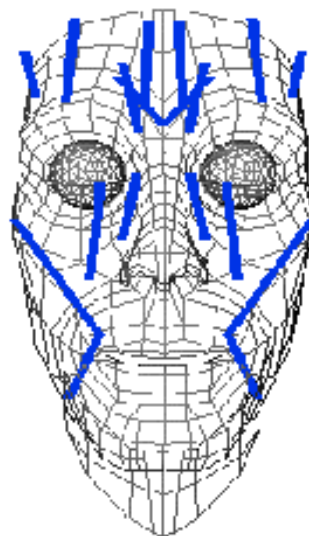# Animation of Face

◆ Muscle Simulation

- Parke and Waters system is most widely used
- "Computer Facial Animation" book examples
- Uses 18 muscles in example
- Open Source, with OpenGL
  - ◆ http://expression.sourceforge.net/

Face models

Parkes (1975)

Waters 1987

What is MPEG ?

◆ "Moving Picture Coding Experts Group," established in 1988 to create standard for delivery of video and audio.

◆ **MPEG-1** Target: VHS quality on a CD-ROM (352 x 288 + CD audio @ 1.5 Mbits/sec)
  ■ Standard had three parts: Video, Audio, and System (control interleaving of streams)

◆ **MPEG-2**
  ■ Unlike MPEG-1 which is basically a standard for storing and playing video on a single computer at low bit-rates, MPEG-2 is a standard for digital TV. It meets the requirements for HDTV and DVD (Digital Video/Versatile Disc).

◆ **MPEG-4**
  ■ **Version 1 approved Oct. 1998, Version 2 was to be approved Dec. 1999.**
  ■ **Originally targeted at very low bit-rate communication (4.8 to 64 Kb/sec), it now aims at the following ranges of bit-rates:**
    ◆ **video -- 5 Kb to 5 Mb per second**
    ◆ **audio -- 2 Kb to 64 Kb per second**

Samples versus Objects

◆ Traditional video coding is sample based (blocks of pixels are compressed)

◆ MPEG-4 provides visual object representation for better compression and new functionalities

◆ Objects are rendered in the terminal after decoding object descriptors

Object-based Functionalities

◆ User can choose display of content layers

◆ Individual objects (text, models) can be searched or stored for later used

◆ Content is independent of display resolution

◆ Content can be easily repurposed by provider for different networks and users

MPEG-4 Object Composition

◆ Objects are organized in a scene graph

◆ Scene graphs are specified using a binary format called BIFS (Binary Format for Scene, based on VRML)

◆ Both 2D and 3D objects, properties and transforms are specified in BIFS

◆ BIFS allows objects to be transmitted once and instanced repeatedly in the scene after transformations

MPEG4 Standards

◆ Standardized ways to support:

- Coding: audio, visual, audiovisual content
- Composition:
  - describing how these objects are composed together to produce compound media objects
- multiplex
  - multiplex and synchronize data associated with media objects

◆ Designed to encode low bandwidth data (scalability: from 5 Kb to 5 Mb per second)


MPEG4 Standards

◆ Parameters are sent over transmission lines and reconstructed at client (3D models at both end of transmission just have to comply with MPEG4-FA rules)
Facial Definition Parameters (FDP)
68 Face Animation Parameters (FAPs)
FAP 1 = 14 static visemes
FAP 2 = 6 primary facial expressions
Anger, fear, joy, disgust, sadness, surprise

