Facial Animation

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Outline

- Motivation
- History of facial animation
- Head anatomy
- Animation techniques (2D & 3D)
- Speech animation

Motivation Pictures

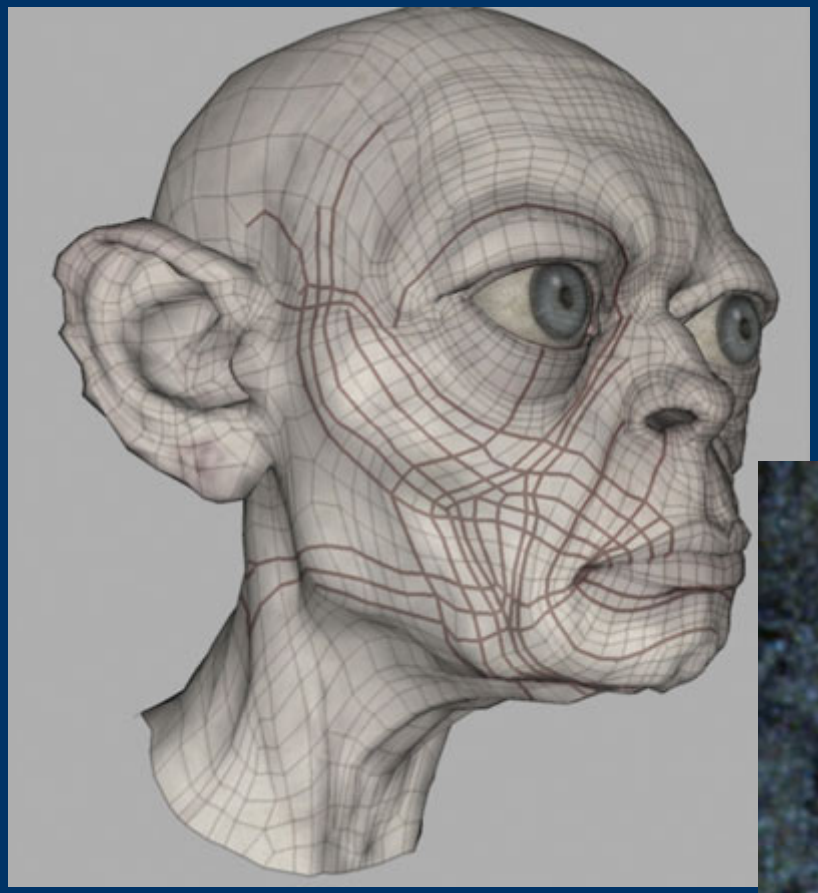


Photo courtesy New Line, http://www.newline.com

Motivation & Applications

- Entertainment and visual effects
- Interactive games

Photo courtesy Disney, www.disney.com

Motivation & Applications (cont.)

- Teleconferencing

Photo courtesy SeeStorm, www.seestorm.com

Motivation & Applications (cont.)

- Human computer interaction

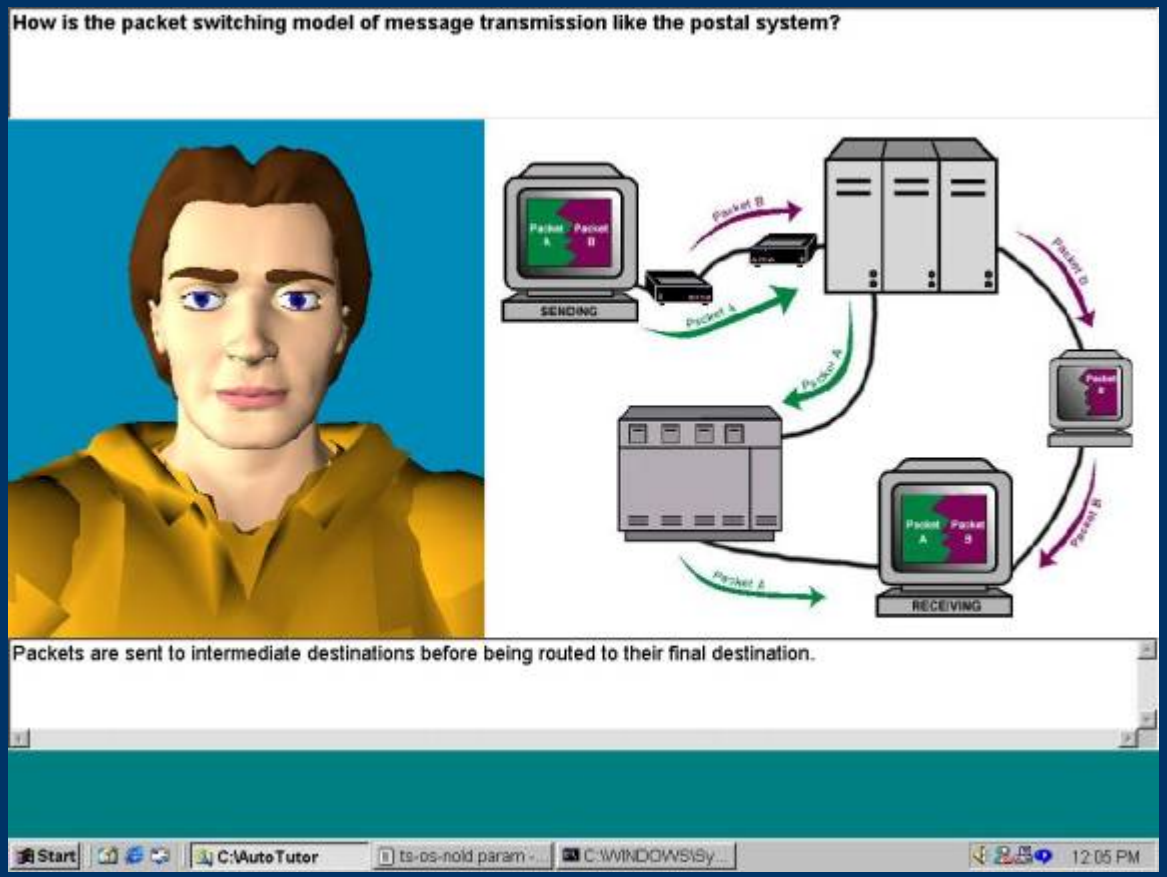


Photo courtesy Graesser C., Teaching Tactics and Dialog in AutoTutor

Motivation & Applications (cont.)

- Social agents, virtual reality

Photo courtesy SecondLife, www.secondlife.com

Motivation & Applications (cont.)

- Entertainment and visual effects
- Interactive games
- Teleconferencing
- Human computer interaction
- Social agents, virtual reality
- Perception research
  - McGurk effect (video)
  - Must be perceptually correct!

