Muscle Based facial Modeling

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Facial Modeling Techniques

- Facial modeling/animation
  - Geometry manipulations
    - Interpolation
    - Parameterizations
    - finite element methods
    - muscle based modeling
    - visual simulation using pseudo muscles
  - Image manipulations

Muscle Based Modeling

- Three categories
  - mass-spring systems
    - propagate muscle forces in an elastic spring mesh
    - Single layer spring mesh
  - vector representation
    - Definitions of muscle models
    - A very successful muscle model was proposed by Waters
  - layered spring meshes
    - extends a mass-spring structure into three connected mesh layers
    - More accurate thus more computational cost

Vector representation

- **A Facial Expression Parameterization by Elastic Surface Model**
- A muscle model for animating three-dimensional facial expression
- Analysis and synthesis of facial expressions with hand-generated muscle actuation basis
- Realistic modeling for facial animation

A Facial Expression Parameterization by Elastic Surface Model

- A novel parameterization of facial expressions is introduced
- Parameters can be learned from existing face models or created from scratch
- Obtained parameters can be applied on target face to generate similar expressions on the target models
- Adopt a muscle-based animation system to obtain the parameters indirectly

Presentation Outline

- Elastic skin model
- Facial Parameter Estimation
- Facial Expression Cloning
- Facial Deformation by Muscle Contraction