MPEG-4 Elements with Examples
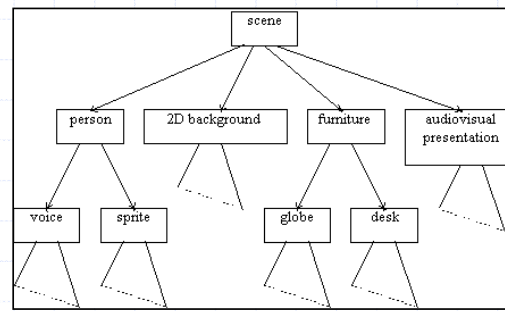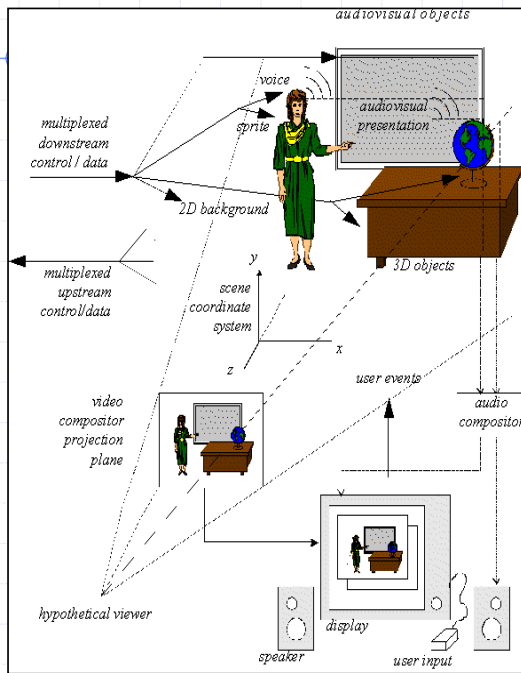
◆ Scene – Background + n Audio-Visual Objects (AVOs); defined in terms of a scene descriptor

◆ Scene descriptor data represented using BIFS which provides:

- spatio-temporal relationships between AVOs
- behavior and interactivity of AVOs and scenes
- protocol to modify/animate the scene in time
- binary encoding for the scene

Sprite Coding - 2
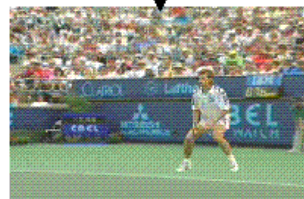
Building an mpeg4 head

- ◆ Minimum 50 vertices
  - ▪ Build shape and define location of 'feature points' to be used by mpeg4
- ◆ Defining FAPs
  - ▪ For each FAP, define movement of feature points
  - ▪ Define how each movement affects neighbouring vertices
- ◆ Mpeg4 is just a frame work trying to unify and standardize the different approaches

Facial Definition Parameters (FDPs)

- ◆ FDPs
  - ▪ Responsible for the appearance of the face
  - ▪ Represent distances between important locations in the face, and texture of the face
  - ▪ transform generic face into a particular face - shape and (optional) texture
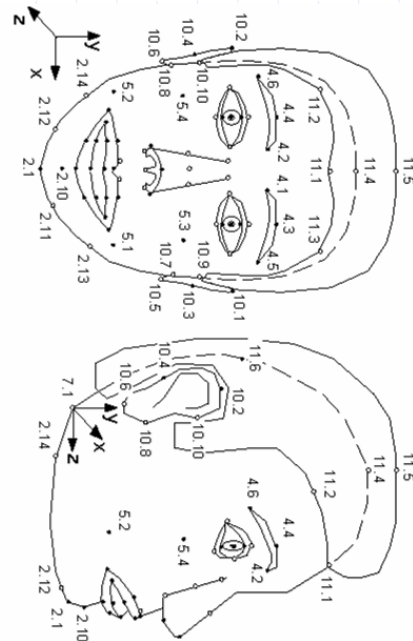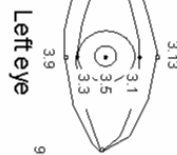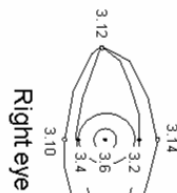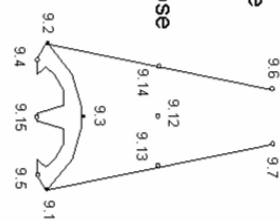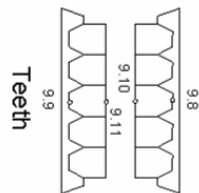
Facial Animation Parameters (FAPs)