Challenges of Facial Animation

1) Creates realistic face animation
2) Operates in real-time
3) Animation is “fully” automated
4) Easy adaptation to individual faces

Brief history

- 1971 – Parke – Initial 3D polygonal faces (< 100 polygons)
- 1974 – Parke – First parametrized model, speech synchronized animation

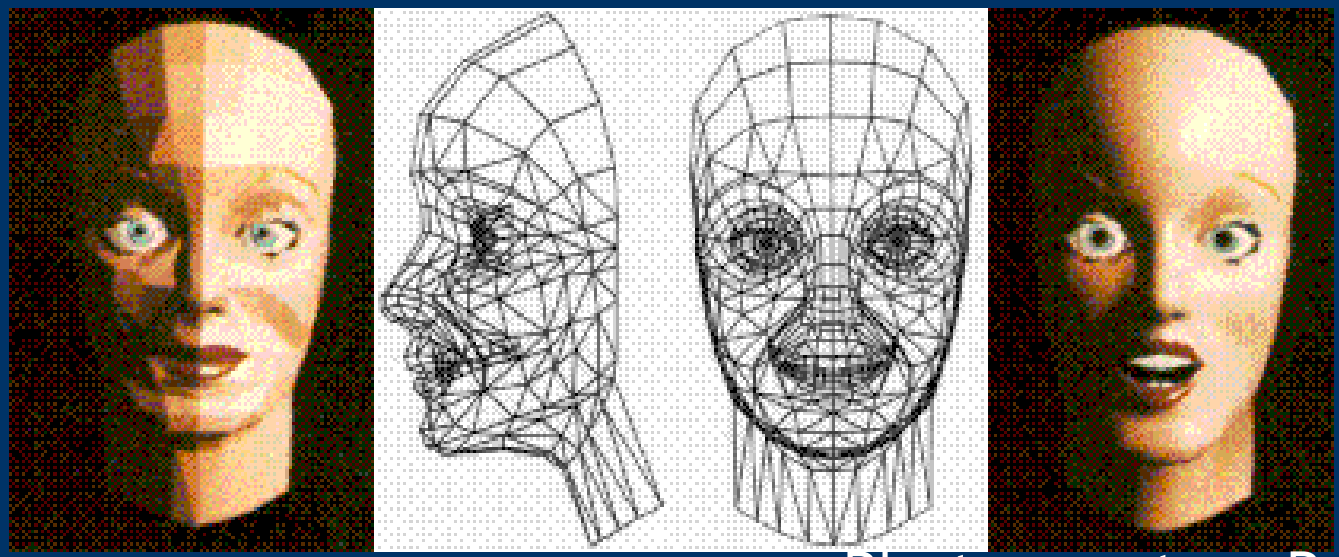
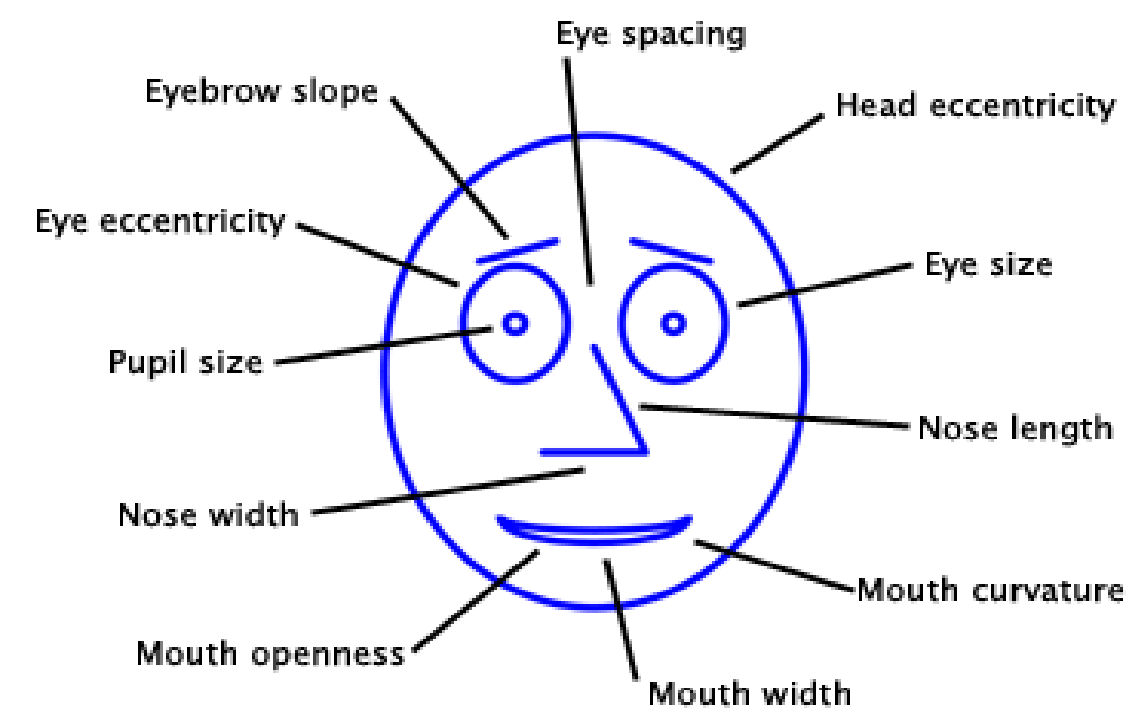


Photo courtesy Parke Frederic

Brief History (cont.)

- Chernoff's faces – representation of multi-dimensional data



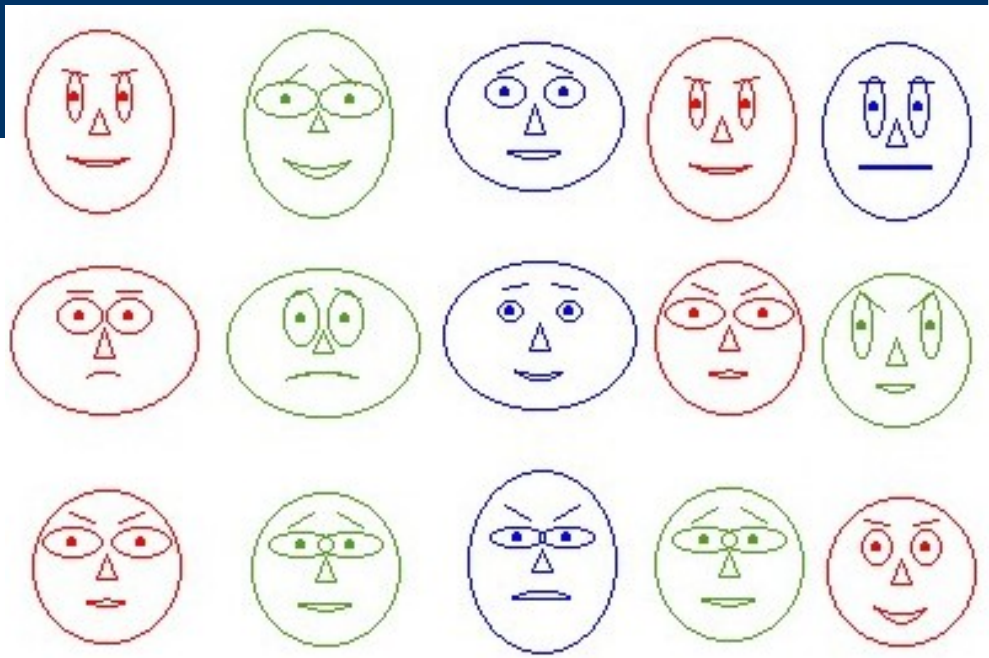


Photo courtesy http://mapmaker.rutgers.edu/355/links.html

Brief History (cont.)

- 1974 – Parke – First parametrized model, speech synchronized animation
- 1981 – Platt – First muscle simulation model
- 1980s
  - Lewis and Parke – Automatic speech synchronization
  - Waters – new muscle model
- 1990s – Pelachaud – Speech co-articulation

Brief History (cont.)

