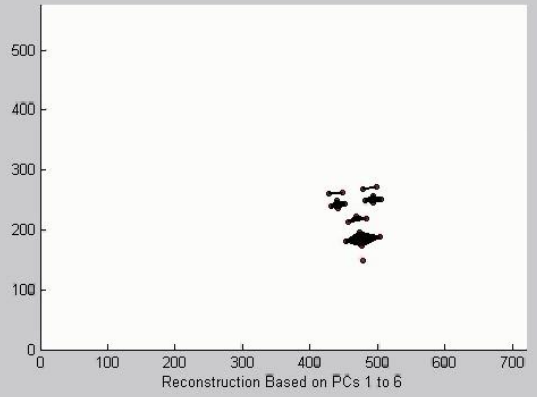
600
700
Actual Tracked Points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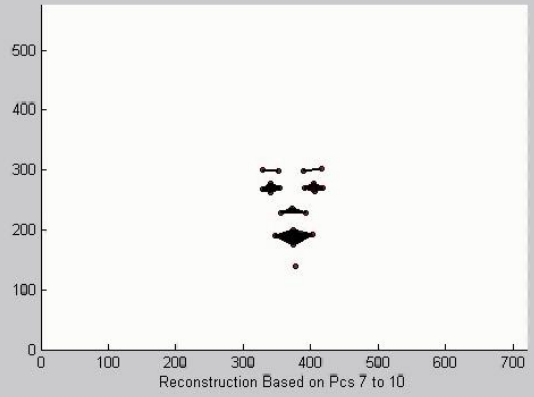
700
Reconstruction Based on PCs 1 to 6


500
400
300
200
100
0
0
100
200
300
400
500
600
700
Reconstruction Based on Pcs 7 to 10

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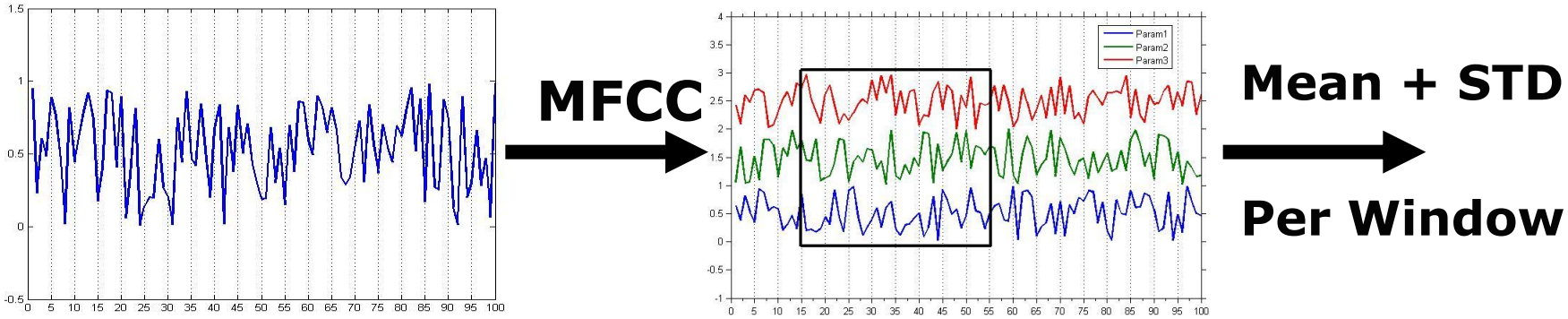
# FEATURE EXTRACTION

- Visual features
  - b1 – b5, b6 – b10 per frame
- Audio features
  - Mean + STD of MFCC, Pitch, Energy over 320ms window
  - Pitch Unvoiced Ratio



