Lecture 9

Facial animation

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Facial Animation

- The face is deformable
- Need to decide how all the vertices on the surface shall move
  - Manually create them
  - Muscle-based models
  - Capture real human data
Manual Synthesis

- Need to edit the surface of the face, using surface editing techniques
- Produce a number of keyframes, and interpolate the expressions
Performance Based Animation

- Manually creating the keyframes by mouse is too tedious
- The animators can use interactive input devices data gloves, or 3D trackers to edit the face
- Expression mapping: various expressions are digitized directly from a real person
Examples of Performance Based Animation

Human facial movements and phonemes are digitized to be used by animated character
Muscle Based Animation

- Uses a mass-and-spring model to simulate facial muscles.
- Muscles are of two types: linear muscles that pull and elliptic muscles that squeeze.
- Muscle parameters: muscle vector and zone of muscle effect.
Modeling the Primary Facial Expressions

- Basic facial expressions that are considered to be generic to the human face:
  - Happiness, Anger, Fear, Surprise, Disgust and Sadness.
- Facial Action Coding System (FACS) : Ekman ‘77
  - a widely used notation for the coding of facial articulation.
  - 66 muscle actions and the resulting effects
  - Describes the action units (muscles) involved in the six basic expressions
Examples of Facial Expressions

- Neutral face
- Happiness
- Fear
- Anger
- Surprise
- Disgust
Realistic models

- If we want to simulate the expressions of real humans, we need to scan the surface of faces.
- We need the
  - Geometry data
  - Texture

of the face
Cyberware Color Digitizer

- A laser range scanner
  - Rotates 360 degrees around the subject
  - Laser stripes are projected on to the head
- The range data is obtained
- The color texture data is obtained at the same time
A Generic Face Mesh

- Reduce the large array of range data to a geometric surface model
- A generic face mesh is fit into the range data
Adaptation Procedure

1. Locate nose tip
2. Locate chin tip
3. Locate mouth contour
4. Locate chin contour
5. Locate ears
6. Locate eyes
7. Activate spring forces
8. Adapt hair mesh
9. Adapt body mesh
10. Store texture coordinates
The Anatomical Model

- The face can be modeled by two layers and three surfaces
  - Dermal-fatty Layer
  - Muscle Layer
  - Epidermal surface
  - Fascia Surface
  - Skull Surface
The Volume Preservation Forces

- The human skin is incompressible
- Volume preservation force is needed to simulate the wrinkles
- Pressing the node upwards proportionally to the decrement of the volume
Geometry models for other head components

- Teeth, eyes, and neck are modeled separately
  - These data are difficult to be captured by the scanner
From Lee and Terzopoulos
Photometric capturing

- Nowadays, we can capture the facial movements in real-time
- Using multiple photometric cameras
- Capturing the surface shape as well as the textures
Overview of Photogrammetric Measurement

Setup of cameras and projectors

Photographs from different views

Mesh
Like this...
Expression Cloning

- So we can capture the movements of the face
- Let’s use such data to control the faces of other characters
Problem

- We cannot directly use the movements of the face, as the face shape can be different.
Expression Cloning Outline

Motion capture data or any animation mechanism

Source model

Dense surface correspondences

Deform

Target model

Motion transfer

Source animation

Cloned expressions

Target animation
Source Animation Creation

- Use any existing facial animation method
- Motion capture data
  - can also be hand made expressions

Motion capture data + Source model → Source animation
Mapping the original face mesh to the target face

- Specify some corresponding points on the target face, such as
  - Nose tip
  - Eye sockets
  - Lip contact line
  - Chin
  - etc
Automatic dense correspondence

- The source model is deformed to the target model
- The corresponding points are used to find the dense correspondence
- Finally, the source model is fitted to the target model by cylindrical projection
Using Radial Basis Functions to compute the dense correspondence

- Radial Basis Functions (RBF) are often used to create a mapping for a given data

- Input $x_i$  Output $y_i$  ($l = 0,1,\ldots,n-1$)
  - Want a continuous mapping that satisfies
    - $F(x_i) = y_i$
  - While minimizing the oscillation
Radial Bases Function

- Input, output
- Represent $F$ by sum of radial bases
- Unknowns
- Constraints

\[
\{(x_i, y_i)\}_{i=1}^{m}
\]

\[
f(x) = \sum_{i=1}^{m} c_i \phi_i(\|x - x_i\|)
\]

\[
\{c_i\}(i = 1, \ldots, m)
\]

\[
f(x_i) = y_i \quad (i = 1, \ldots, m)
\]

\[
\begin{bmatrix}
y_1 \\ \vdots \\ y_m
\end{bmatrix} =
\begin{bmatrix}
\phi_{11} & \cdots & \phi_{1m} \\ \vdots & \ddots & \vdots \\ \phi_{m1} & \cdots & \phi_{mm}
\end{bmatrix}
\begin{bmatrix}
c_1 \\ \vdots \\ c_m
\end{bmatrix}
\]

\[
\phi_{ij} = \phi(\|x_i - x_j\|) = \phi_{ji}
\]
Amending the motion vectors

- The size and shape of the surface points are different between the source and target model
- We need to adjust the direction and magnitude of the motion vectors
- Rotation: adjusted by the difference of the normal vectors of the source and target
- Magnitude: Scaled by the local size variation
Results
Summary

• Facial animation
  - Manual editing
  - Muscle-based model
  - Capturing human motion
  - Expression Cloning
Readings

- Yuencheng Lee, Demetri Terzopoulos, and Keith Waters, *Realistic Modeling for Facial Animation* SIGGRAPH ’95