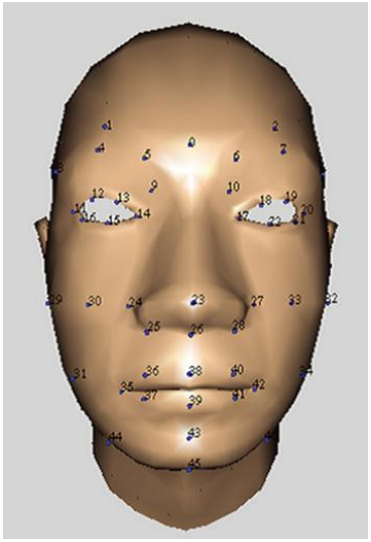
Elastic skin model

- By minimizing the elastic energy, we get

$$-k_s \Delta d + k_b \Delta^2 d = 0, \quad p_i \notin H \bigcup F,$$

$$d(p_i) = d_i, \quad p_i \in H,$$

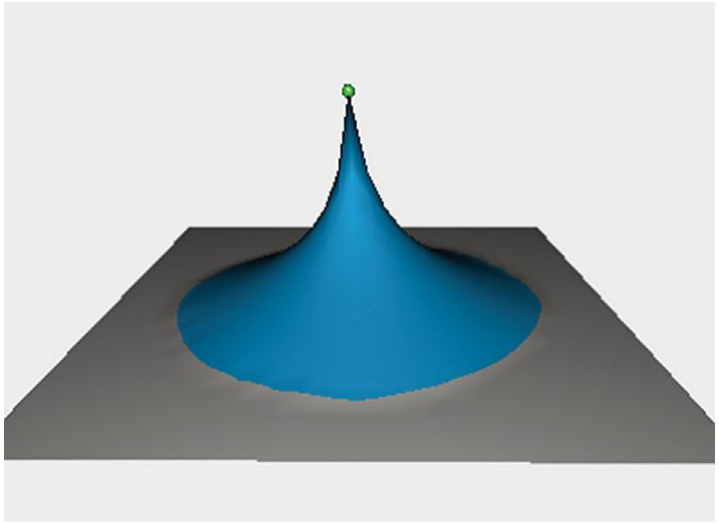
$$d(p_i) = 0, \quad p_i \in F,$$

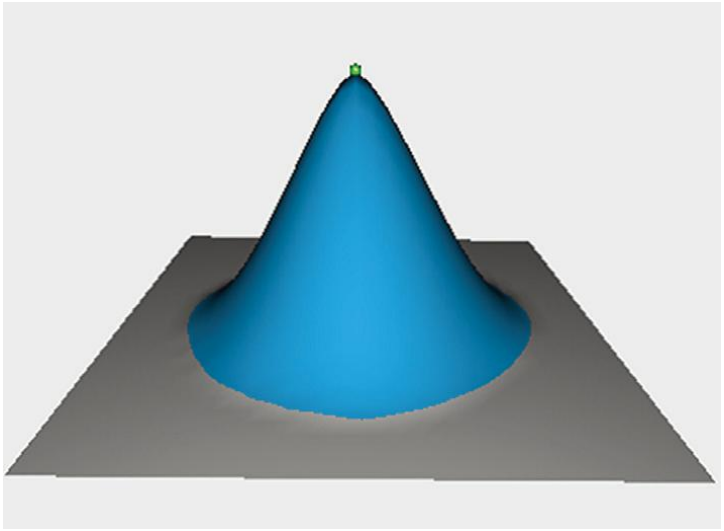


  - d is the displacement
  - ks and kb are stretching and bending parameters
  - H is the handle vertices, and F is the fixed vertices

Elastic skin model

- Results of deformation for two extreme cases
  - Pure stretching (ks = 1, kb = 0)
  - Pure bending (ks = 0, kb = 1)
  - We use the pure bending in facial animation





Facial Parameter Estimation

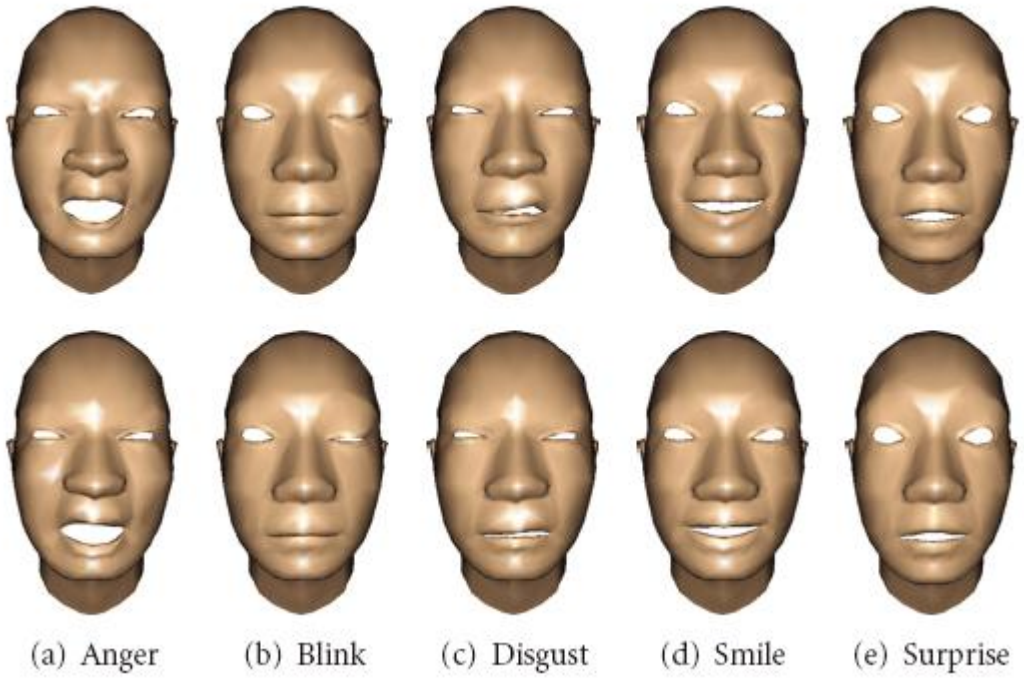
- After some math, we get

$$\begin{pmatrix} d(P_H) \\ d(P_F) \\ d(P) \end{pmatrix} = \begin{pmatrix} B_1 & B_2 & \cdots & B_m \end{pmatrix} \begin{pmatrix} d_1 & d_2 & \cdots & d_m \end{pmatrix}^T,$$