◆FAPs

- Responsible for describing the movement (animation) of the face to render expressions, speech, etc…

- 68 FAPs

- 66 Low level FAPs – displacement of specific single point of the face

- 2 High level – reproduction of a facial expressions and visemes

FAPS and FDPS

Neutral Face Dimensions for FAP Normalization

◆ A number of feature points on a neutral face
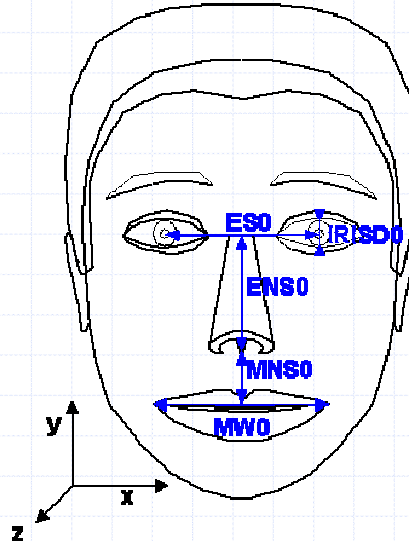
Neutral Face Definition

◆ Head axes parallel to the world axes

◆ Gaze is in direction of Z axis

◆ Eyelids tangent to the iris

◆ Pupil diameter is one third of iris diameter

◆ Mouth is closed and the upper and lower teeth are touching

◆ Tongue is flat, horizontal with the tip of tongue touching the boundary between upper and lower teeth

FACS

◆ Facial Action Coding System

- Paul Eckman and Wallace Fries
- Foundation for most facial animation
- Classified facial expression in terms of "Action Units" AU
- 7 universal categories
    - Sadness, anger, joy, fear, disgust, surprise and neutral

The universal expressions: (a) sadness, (b) anger, (c) joy, (d) fear, (e) disgust, (f) surprise
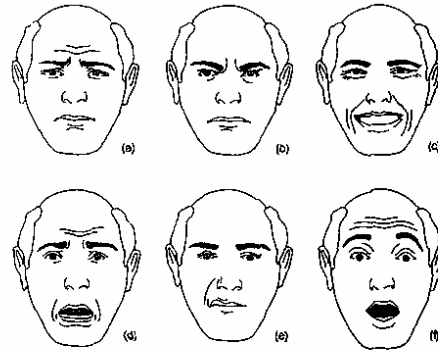
FAP units

description		FAPU Value
IRISD0 = 3.1y -3.3y = 3.2y – 3.4y	Iris diameter in neutral face	ODOSD = IRISD0 / 1024
ES0 = 3.5x-3.6x	Eye separation	ES = ES0/1024
ENS0 = 3.5y – 9.15y	Eye-nose separation	ENS = ENS0 / 1024
MNS0 = 9.15y – 2.2y	Mouth-nose separation	MNS = MNS0 / 1024
MW0 = 8.3x = 8.4x	Mouth width	MW = MW0 / 1024
AU	Angle Unit	10° rad

Face Animation

◆ Visemes and Expressions

- Visemes are preset combinations of FAPs
- Visemes used for speech (visual counter part of phoneme)
- Expressions used to show emotions

1	2	3	4	5	6	7	8	9	10	11	12	13	14
(p,b,m) put bed mill	(f,v) far voice	(T,D) think that	(t,d) tip doll	(k,g) call gas	(tS,dZ,S) chair join she	(s,z) sir zeal	(n,l) lot not	(r) red	(A:) car	(e) bed	(I) tip	(Q) top	(U) book

---

Face Animation Parameter Normalization

◆ Face Animation Parameters (FAPs) are normalized to facial dimensions

◆ Each FAP is measured as a fraction of neutral face mouth width, mouth-nose distance, eye separation, or iris diameter

◆ 3 Head and 2 eyeball rotation FAPs are Euler angles

Facial animation in MPEG-4

◆ Motion represented by FAPs
(Facial Animation Parameters)