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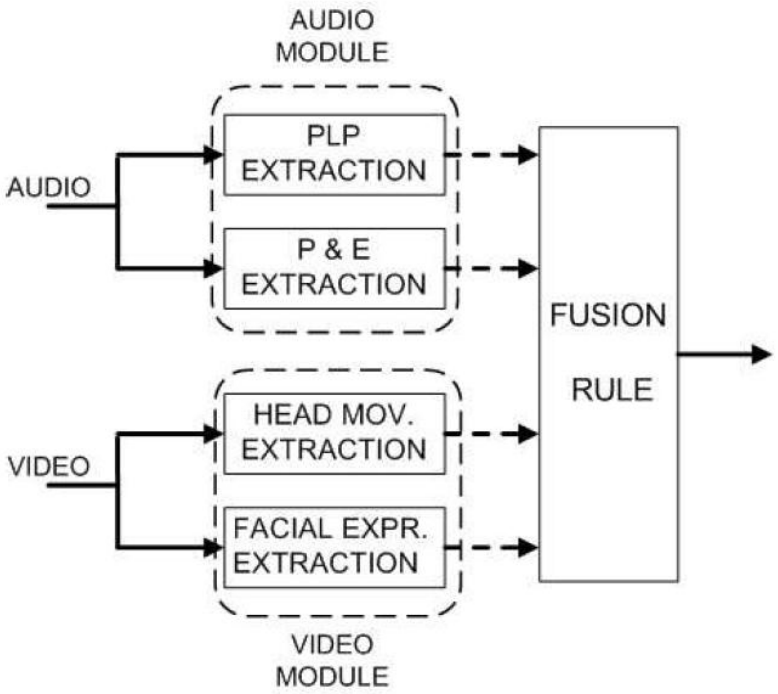
# SYSTEM OVERVIEW

- Leave-one-subject-out cross validation
- 2 / 3 classes: Laughter vs Speech
- Decision / Feature Level Fusion



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# RESULTS – LAUGHTER vs SPEECH

| *Cues* | *Features* | *F1* | *CR* |
|---|---|---|---|
| *FACE* | *b6 – b10* | *84.28* | *85.06* |
| *HEAD* | *b1 – b5* | *50.71* | *51.02* |
| *PROSODY* | *Pitch + energy* | *72.69* | *74.43* |
| *CEPSTRAL FEATURES* | *MFCC* | *86.16* | *86.69* |

| *Fusion* | *F1* | *CR* |
|---|---|---|
| *FACE + MFCC (DF)* | *93.17* | *93.37* |
| *FACE + MFCC + P&E (FF)* | *94.37* | *94.59* |