- 1990s – MPEG-4 Facial coding
- 2000s – Commercial successful
  - Computer games: Sims
  - Movies: Shrek, Final Fantasy, Lord of the Rings, StarWars Episode III, The Matrix Revolutions

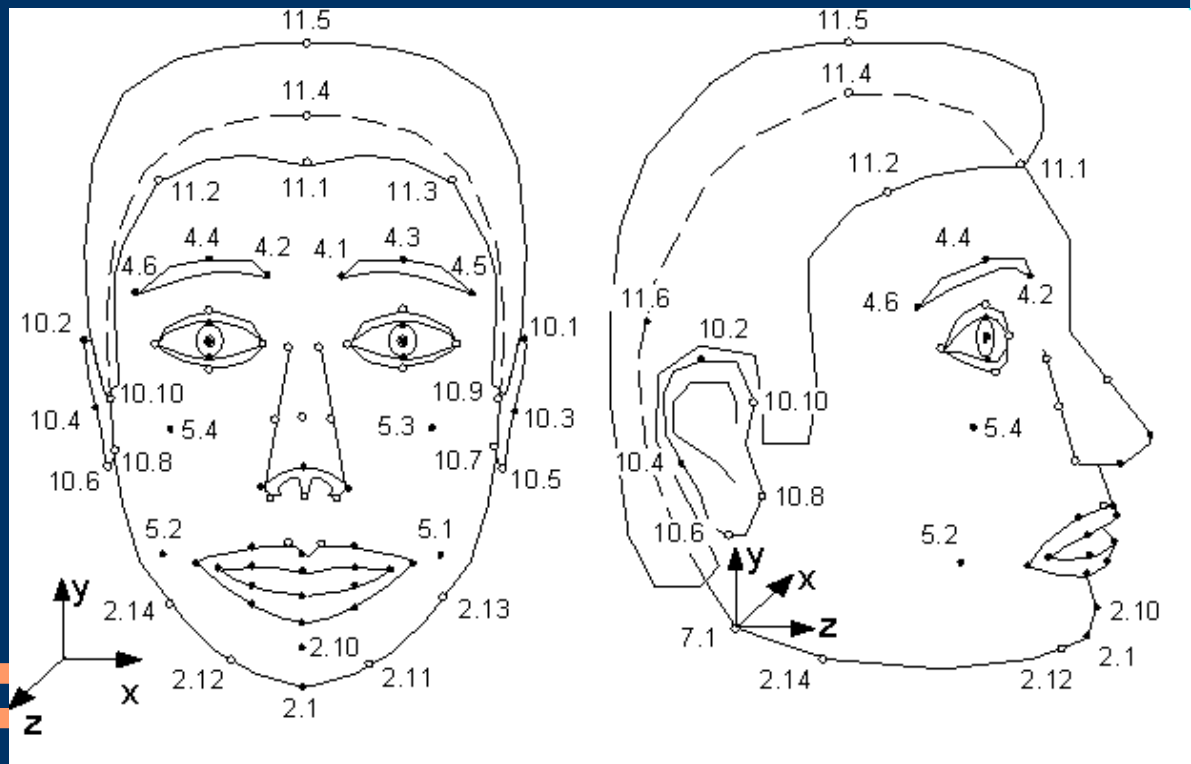


Photo courtesy
http://www.icp.inpg.fr/~elisei/

Head Anatomy

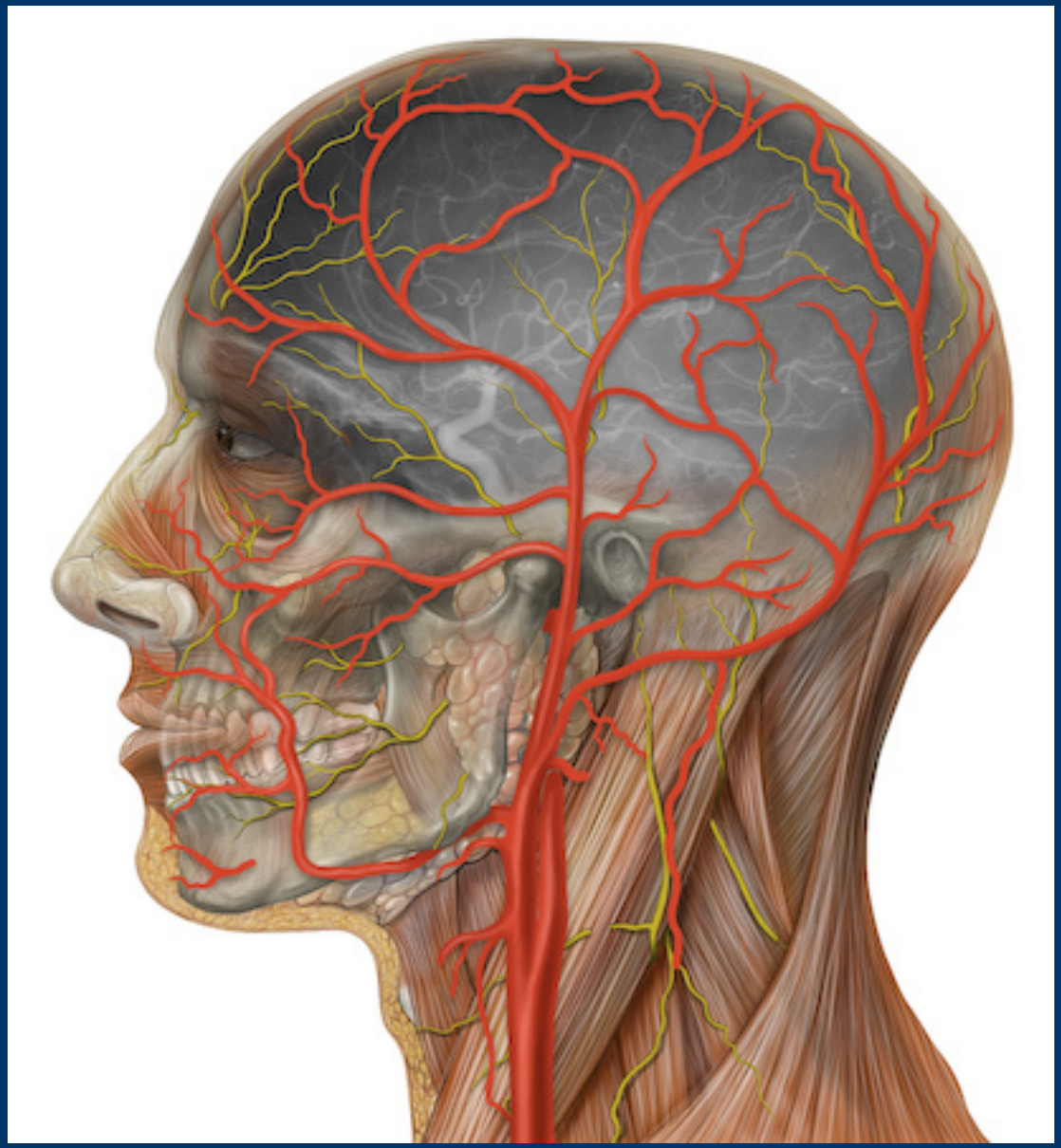
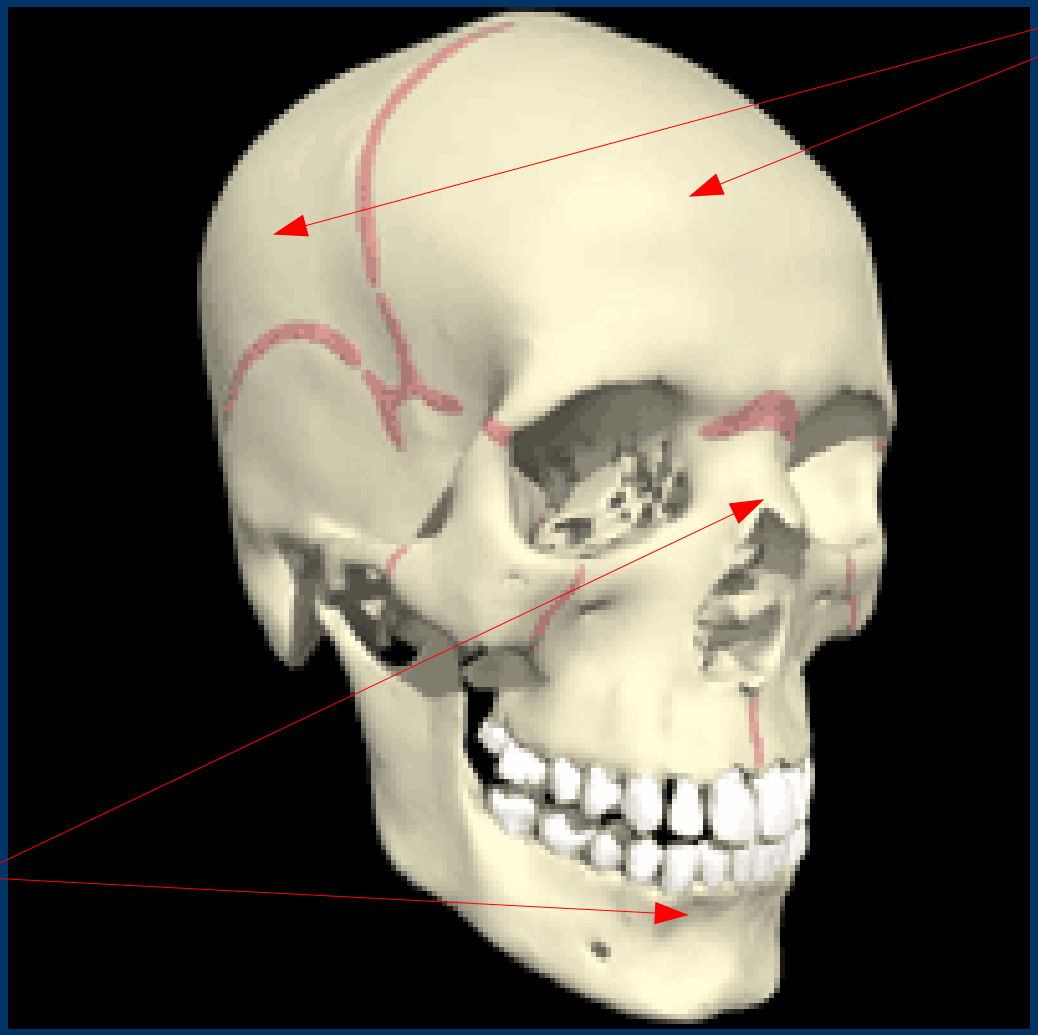