  - m is the number of handle points
  - {Bi} are determined by handle points
  - {di} are facial parameters can be computed by using least square approximation method
  - {di} are corresponding to facial expression

Facial Parameter Estimation

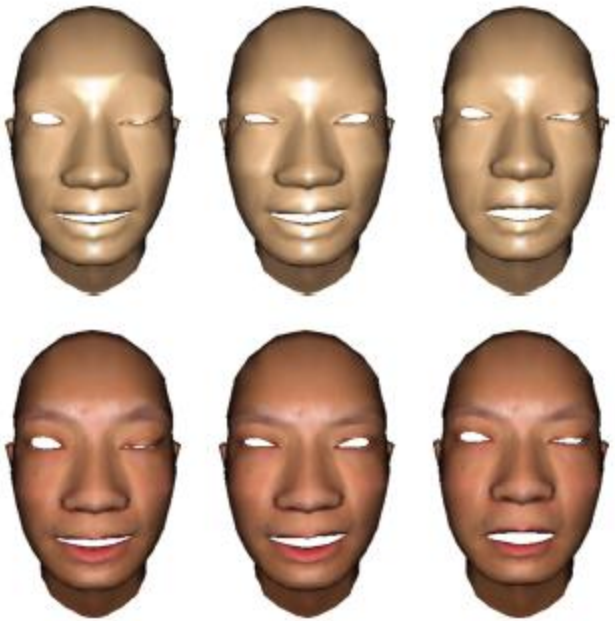
- Generated face models by applying facial parameters
  - Original
  - Generated



Facial Parameter Estimation

- Facial Expression Blending

$$\begin{pmatrix} d(P_H) \\ d(P_F) \\ d(P) \end{pmatrix} = \begin{pmatrix} B_1 & B_2 & \cdots & B_m \end{pmatrix} \times \begin{pmatrix} \Sigma w_k d_1^k & \Sigma w_k d_2^k & \cdots & \Sigma w_k d_m^k \end{pmatrix}^T,$$



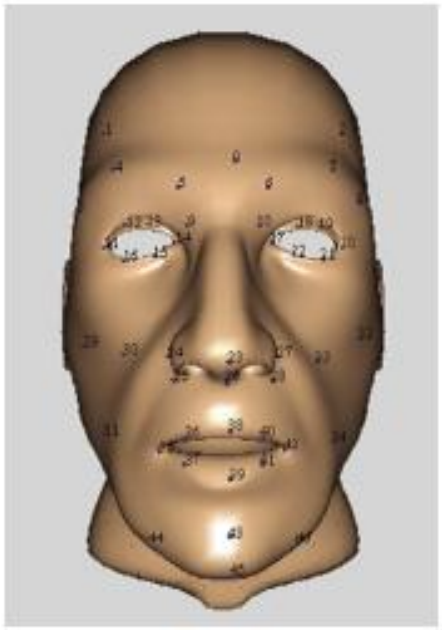
(a) Smile + blink (b) Smile + disgust (c) Mixed expression

Facial Expression Cloning

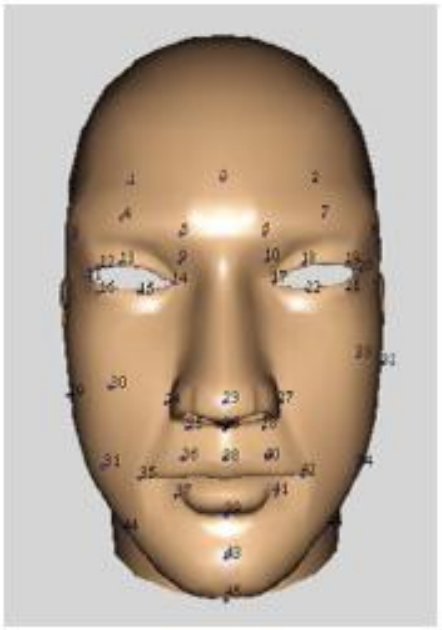
- Expression cloning copies expressions of a source face model onto a target face model
- The mesh structure of the models needs not to be the same
- Our proposed facial parameterization can be used for this purpose

