Computer Animation

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March 2013

Lecture slides based on previous versions produced by Marco Gillies and Aitor Rovira

- videos\SIGGRAPH Asia 2011 _ Computer Animation Festival Trailer.flv

- And if we have the internet we will watch:

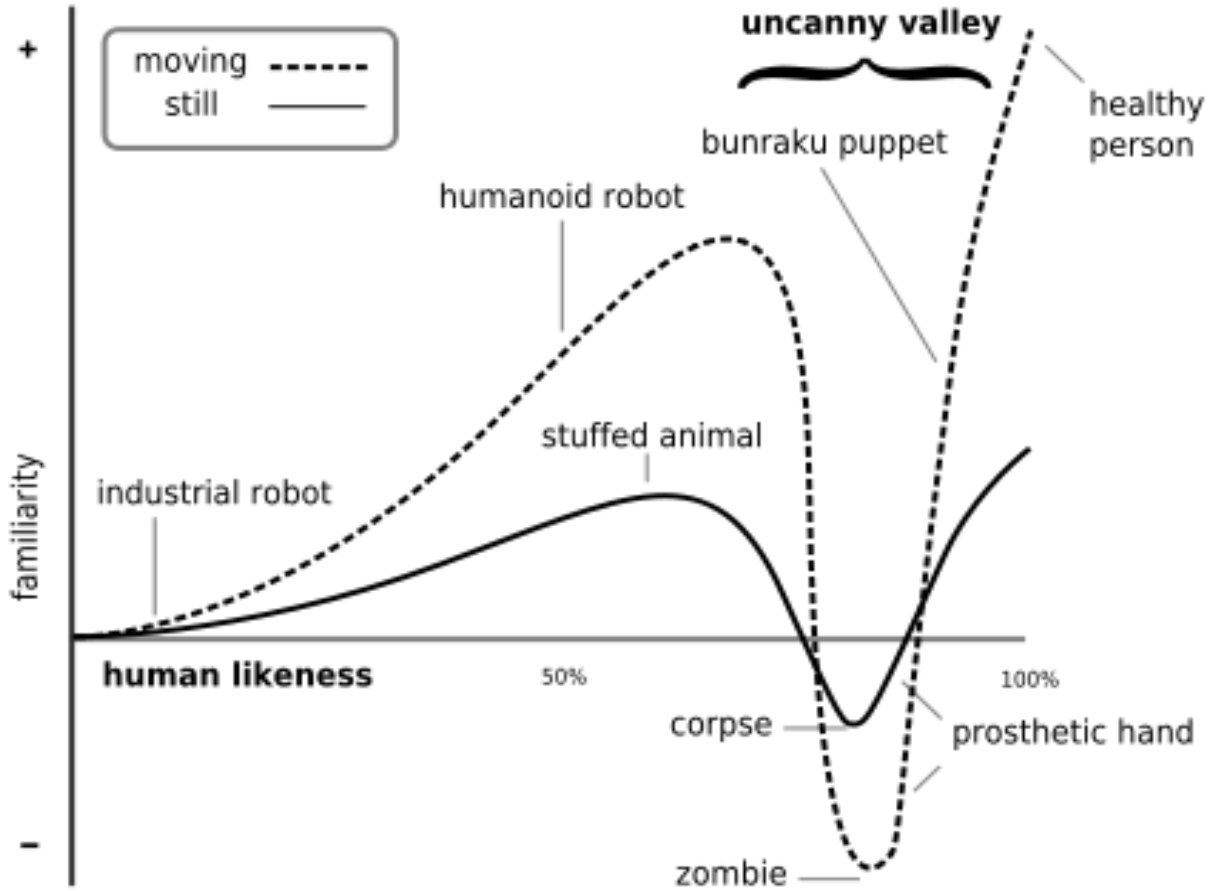
https://www.youtube.com/watch?v=CE2G96KbtAw

Character Animation

Character Animation

- Realistically representing a human is a great challenge:
  - The human form is very complex (over 200 bones, 600 muscles)
  - Human motion is not computationally well defined
  - Many factors have an impact on human motion: genetic, culture, personality, emotional states, etc.
  - We are very familiar with human figure and therefore everybody is a critical observer