◆ e.g. raise_l_o_eyebrow, raise_r_i_eyebrow,
open_jaw

◆ Normalized to standard distances of rigid areas in the
face, e.g. left eye to right eye (ES0) or nose to eye
level (ENS0)
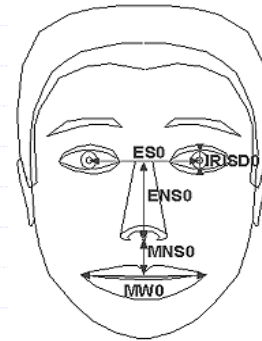
MPEG-4 Visemes and Expressions

◆ A weighted combination of 2 visemes and 2
facial expressions for each frame

◆ Decoder is free to interpret effect of visemes
and expressions after FAPs are applied

◆ Definitions of visemes and expressions using
FAPs can also be downloaded

Facial Expressions

expression_select	expression name	textual description
0	na	na
1	joy	The eyebrows are relaxed. The mouth is open and the mouth corners pulled back toward the ears.
2	sadness	The inner eyebrows are bent upward. The eyes are slightly closed. The mouth is relaxed.
3	anger	The inner eyebrows are pulled downward and together. The eyes are wide open. The lips are pressed against each other or opened to expose the teeth.
4	fear	The eyebrows are raised and pulled together. The inner eyebrows are bent upward. The eyes are tense and alert.
5	disgust	The eyebrows and eyelids are relaxed. The upper lip is raised and curled, often asymmetrically.
6	surprise	The eyebrows are raised. The upper eyelids are wide open, the lower relaxed. The jaw is opened.

FAP Groups

| Group	Number of FAPs
1: visemes and expressions	2
2: jaw, chin, inner lowerlip, cornerlips, midlip	16
3: eyeballs, pupils, eyelids	12
4: eyebrow	8
5: cheeks	4
6: tongue	5
7: head rotation	3
8: outer lip positions	10
9: nose	4
10: ears	4

FAPs and Archetypal Expressions

Anger	squeeze_l_eyebrow (+) lower_t_midlip (-) raise_l_i_eyebrow (+) close_t_r_eyelid (-) close_b_r_eyelid (-)	squeeze_r_eyebrow(+) raise_b_midlip (+) raise_r_i_eyebrow (+) close_t_l_eyelid (-) close_b_l_eyelid (-)
Sadness	raise_l_i_eyebrow (+) close_t_l_eyelid (+) raise_l_m_eyebrow (-) raise_l_o_eyebrow (-) close_b_l_eyelid (+)	raise_r_i_eyebrow (+) close_t_r_eyelid (+) raise_r_m_eyebrow (-) raise_r_o_eyebrow (-) close_b_r_eyelid (+)
Surprise	raise_l_o_eyebrow (+) raise_l_i_eyebrow (+) raise_l_m_eyebrow (+) squeeze_l_eyebrow (-) open_jaw (+)	raise_r_o_eyebrow (+) raise_r_i_eyebrow (+) raise_r_m_eyebrow(+) squeeze_r_eyebrow (-)

Joy	close_t_l_eyelid (+) close_b_l_eyelid (+) stretch_l_cornerlip (+) raise_l_m_eyebrow (+)	close_t_r_eyelid (+) close_b_r_eyelid (+) stretch_r_cornerlip (+) raise_r_m_eyebrow(+)
	lift_l_cheek (+) lower_t_midlip (-) OR open_jaw (+)	lift_r_cheek (+) raise_b_midlip (-)
Disgust	close_t_l_eyelid (+) close_t_r_eyelid (+) lower_t_midlip (-)	close_b_l_eyelid (+) close_b_r_eyelid (+) open_jaw (+)
	squeeze_l_cornerlip (+) AND / OR squeeze_r_cornerlip (+)	
Fear	raise_l_o_eyebrow (+) raise_l_m_eyebrow(+) raise_l_i_eyebrow (+) squeeze_l_eyebrow (+) open_jaw (+)	raise_r_o_eyebrow (+) raise_r_m_eyebrow (+) raise_r_I_eyebrow (+) squeeze_r_eyebrow(+) close_t_r_eyelid (-)
	OR close_t_l_eyelid (-)	lower_t_midlip (-)
	OR lower_t_midlip (+)	