Facial Expression Cloning

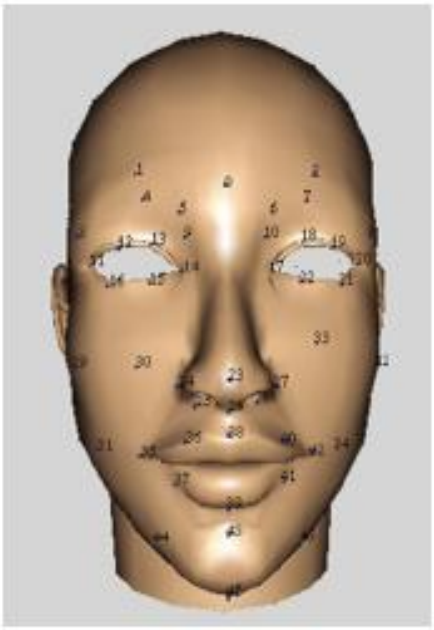
- Selects the facial control points on the targets



(a) Target model 1



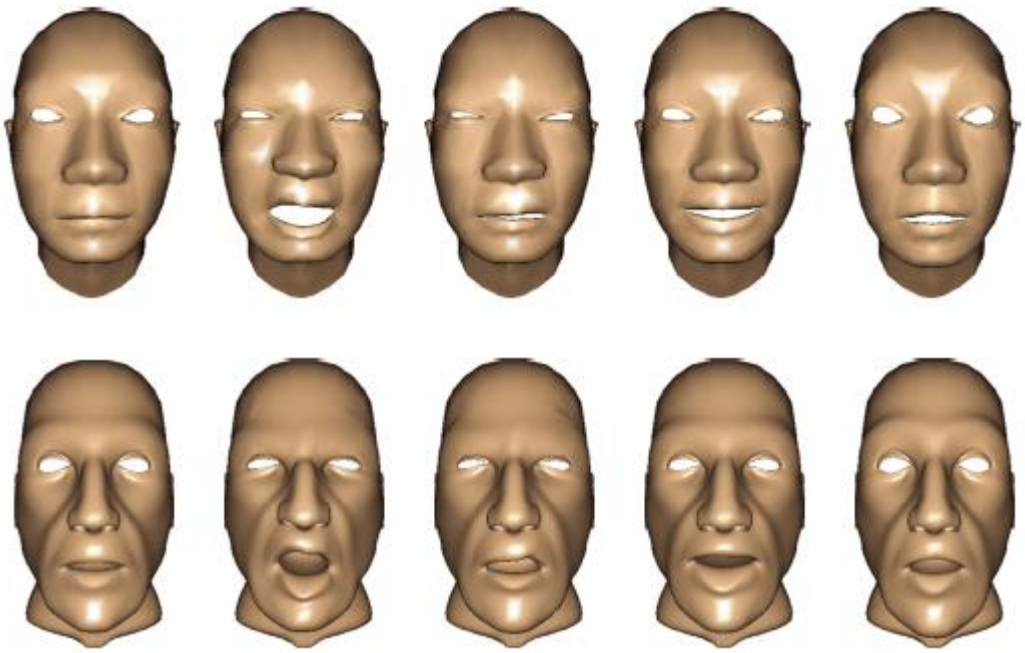
(b) Target model 2



(c) Target model 3

Facial Expression Cloning