Photo courtesy,
http://www.flickr.com/photo/patrlynch/450142019/

Head Components (Topology)

- Skull
- Facial muscles
- Skin
- Eyes
- Teeth
- Tongue
- (Ears, Lips, Hair)

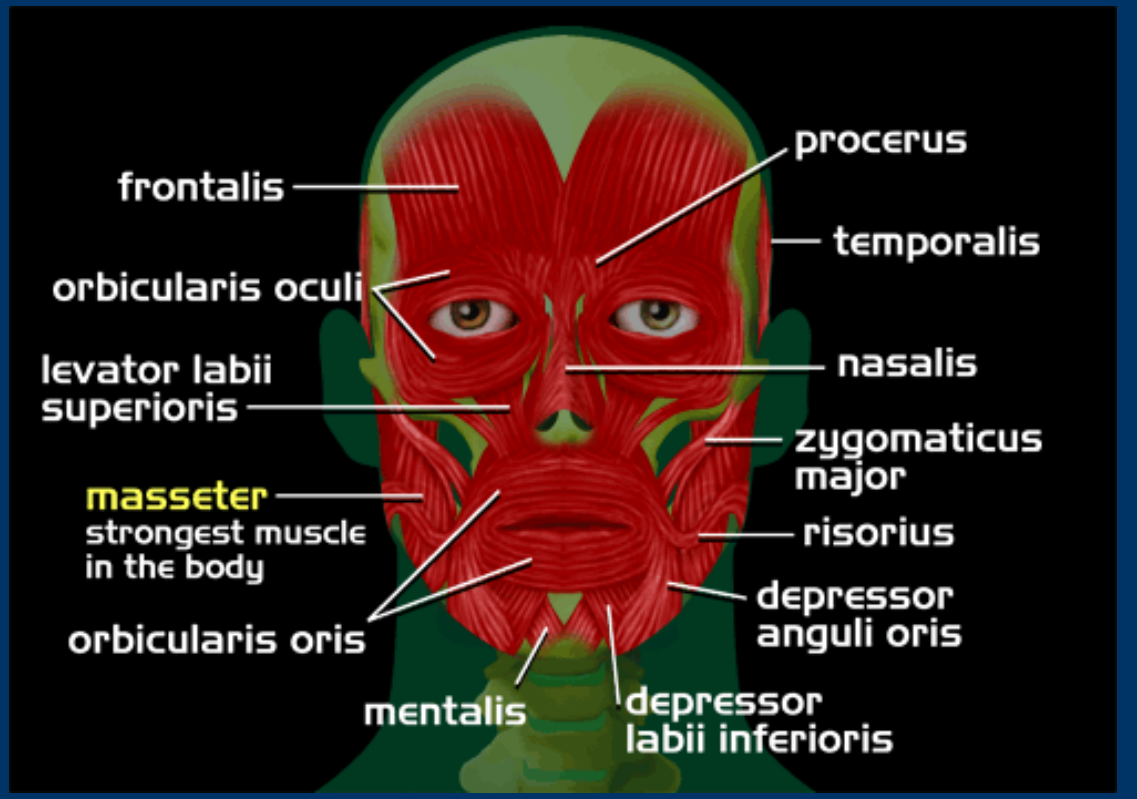
Skull



Picture courtesy AnatomyPix, www.anatomypix.com

Facial Muscles

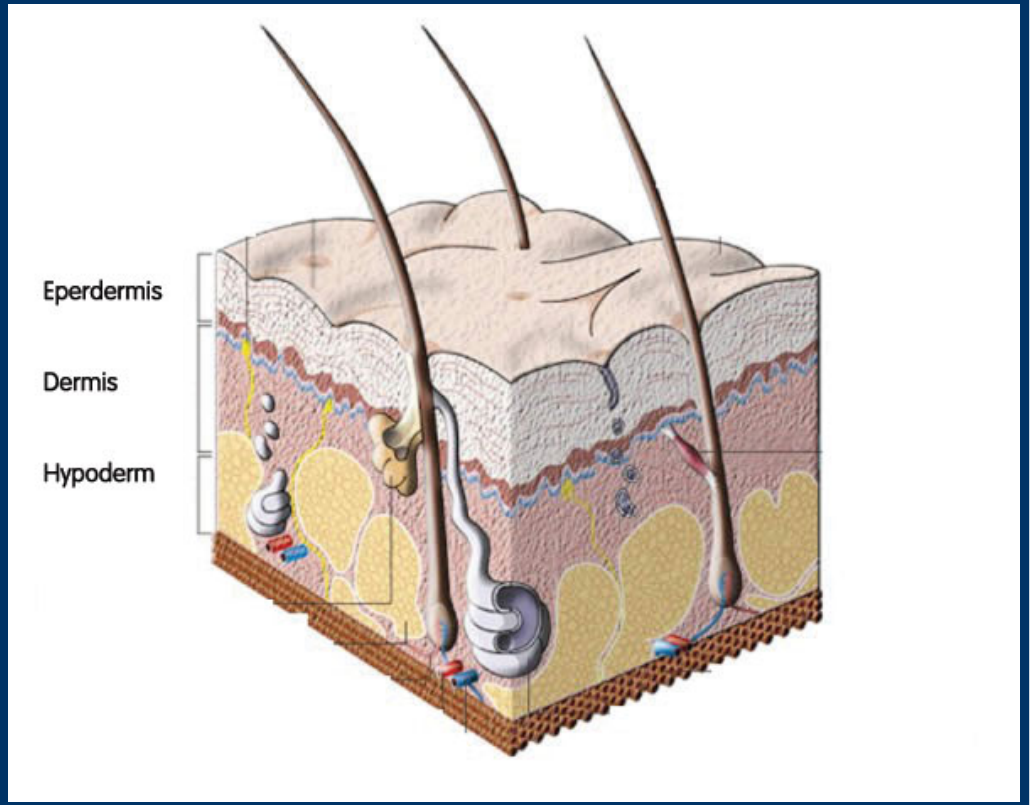
- Expression muscles
- 3 types
- Sphincter
  - Orbicularis oculi
- Linear
  - Zygomaticus
- Sheet
  - Frontalis

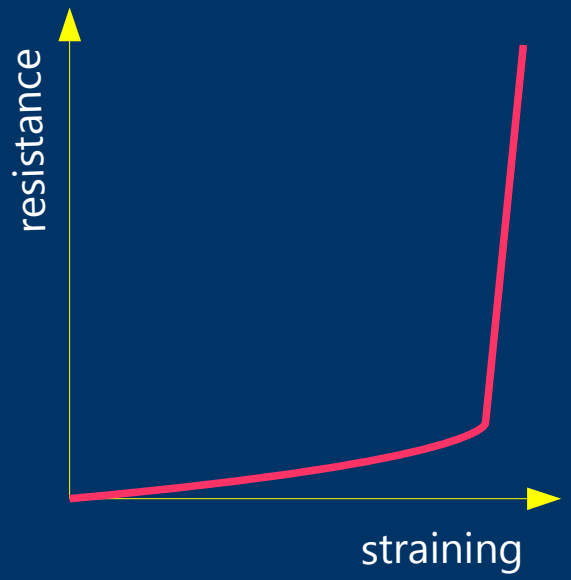


Pictures courtesy www.hbcprotocols.com

Skin

- 3 layers
- Elastic properties
- Non-linear strain curve





Picture courtesy Human D. R., http://www.hrsdc.gc.ca

Head anatomy (cont.)

- Look in the medical anatomy atlas !
- Knowledge of head anatomy ➔ Facial animation

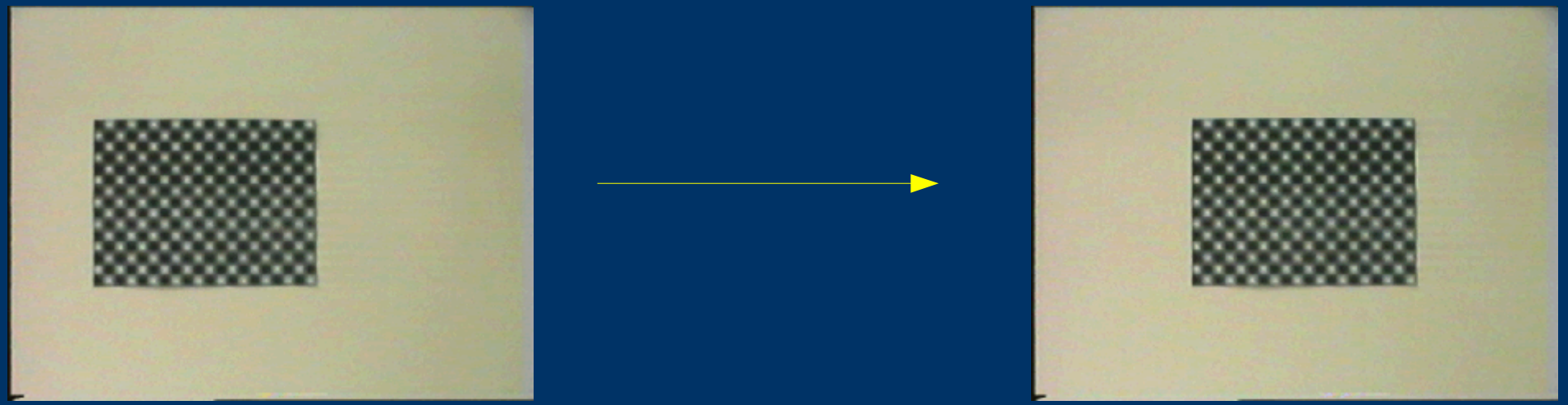
2D Facial Animation (video show)

- Source data and face representation = images or video
- Example: Ezzat – MikeTalk system, 1999
- Based on morphing keyframe images
- Keyframe represents part of speech