Lip FAPs

◆ Mouth closed if sum of upper and lower lip FAPs = 0
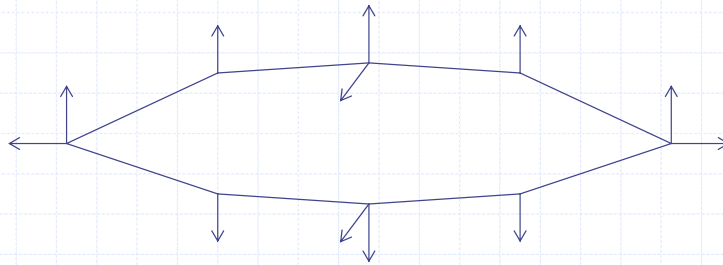
Face Model Independence

◆ FAPs are always normalized for model independence

◆ FAPs can be used without MPEG-4 systems (independence)

◆ Private face models can be accurately animated with FAPs

◆ Face models can be simple or complex depending on terminal resources (scalability)

Viseme and Related Phonemes

Viseme #	phonemes	example
0	none	na
1	p, b, m	put, bed, mill
2	f, v	far, voice
3	T,D	think, that
4	t, d	tip, doll
5	k, g	call, gas
6	tS, dZ, S	chair, join, she

7	s, z	sir, zeal
8	n, l	lot, not
9	r	red
10	A:	car
11	e	bed
12	I	tip
13	Q	top
14	U	book

References

1. Parke, Frederic I. And Waters, Keith. "Computer Facial Animation" A K Peters., Wellesly, Mass. 1996
2. Pighin, Frederic, et. al. "Synthesizing Realistic Facial Expressions from Photographs". Siggraph 1998
3. Gray, Henry. "Gray's *Anatomy of the Human Body*" Online http://www.bartleby.com/107/
4. Cohen, M. M., & Massaro, D. W. "Modeling coarticulation in synthetic visual speech". In N. M. Thalmann & D. Thalmann (Eds.) *Models and Techniques in Computer Animation*. Tokyo: Springer-Verlag. 1993
5. Nitchie, E.B. "How to Real Lips for Fun and Profit". Hawthorne Books, New York, 1979
6. A. Haro, B. Guenter, and I. Essa. "Real-time, Photo-realistic, Physically Based Rendering of Fine Scale Human Skin Structure". *Proceedings 12th Eurographics Workshop on Rendering*, London, England, June 2001
7. Lundgren, Ulf. "Description of how the model was created" http://www.lost.com.tj/Ulf/artwork/3d/behind.html

References

8.   Osterman, J. and Tekalp, Murat. "Face and 2-D Mesh Animation in MPEG-4". Online at http://www.cselt.it/leonardo/icjfiles/mpeg-4_si/8-SNHC_visual_paper/8-SNHC_visual_paper.htm

9.   http://www.nvidia.com/developer

10.   L. Moccozet and N. M. Thalmann, "Dirichlet free-form deformations and their application to hand simulation", Proceedings of the Computer Animation'97, pp93-102, 1997.

11.   K. Waters, A muscle model for animating three-dimensional facial expression. In Maureen C. Stone, editor, Computer Graphics (Siggraph proceedings, 1987) vol. 21 pp. 17-24

Some URLs

- ViDe: http://www.vide.net
- The ViDe MPEG-4 WG: http://www.vide.net/vod/mpeg4/
- The ViDe MPEG-4 RFI/SOI: http://www.vide.net/vod/mpeg4/rfi1.html
- Overview of the MPEG-4 Standard (Rob Konen): http://www.cselt.it/mpeg/standards/mpeg-4/mpeg-4.htm
- The MPEG-4 Industry Forum: http://www.m4if.org/