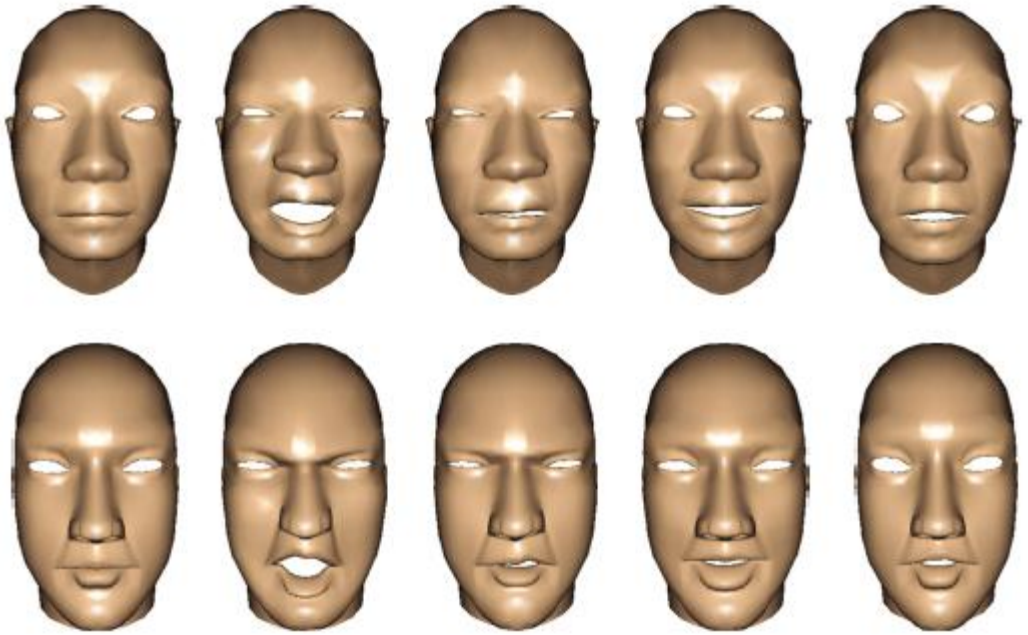
- Target models generated by expression cloning



(a) Neutral (b) Anger (c) Disgust (d) Smile (e) Surprise

Facial Expression Cloning

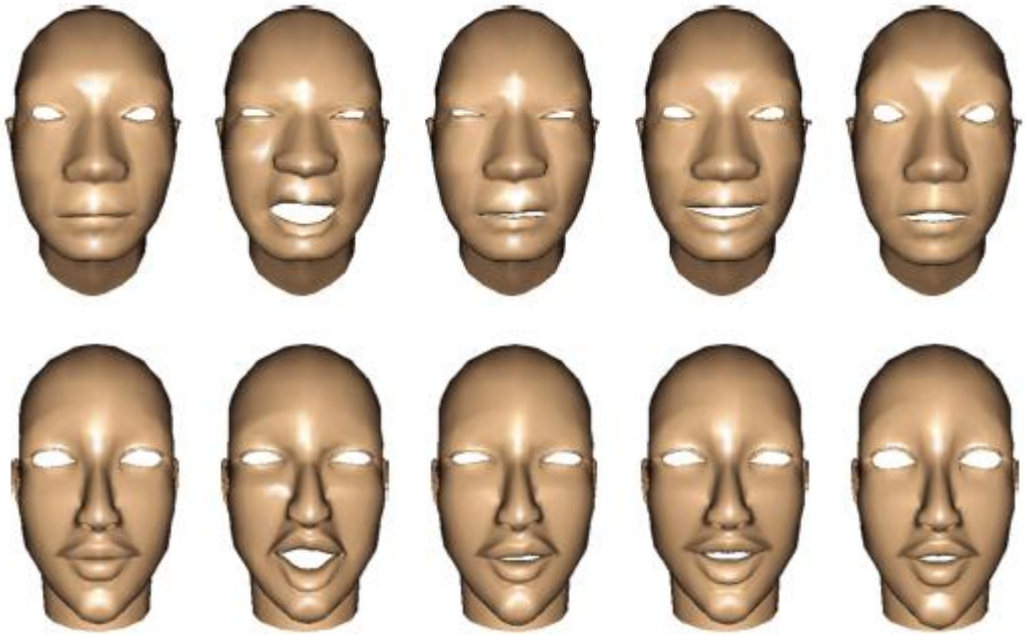
- Target models generated by expression cloning



