Audiovisual-to-articulatory speech inversion using Active Appearance Models for the face and Hidden Markov Models for the dynamics

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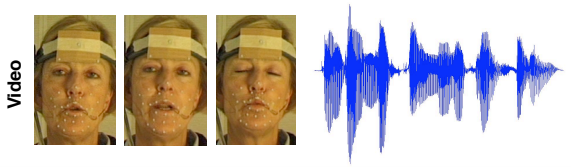
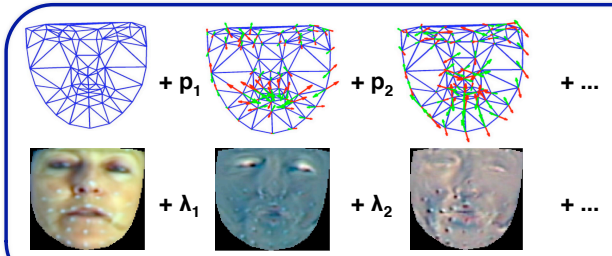
Active Appearance Modeling

❑Automatic visual feature extraction from frontal view, without markers
❑Account for both facial shape and appearance variations



Switching Linear Modeling

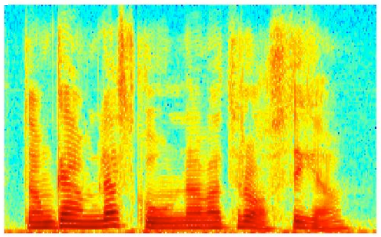
❑Complex audiovisual-articulatory interactions are captured in a piece-wise manner
❑Constituent mappings are built using Canonical Correlation Analysis



Speech inversion ?

❑Recover vocal tract geometry from the speech signal and speaker's face
❑Applications in Speech Therapy, Language Tutoring, Speech Coding,

y_v y_a

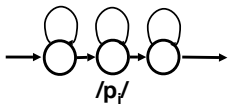


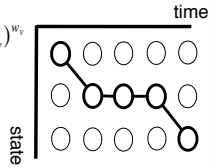
spectral characteristics/MFCC

Switching Process

❑Switching is governed by a hidden Markov process
❑Phoneme/Viseme HMMs are trained using Baum-Welch
❑State sequence determined using the Viterbi algorithm

$$b(c \mid y) \propto N(y_a;\mu_{c,a},\Sigma_{c,a})^{w_a} N(y_v;\mu_{c,v},\Sigma_{c,v})^{w_v}$$



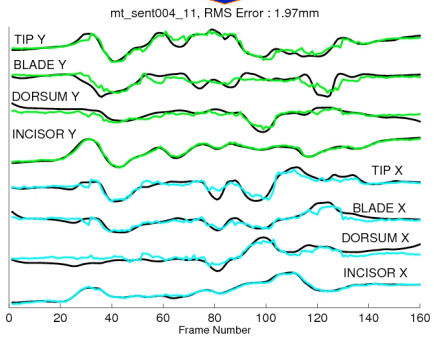


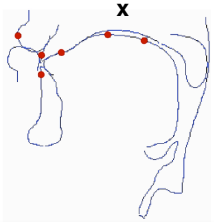
Audiovisual Fusion

❑Audio and visual mapping switching processes can interact at various synchronization levels

Features	Level	Type	States	RMS(mm)	ρ_{xx}
Audio (A)	Phoneme	HMM	2	2.56	0.60
Qualisys (QS)	Phoneme	HMM	2	2.30	0.65
A-QS	Phoneme	HMM	3	2.24	0.66
A-QS	Phon.-Phon.	HMM+LF	2-2	2.02	0.71
A-QS	Phon.-Viseme	HMM+LF	2-2	1.99	0.72
A-QS	**Phoneme**	**MS-HMM**	**2**	**1.95**	**0.74**

LF: Late Fusion, MS: Multistream





Maximum A Posteriori Estimation

Time t, state i:

$$y_t = A_i x_t + \varepsilon_t$$

Maximum A Posteriori articulatory parameter estimate:

$$\hat{x} = (\sigma_x^{-1} + A_i^T Q_i^{-1} A_i)^{-1}(\sigma_x^{-1}\bar{x} + A_i^T Q_i^{-1} y)$$

Q_i is the covariance of the approximation error

The prior of x is considered to be Gaussian determined at the training phase

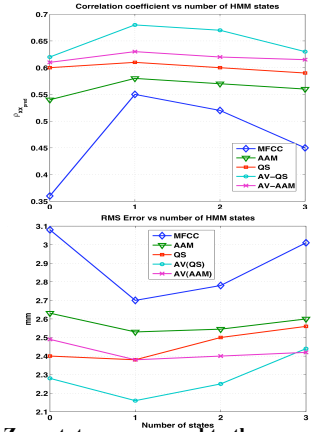
$$x_{prior} \sim N(\bar{x},\sigma_x)$$

Canonical Correlation Analysis

❑Analyze the co-variability of audiovisual and articulatory data
❑Determine the linear mappings by only keeping the first canonical correlation directions

Evaluation

❑Exploiting jointly audio and visual information in the proposed scheme clearly improves performance relative to either audio or visual- only estimation.



Zero states correspond to the case of a global linear model.

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