DATA-DRIVEN SYNTHESIS OF EXPRESSIVE VISUAL SPEECH USING AN MPEG-4 TALKING HEAD

Jonas Beskow & Mikael Nordenberg, 2006

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EVALUATION OF THE EXPRESSIVITY OF A SWEDISH TALKING HEAD IN THE CONTEXT OF HUMAN-MACHINE INTERACTION

Jonas Beskow & Loredana Cerrato,

2005

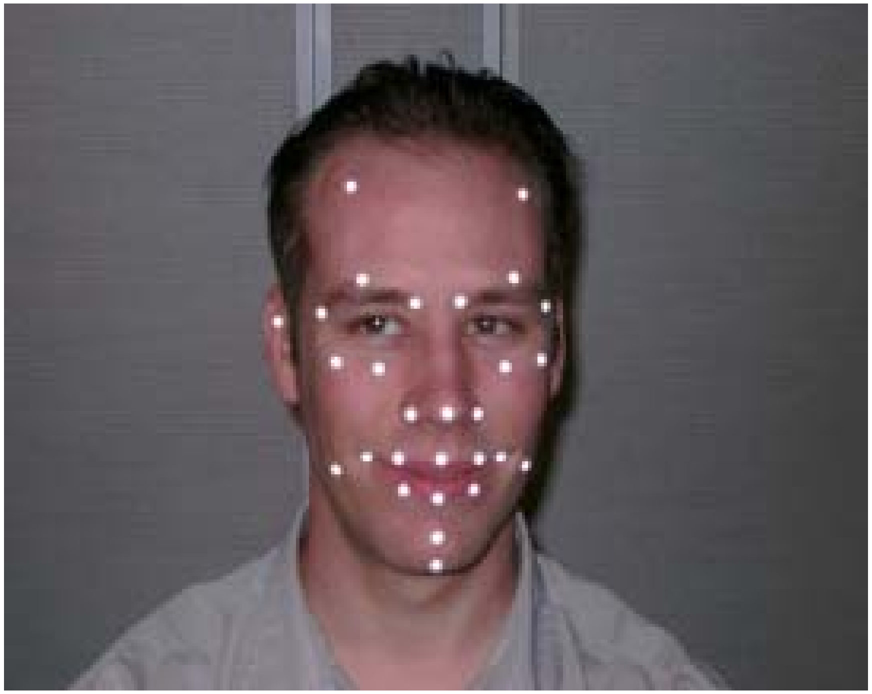
Synthetic Expressive Visual Speech

- Applications in web services, automated tutors, virtual avatars in computer games, animation
- Emotions modeled independently using principal components and coarticulated alongside synthetic speech

Develop emotionally indexed corpus of expressions

- 75 short sentences
- Each rendered with happiness, sadness, surprise, disgust, fear, anger, and neutral
- 525 total utterances
- 29 IR- sensitive markers attached to speaker's face
  - 4 reference markers on ears and forehead
  - Setup conforms to MPEG-4 feature point (FP) configuration
  - Sub-millimeter accuracy
  - 60 frames/second
- Sync signal fed into digital video and audio track

Marker placement on the face of a Swedish, amateur actor



Talking Head

- MPEG-4 facial animation standard
- Textured, 3D, male face with 15K polygons
- Face controlled by facial animation parameters (FAPs), corresponding to a number of feature points on the face.
- 68 FAPs are specified in MPEG-4, but 38 relevant FAPs were used in this work
  - Relevancy was empirically determined
- FAPs expressed in normalized FAPUs (Facial Animation Parameter Units) which take the distances between facial landmarks to normalize across specific facial models

Control of the Head

- Face is controlled by deformations applied to the FAPs
- Features like head and eye rotations use rotational deformation
- Other deformations are centered on one vertex
  - Surface distance to surrounding, outer vertices is calculated
  - Weighting function:
  - w = vertex weight, d = edge distance, r = FAP-specific influence radius

$$w = e^{\frac{-d^2}{r^2}}$$

Snapshots taken at 0.1 s from “I will buy…” (in Swedish)

- 1. Happy 2. Angry 3. Surprised 4. Sad

Cohen-Massaro model of coarticulation

- Each phonetic segment has a target vector of articulatory parameters
- These are smoothed over time using exponential growth and decay of parameters with slopes that can be adjusted for each parameter
- As such, parameters can be said to have a trajectory with different coefficients for growth and decay
- This study minimizes error between predicted and measured trajectories of individual features
  - Prior work had set the constants empirically