(a) Neutral (b) Anger (c) Disgust (d) Smile (e) Surprise

Facial Expression Cloning

- Target models generated by expression cloning



(a) Neutral (b) Anger (c) Disgust (d) Smile (e) Surprise

Facial Deformation by Muscle Contraction

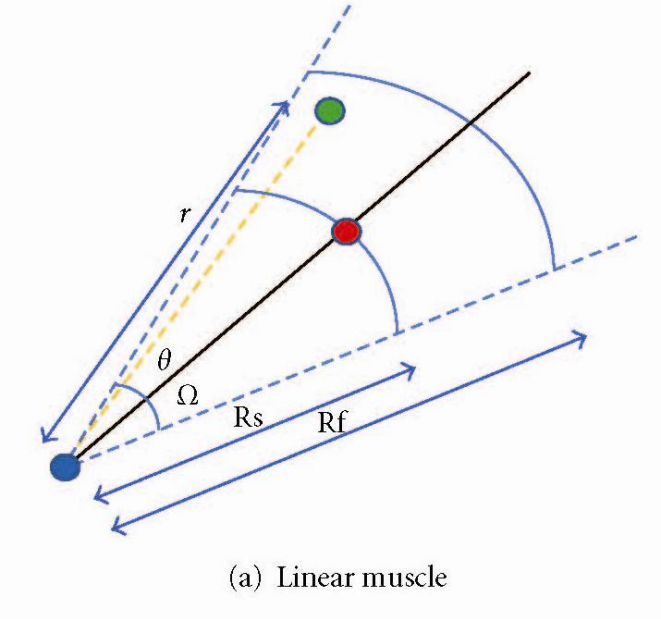
- Recall the function of Parameter Estimation

$$\begin{pmatrix} d(P_H) \\ d(P_F) \\ d(P) \end{pmatrix} = \begin{pmatrix} B_1 & B_2 & \cdots & B_m \end{pmatrix} \begin{pmatrix} d_1 & d_2 & \cdots & d_m \end{pmatrix}^T,$$

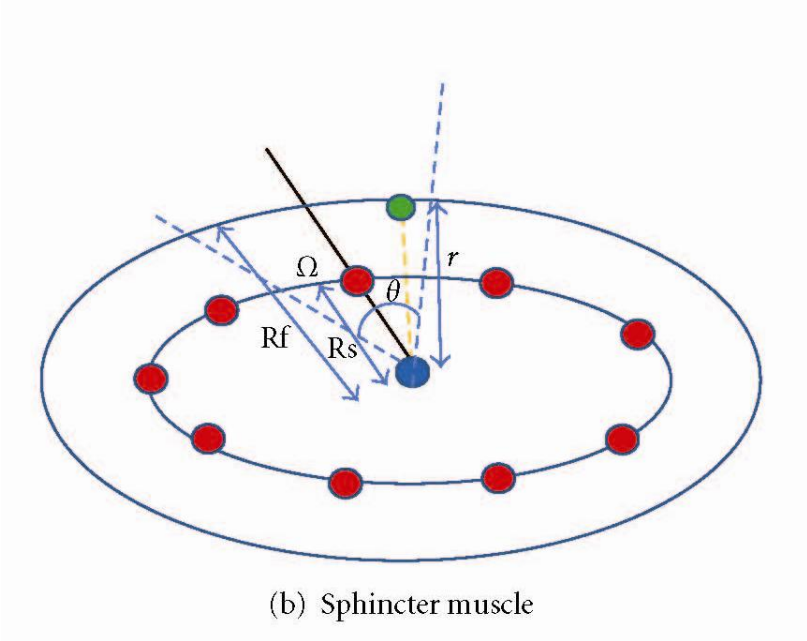
- The base function {Bi} represents characters of face model with neutral expression
  - {Bi} represent muscle configurations (zone of maximum and minimum influences, etc.)
  - {di} represent amounts of muscle contractions