Picture courtesy Ezzat MikeTalk system

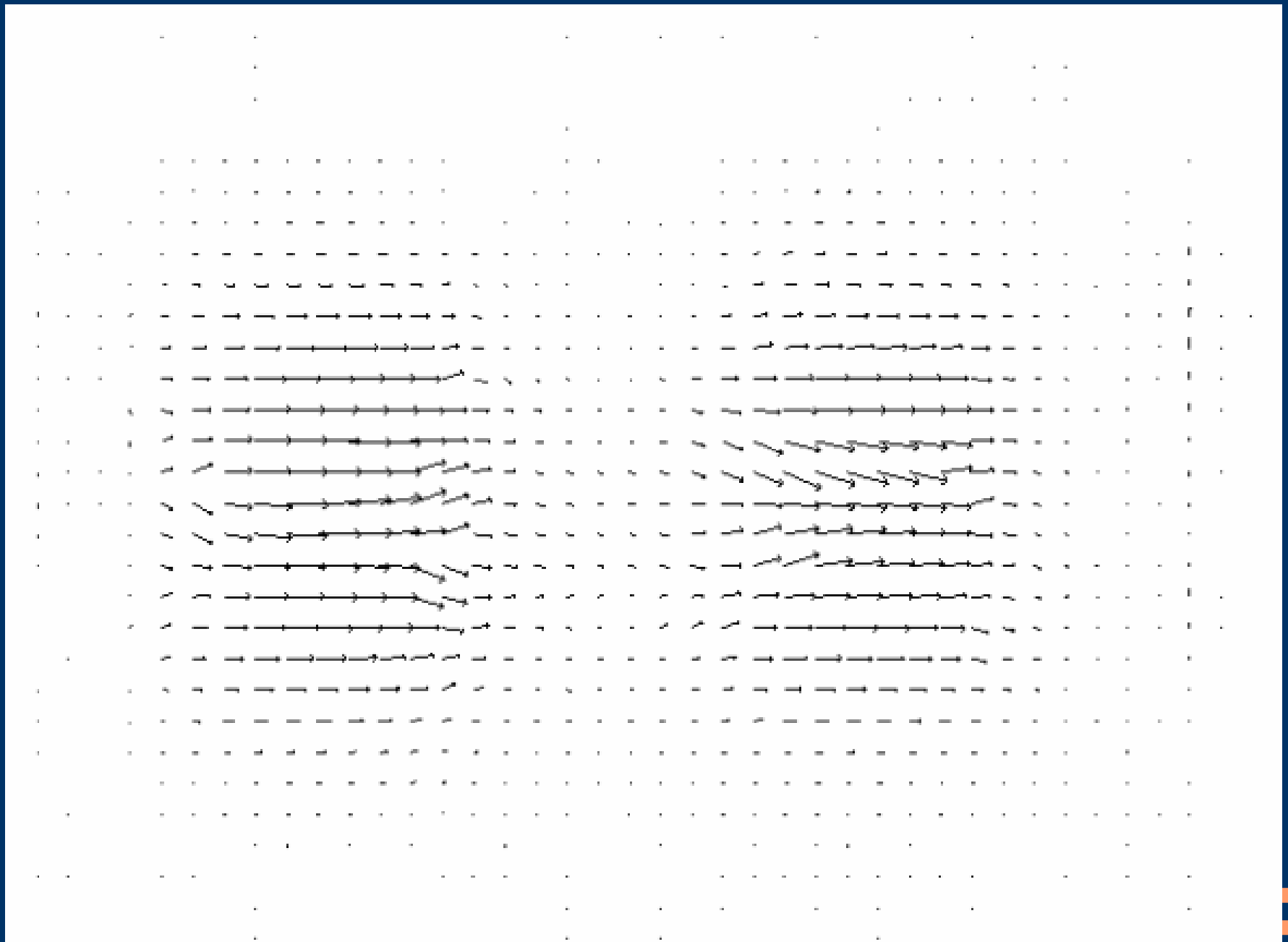
Optical flow algorithm

- How to change one image to another?
- Computer vision algorithm
  - For all image combinations enumerate motion vectors (optical flow)



Picture courtesy http://www.codeproject.com/cs/media/Optical_Flow_Estimation.asp

Optical flow (motion vectors)



2D Facial Animation (cont.)

Advantages

- Videorealistic
- Fairly simple head appearance change

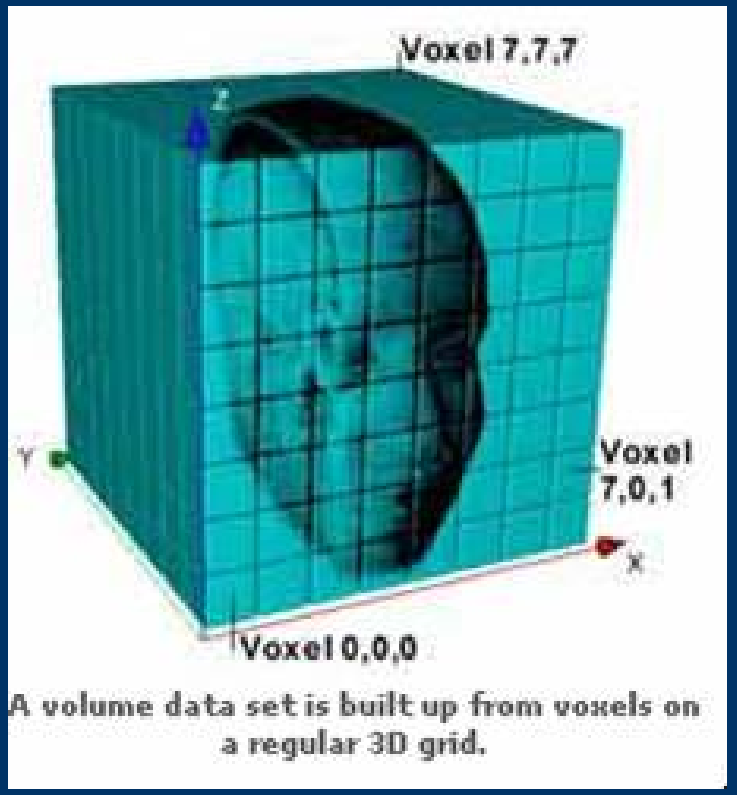
Disadvantages

- Constrained head manipulating
- Photo stability
- Image transition ➔ pixels move ➔ holes !

3D Head Representation

Volume representations
- Voxel representation

Surface representations
- NURBS surfaces
- Polygonal surfaces

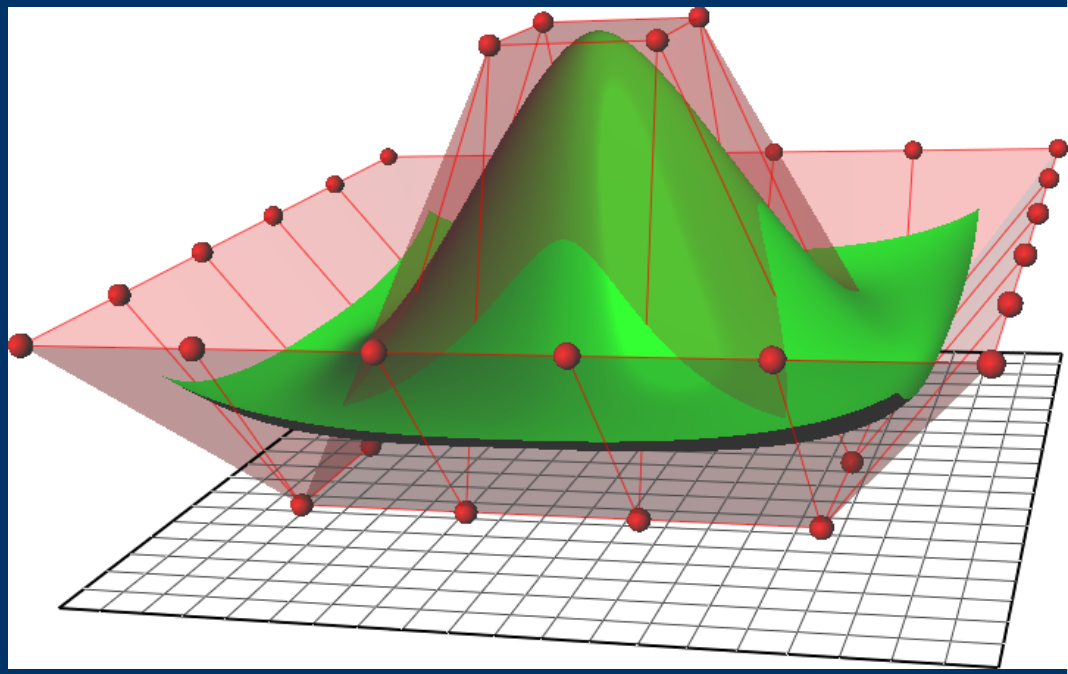


A volume data set is built up from voxels on a regular 3D grid.