Uncanny Valley

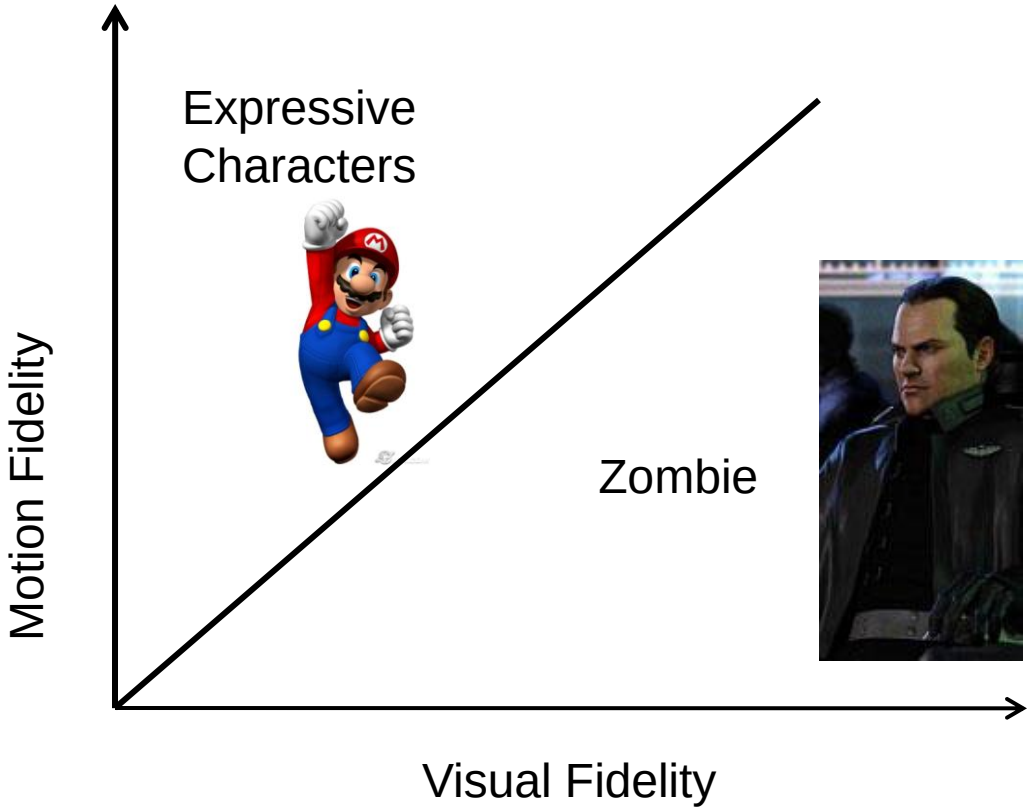


Masahiro Mori 1970’

Uncanny Valley

- videos\The Uncanny Valley.flv
- videos\shy man 3.mpg

Zombie Line



Glenn Entis 2007

Character Animation

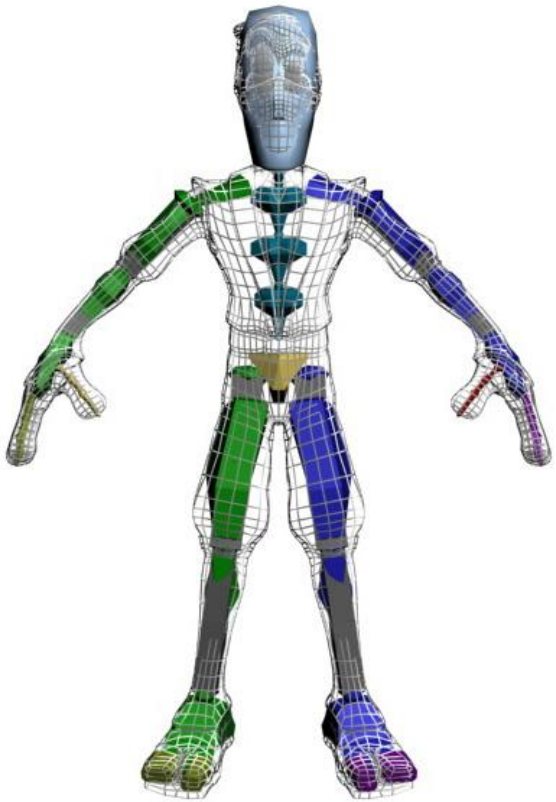
- Human Body Animation
- Facial Animation