Facial Deformation by Muscle Contraction

- Two types of muscles
  - Linear Muscle
  - Sphincter Muscle



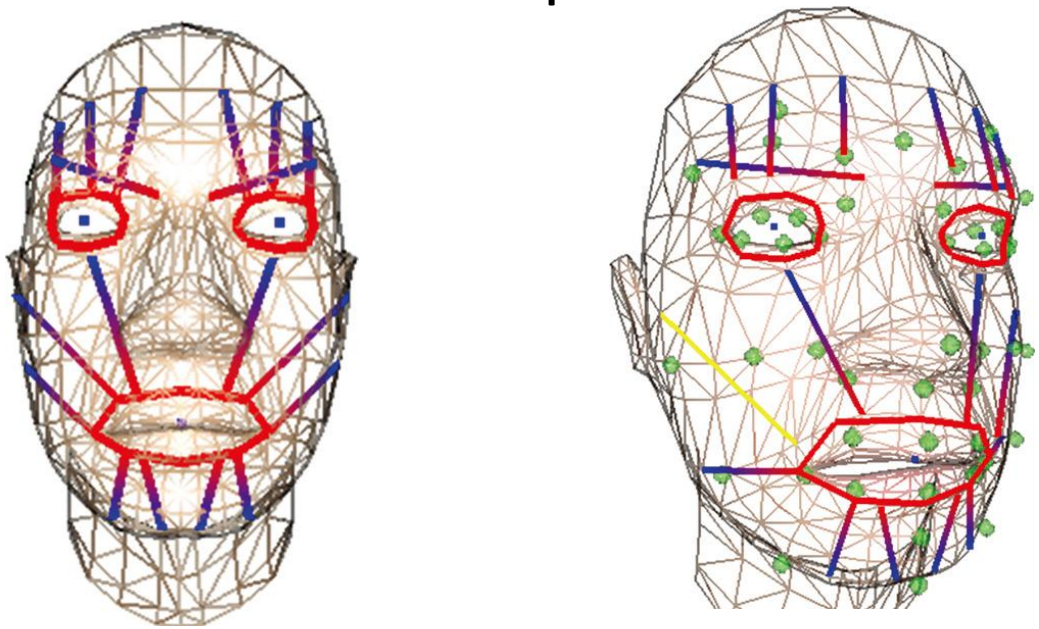
(a) Linear muscle



(b) Sphincter muscle

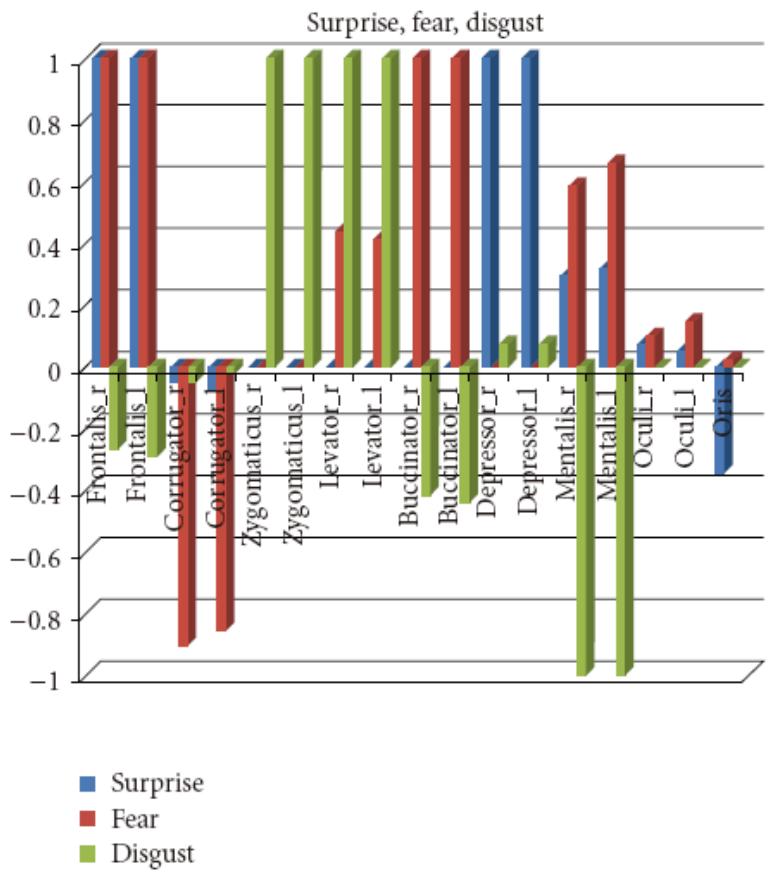
Facial Deformation by Muscle Contraction