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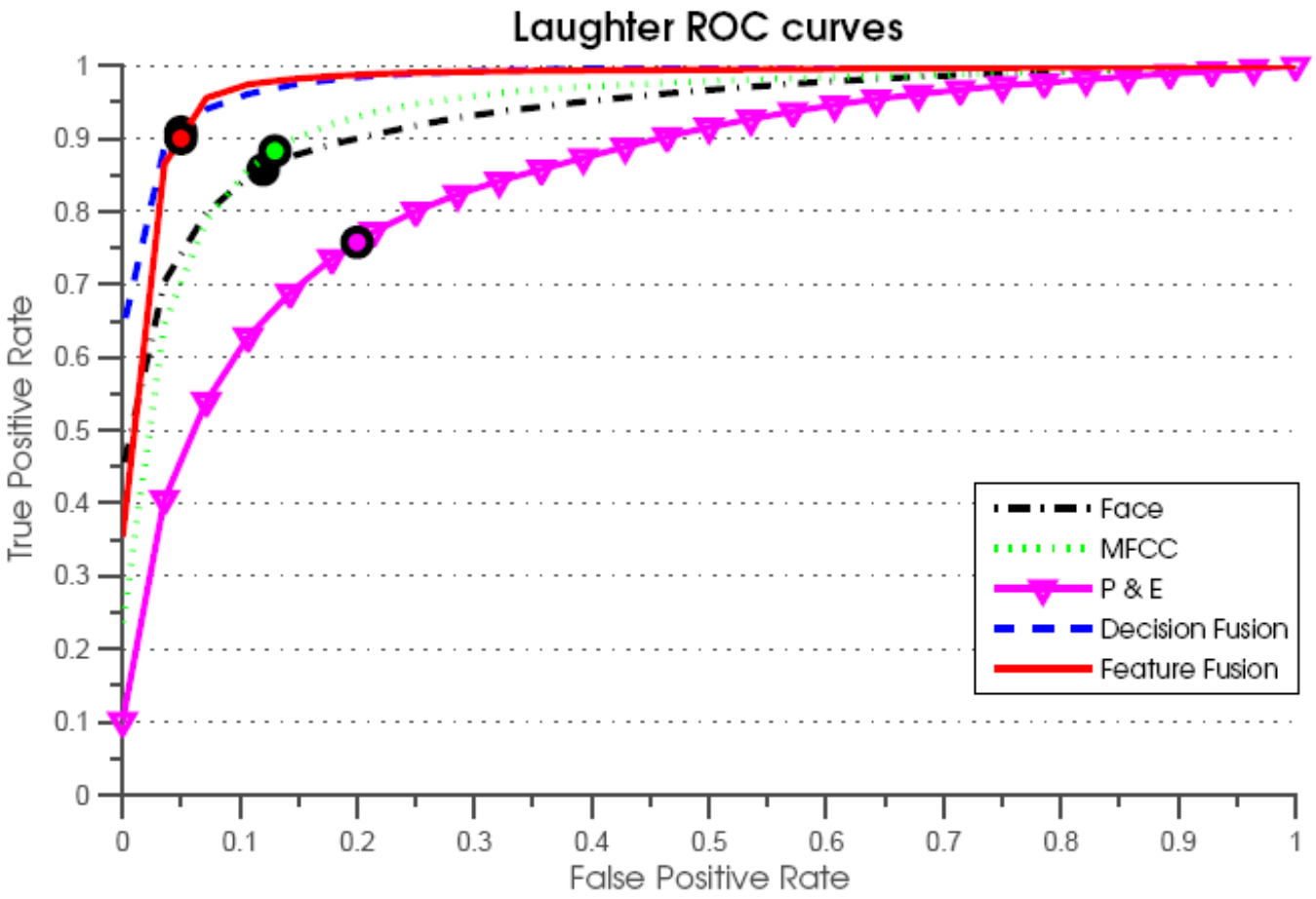
# RESULTS – AUDIOVISUAL



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# RESULTS – Voiced Laughter vs Unvoiced Laughter vs Speech

| *Cues* | *Features* | *F1 Unvoiced* | *F1 Voiced.* | *F1 Speech* | *CR* |
|---|---|---|---|---|---|
| *FACE* | *b6 – b10* | *37.21* | *57.48* | *84.39* | *67.03* |
| *HEAD* | *b1 – b5* | *19.32* | *34.56* | *49.72* | *37.27* |
| *PROSODY* | *Pitch + energy* | *57.24* | *59.65* | *74.39* | *66.20* |
| *CEPSTRAL FEATURES* | *MFCC* | *57.97* | *69.14* | *85.68* | *74.83* |

| *Fusion* | *F1 Unvoiced* | *F1 Voiced* | *F1 Speech* | *CR* |
|---|---|---|---|---|
| *FACE + MFCC + PE (DF)* | *66.14* | *74.62* | *91.89* | *81.00* |
| *FACE + MFCC + P&E + HEAD(FF)* | *66.80* | *78.86* | *94.14* | *83.51* |