Human Body Animation

- Skeletal Animation (FK, IK)
- Motion Capture
- Skinning
- Multi-layer Methods

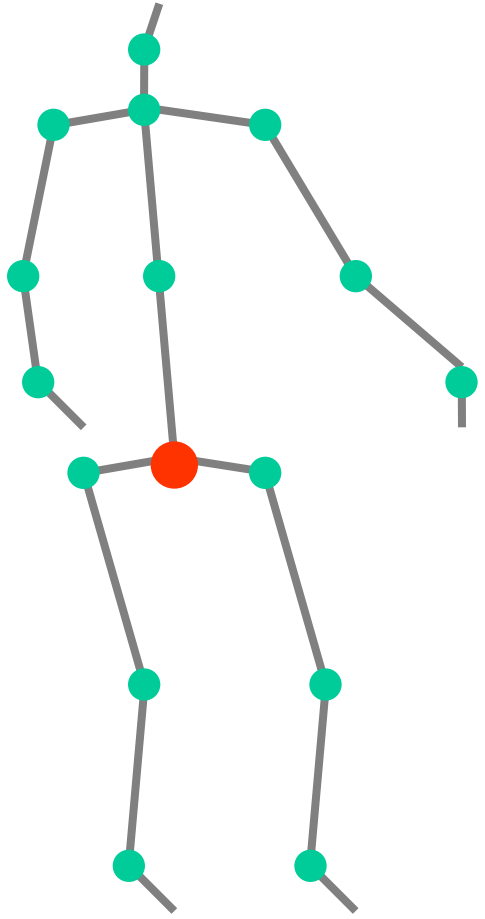
Skeletal Animation

- A character is represented in two parts: a skeleton (biped) and a mesh
- The fundamental aspect of human body motion is the motion of the skeleton



Typical Skeleton

- Circles are rotational joints lines are rigid links (bones)
- The red circle is the root (define the position and orientation of the character)
- The character is animated by rotating joints and moving and rotating the root

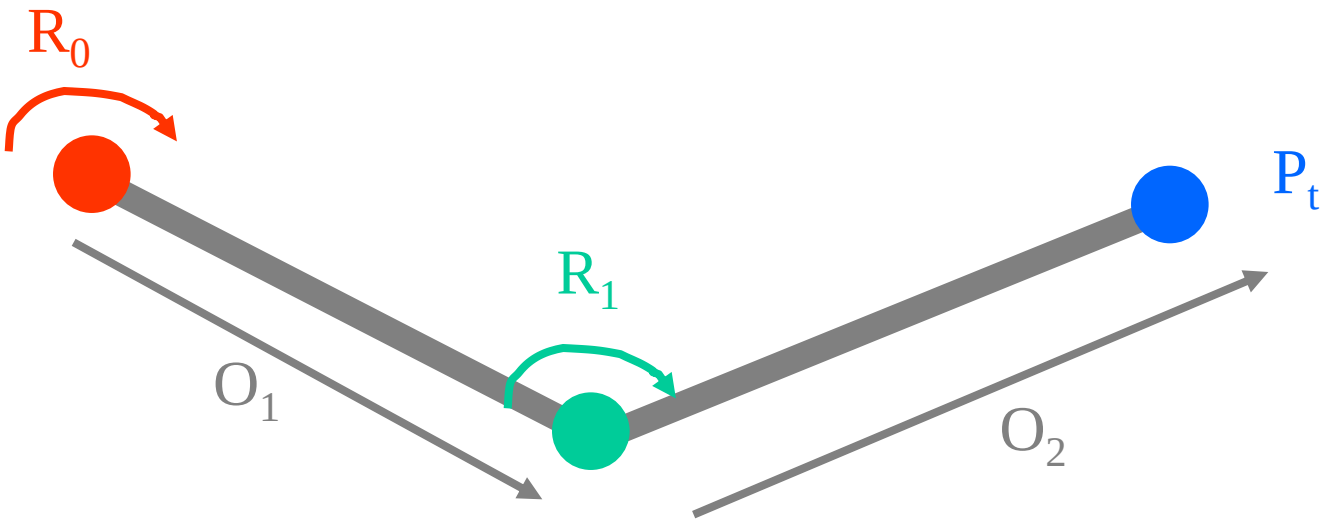


Animate the Skeleton

- Key Frame animation (set the key frame and the computer does the interpolation)
- Motion Capture (data-driven)