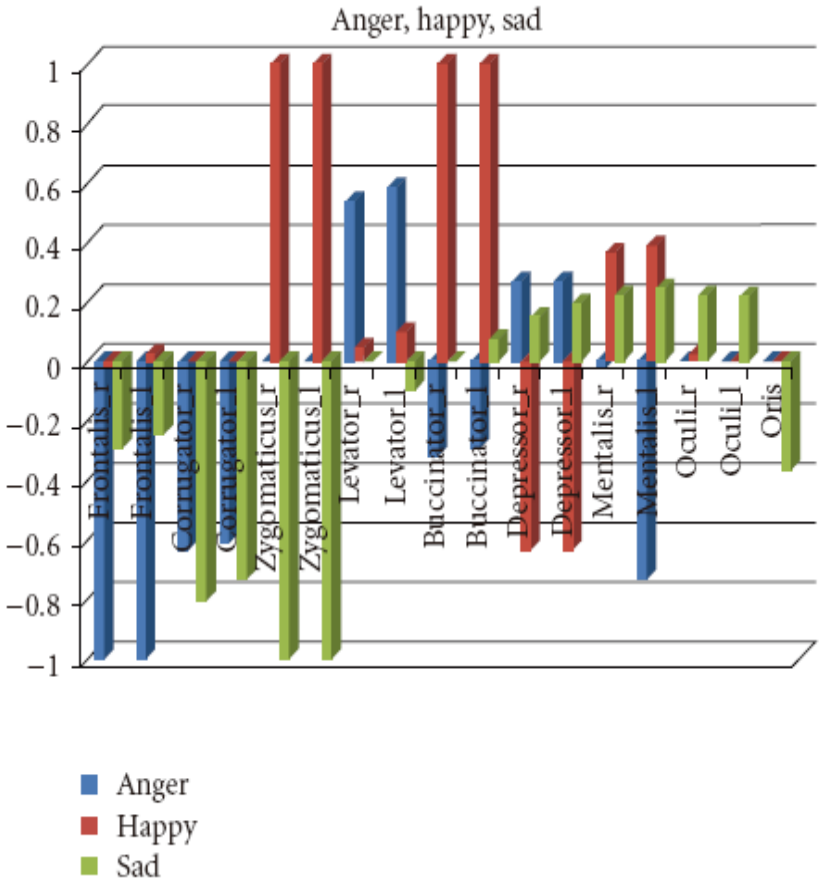
- Facial Muscle Registration
- Facial Expression by Muscle Contraction
  - Define 47 control points in human face
  - Impacted via control points



Facial Deformation by Muscle Contraction

- Amounts of muscle contraction for expressions





List of Papers

- [1] J. Noh and U. Neumann, “A survey of facial modeling and animation techniques,” Technical Report 99-705, USC, 1998.
- Research Article - A Facial Expression Parameterization by Elastic Surface Model.
- B. Choe and H.-S. Ko, “Analysis and synthesis of facial expressions with hand-generated muscle actuation basis,” in *ACM SIGGRAPH Courses, 2006.*
- H. Pyun, Y. Kim, and W. Chae, “An example-based approach for facial expression cloning,” in *Proceedings of the ACM SIGGRAPH/Eurographics Symposium on Computer Animation,* pp. 167–176, 2003.