Picture courtesy http://www.science.mcmaster.ca/biochem/faculty

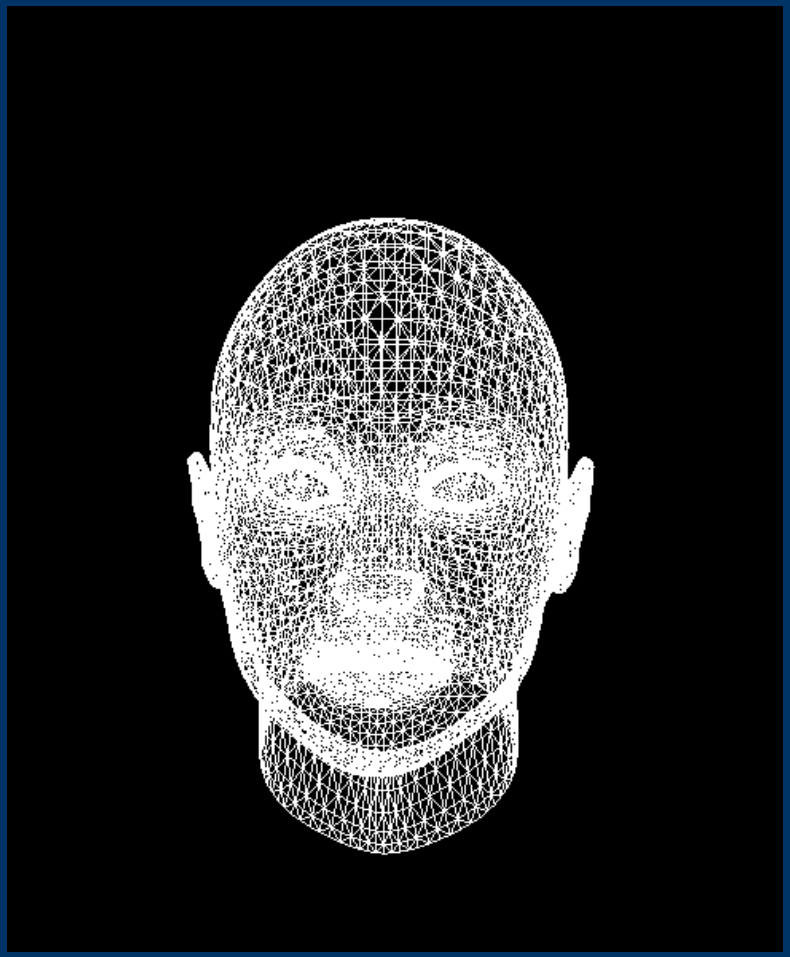
NURBS Surfaces

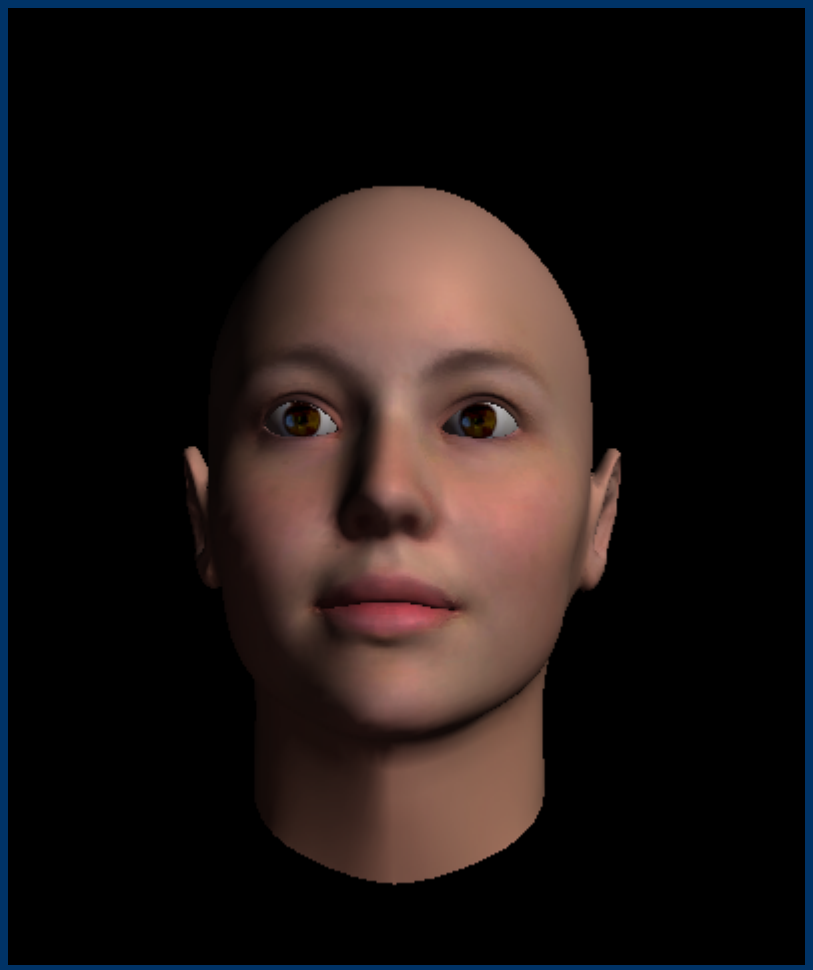
- Non-Uniform Rational B-Spline
- Curves and surfaces
- Order
- Knot vector
- Set of weighted points



Picture courtesy www.wikipedia.org

Polygonal Head Representation





Animation Controlling

- Performance animation – real actor
- Synthetic animation – animation fully controlled by artist/programmer

Performance Driven Animation (video)

- Motion of real human head is detected
- Transferred to head model
- Motion capture – marked feature points on real face
- Problem with data quality – vibrations

Picture courtesy http://graphics.stanford.edu/~echuang/face/

Morph Targets (animation)

- Each facial expression = one polygonal model (morph target, shape)
- Animation – interpolation between morph targets
- Morph targets produced by artist
- Disadvantage: Manual labour !

3D Key-frame Interpolation

Linear interpolation:

$$interpolated = (1-t)*key\_1 + t*key\_2$$

- $0 <= t <= 1$
- Interpolated value – color, vertex position, …

Non-linear interpolation

- Spline, cosinus, sinus
- Acceleration, slowdown – Better!

Interpolation Example

KEY1 INTERPOLATED KEY2

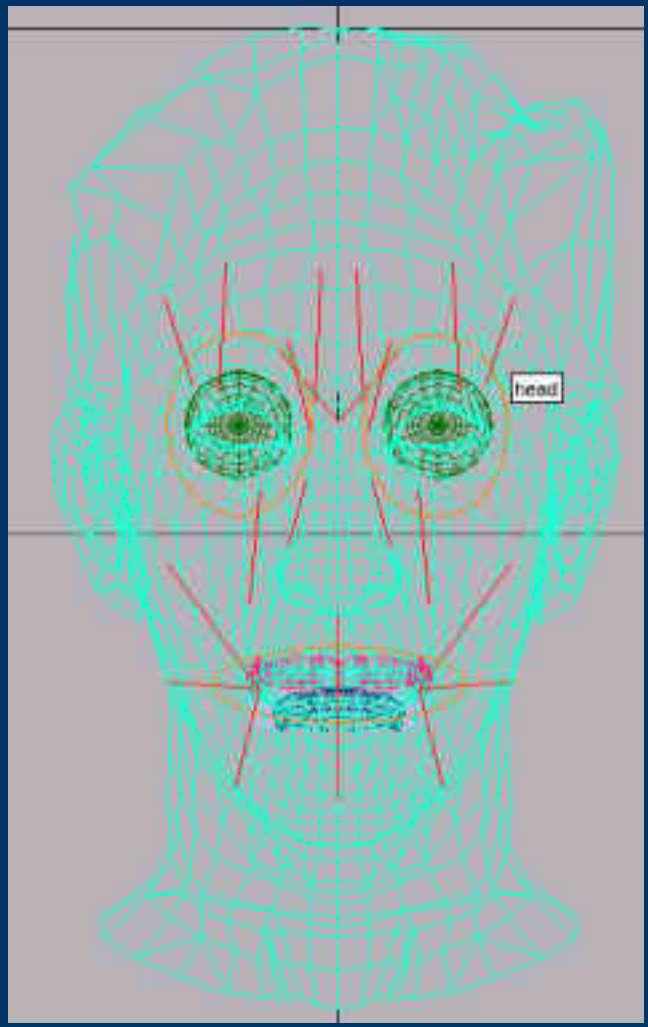
Pictures courtesy Jun-yong Noh, Survey of Facial A.