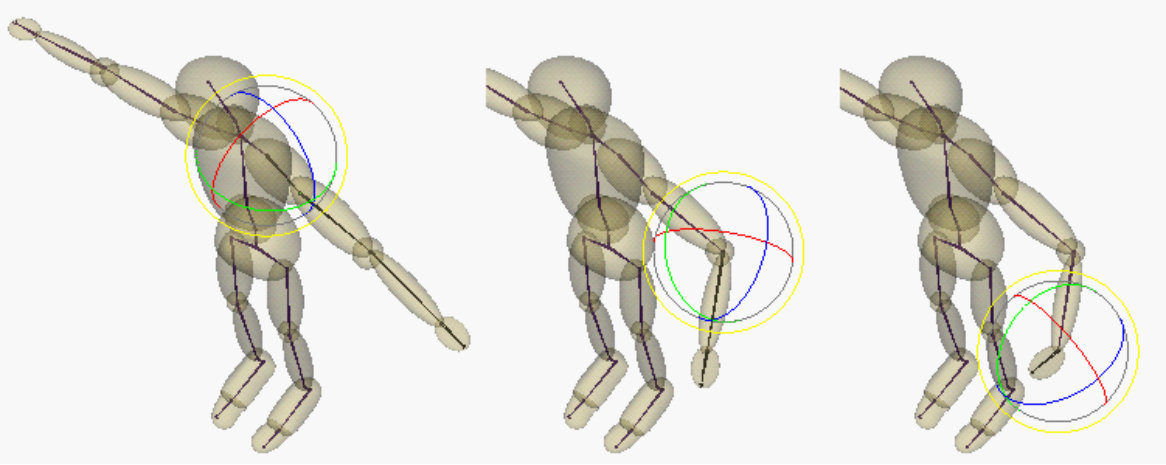
Key Frame Animation: FK and IK

- Forward Kinematics (FK): the animator specifies rotation parameters at each joints.
  - Child object follows the parent
- Inverse Kinematics (IK): the animation specifies the desired position of the “hand”.
  - Parent object follows the child

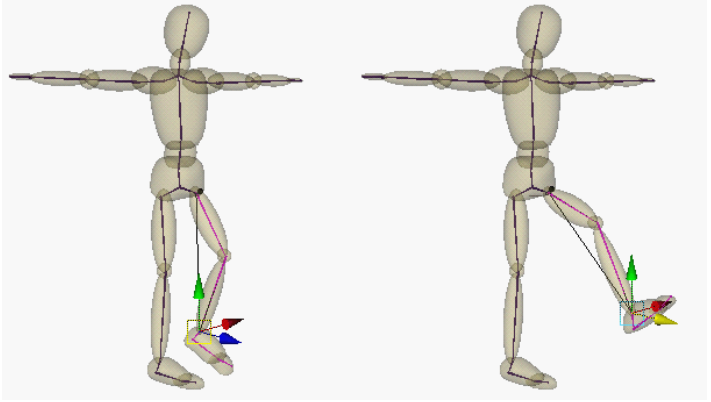


Forward Kinematics

- Pros:
  - Simple, intuitive for certain animation
- Cons:
  - Getting the figure to a desired position can be tedious as it is a trail-and-error process.



Inverse Kinematics



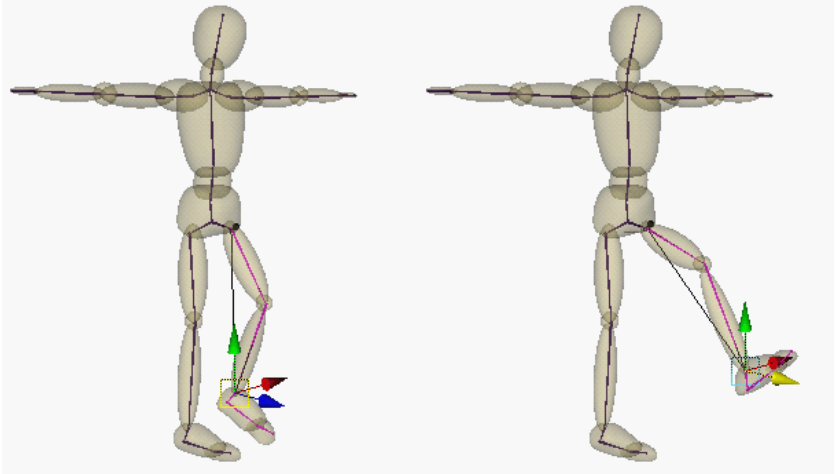
- Methods (many different ways):
  - Matrix methods (Jacobian)
  - Cyclic Coordinate Descent (CCD) IK.pptx

videos\Inverse Kinematics CCD's concept demo.flv

videos\Jacobian PseudoInverse vs Cyclic Coordinate Descent.flv

Inverse Kinematics

- Pros:
  - Very powerful tool.
  - Generally used in animation tools and for applying specific constraints.
- Cons:
  - Computationally intensive