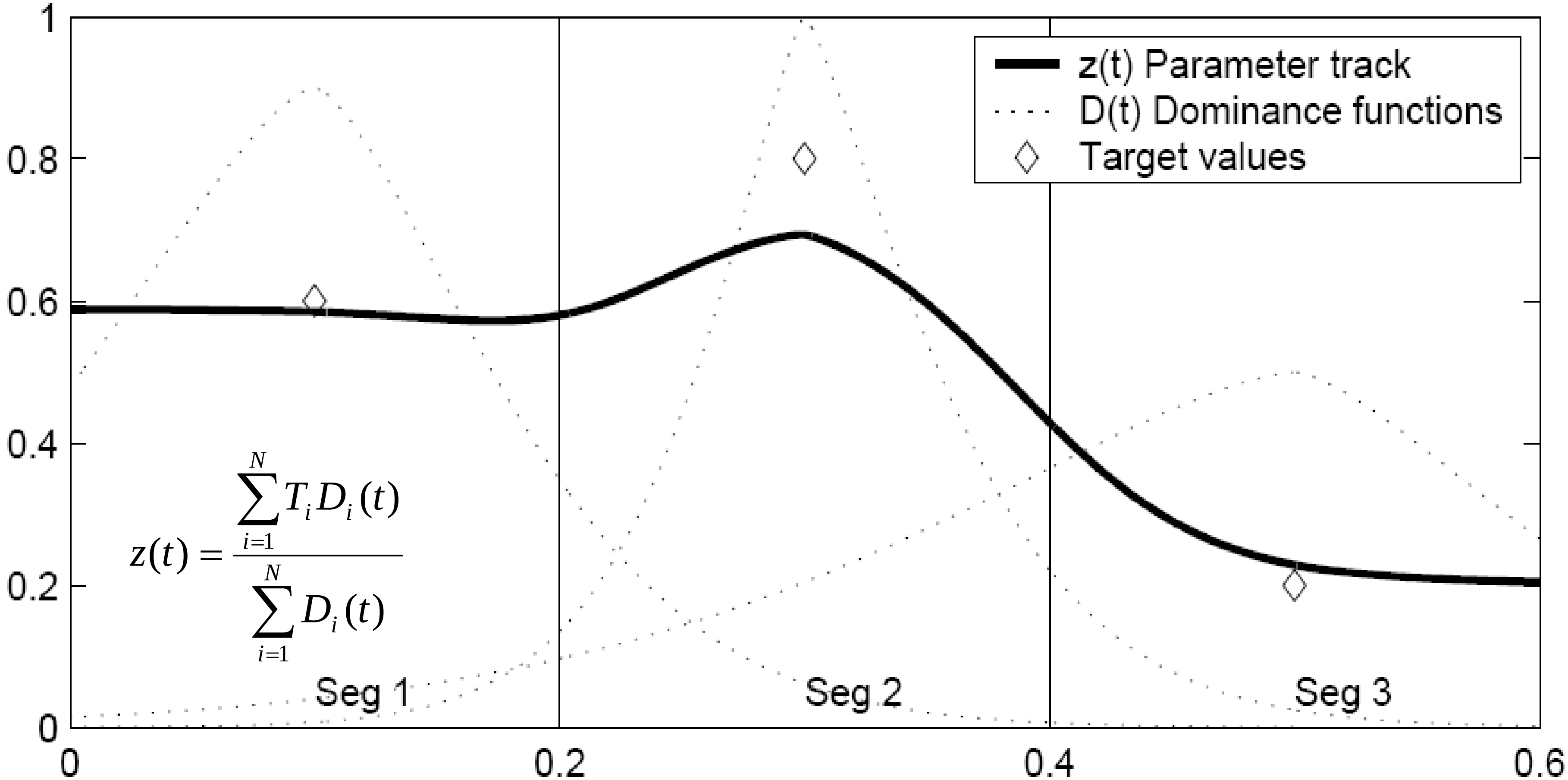


Figure 2 Cohen-Massaro model of a three-segment utterance

$$D_i(t)=\begin{cases} A_i e^{-\theta_i(\tau_i - t)^{c_i}} & t < T_i \\ A_i e^{-\varphi_i(\tau_i - t)^{c_i}} & t \geq T_i \end{cases}$$

Ti – target value

Di(t) – dominance function

Modeling and Synthesis

- Principal component analysis (PCA) performed to reduce co-dependency between adjacent points on face and therefore neighboring FAPs
- Top 10 principal components explain 99% of FAP variation in acted data stream
- 5 separate models trained: happy, sad, angry, surprised, neutral using Gauss-Newton minimization function `fminunc` in Matlab iteratively until the error stopped decreasing
  - Of about 70 sentences for each emotion, 10 used for testing and rest used for training
- Control models created and later integrated with articulation algorithms to produce novel Swedish speech

Tesings

- Models used to synthesize animations in sync with synthesized versions of text sentences
- For 10 test subjects with 4 categories: happy, angry, sad, or neutral
  - 73% happy accurately recognized
  - 60% angry accurately recognized
  - 40% sad accurately recognized
- Viable eyebrow motions arose from training, were especially effective for anger