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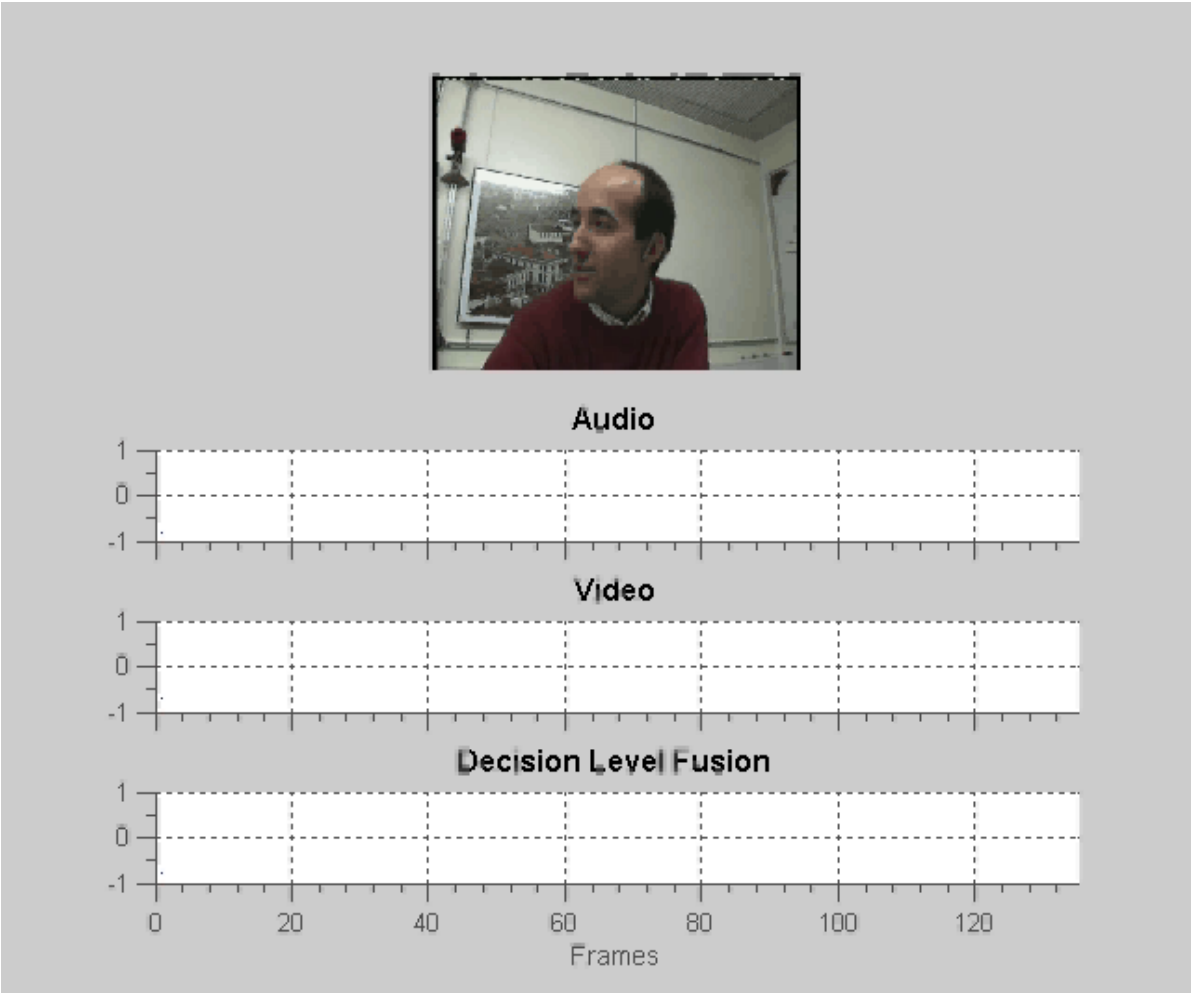
# FEATURE SELECTION

| Speech | Voiced | Unvoiced |
|---|---|---|
| B7 | B7 | Mean Energy |
| Mean MFCC2 | Std Energy | Mean MFCC6 |
| Std MFFC2 | Mean MFCC1 | Mean MFCC1 |
| Std MFCC4 | B10 | B7 |
| B10 | B8 | Mean MFCC2 |
| Std MFCC3 | B4 | B6 |
| Mean Pitch | Mean MFCC3 | Std Pitch |


Audio
1
0
-1
Video
1
0
-1
Decision Level Fusion
1
0
-1
0
20
40
60
80
100
120
Frames

# Conclusions

- Audiovisual fusion leads to improved performance
- Best cues: cepstral features, facial expressions
- High accuracy for speech vs laughter
- Discriminating 2 types of laughter is challenging

THANK YOU! ☺