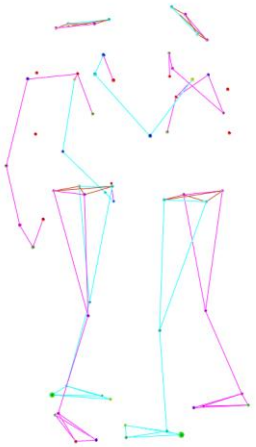
Joint Limits

- Joints are generally represented as full 3 degrees of freedom quaternion rotations
- Human joints can’t handle that range: you cannot bend your elbow backwards!
  - build rotation limits into the animation system
  - generating joints angles to give reasonable values

Animate the Skeleton

- Key Frame animation
- Motion Capture

Motion Capture (Mocap)



- Capturing the movement of an object (in human body animation, an actor) and applied it to a digital model
- Heavily used in films and computer games
  - Highly realistic
  - Especially useful for capturing performance, for instance, for biophysical studies

Motion Capture

- Non-optical Systems
  - Mechanical
  - Magnetic

- Optical Systems
  - Markers
  - Markerless

Mechanical Motion Capture

- Skeletal-structural, directly track body joint angles
- Pros:
  - Self contained (less constrained by area in which you do it)
  - Can directly output joint angles. Real time
- Cons:
  - Bulky
  - Rigid Joints (cannot capture natural movements!)

Magnetic Motion Capture

- Magnetic transmitters on the body
- Have a base station that measures relative positions
- Pros:
  - Real time, accuracy
- Cons:
  - Constrained by the range and accuracy of the magnetic field and wires.

Optical Markers

- Reflective markers and infra-red cameras
- Pros:
  - Lightweight, cheap
  - Most commonly used
- Cons:
  - Problems of occlusion
  - Restricted to a certain 3D space

videos\Motion capture of the aliens for Crysis 2.flv

Markerless Optical Motion Capture

- Just point a camera at someone and figure out their motion.
- Pros:
  - No need to wear special equipment, large capture space, cheap.
- Cons:
  - Difficult computer vision and machine learning issues

Markerless Optical Motion Capture - Kinect

videos\OpenNI with Kinect in Windows 7.flv

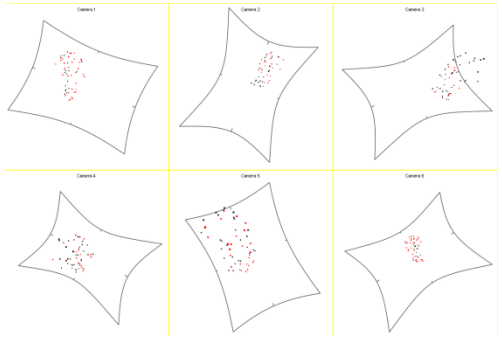
videos\Kinect (OpenNI) sample test.flv

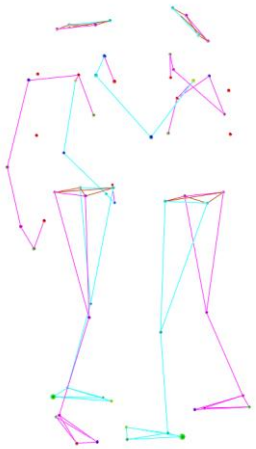
videos\How Kinect Tracks Your Movements HD Video (Developer Diary 3) - Kinect for Xbox 360.mp4