Parametric Models

- Face expression is defined by vector of parameters
- Control parameters deforms local regions
- First – Parke parametrized model:
  - Expression parameters: view direction, shape of eyebrows, shape of mouth, ...
  - Conformation parameters: eyes position, nose length, skin colour
- Animation = Interpolation of parameters

Waters Parametrized Model

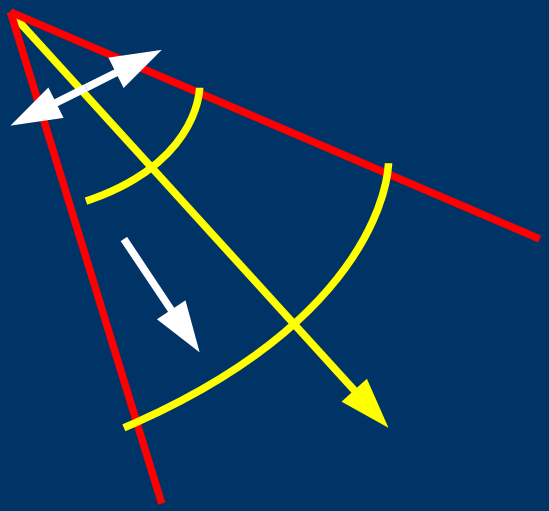
- Pseudo-muscle model
- Defined approximation of human facial muscles (orig. 10 muscles, ext. 20 muscles)
- Each expression = Combination of contraction muscle parameters



Picture courtesy http://expression.sf.net

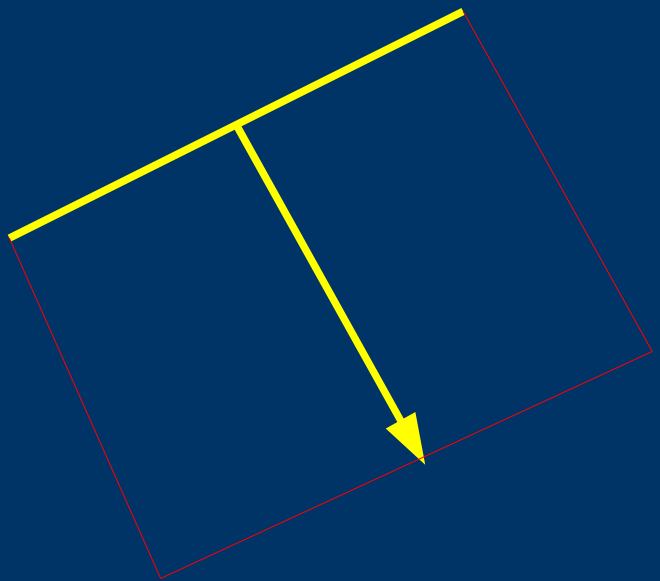
Waters Pseudo-muscles

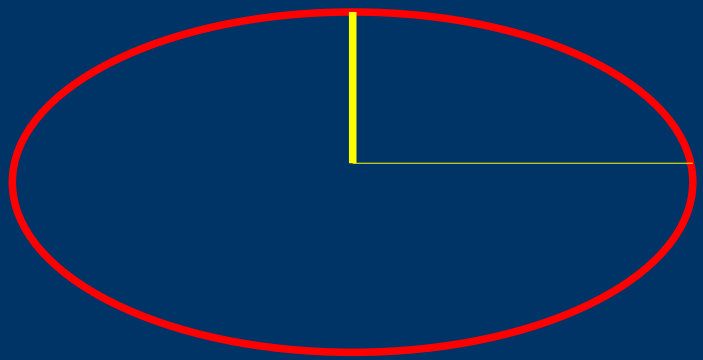
- Muscles = muscle vectors = muscle effect on head deformations
- Linear muscles – Point of muscle origin and direction



Waters Pseudo-muscles (cont.)

- Sheet muscles – line of muscle origin and direction
- Sphincters – center point and two axes of ellipse





Physically Real Models

- Expressions = simulation of real model muscles and skin tissue
- Simulation is time consuming
- Complete model – not possible in current hardware
- Used for local details in parametrized models
- Skin elasticity is simulated by spring networks
- Edges = springs

Video

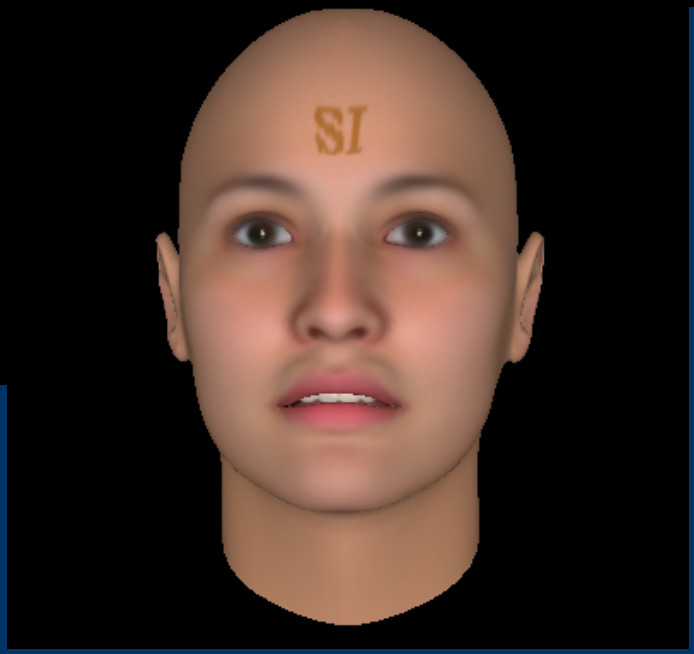
- MEDUSA system
- Pseudo-muscle based system with skin elasticity simulation
- Haber et. al., 2002

Speech Animation

- Simple keyframe morphing not useful for speech – dynamics
- Speech = set of various sounds
- Basic unit of speech = phonemes (sound domain)
- Basic unit of speech = visemes (visual domain)
- English – 45 phonemes, 18 visemes
- No one-to-one mapping

Viseme Examples

Phonemes: D,S,T



Phonemes: F,V

Phonemes: EH

Co-articulation

- Another problem – Influence of phonemes (context)
- Realistic speech: visemes – not static keyframes
- Appearance of viseme = current phoneme + previous phoneme(s) + future phonemes
- Pelachaud, 1991

Text-to-speech System

- Input: Utterance text
- Output: Human voice + phonemes analysis
- Types
  - Formant synthesis
  - Concatenative synthesis
  - Expressive synthesis
- Sound examples

The End

Thank you for your attention ...

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References

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