- The Kinect Paper:

http://research.microsoft.com/apps/pubs/default.aspx?id=145347

Motion Capture Post-processing





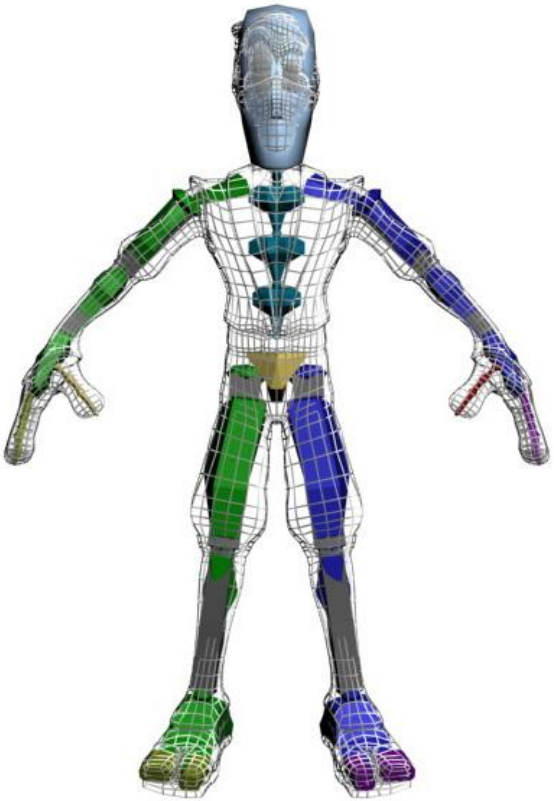
- What you get out is generally a noisy, incomplete set of marker positions
- Need to get rid of noise
- Convert to joint angles (use simple analytic IK type methods)
- Deal with problems of missing markers
- Mo-cap systems all come with standard software to do this

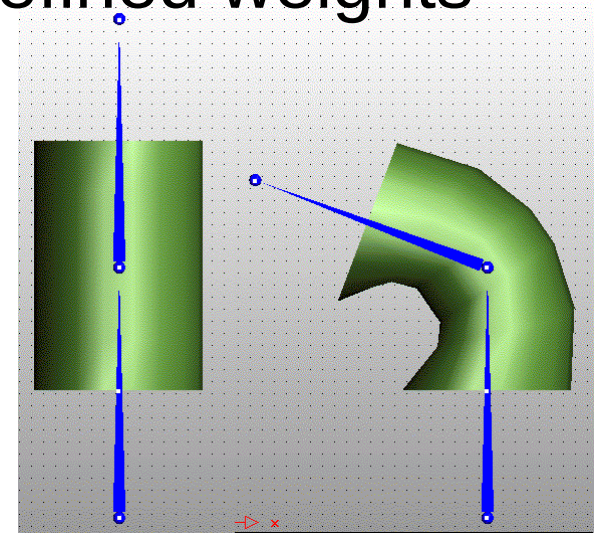
Motion Capture

- Pros:
  - Motion capture produces highly realistic animation.
- Cons:
  - Cleaning process can be time consuming.
  - it is inflexible, you can only play back what you have captured.
    - difficult to apply to new physical situations (picking up a cup from a different place)
    - or new styles (different emotion)

Smooth Skinning

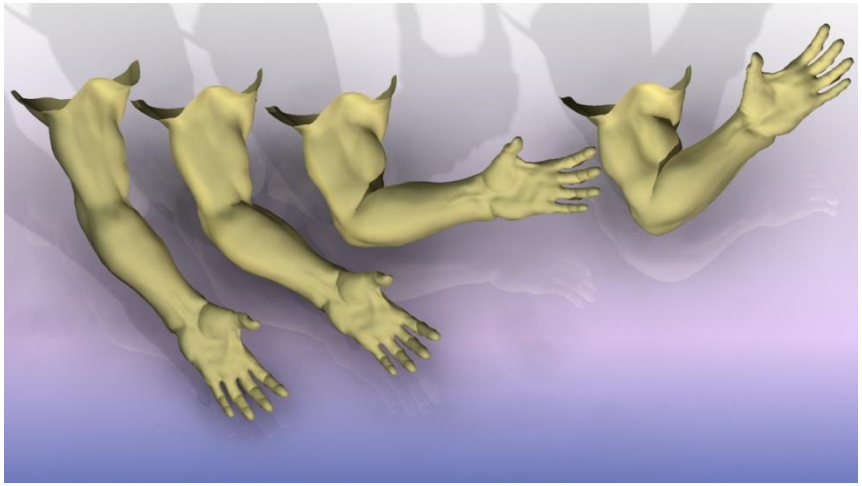
- The mesh has to be attached to the skeleton
- Associate each vertices on the mesh to one or many bones, with defined weights





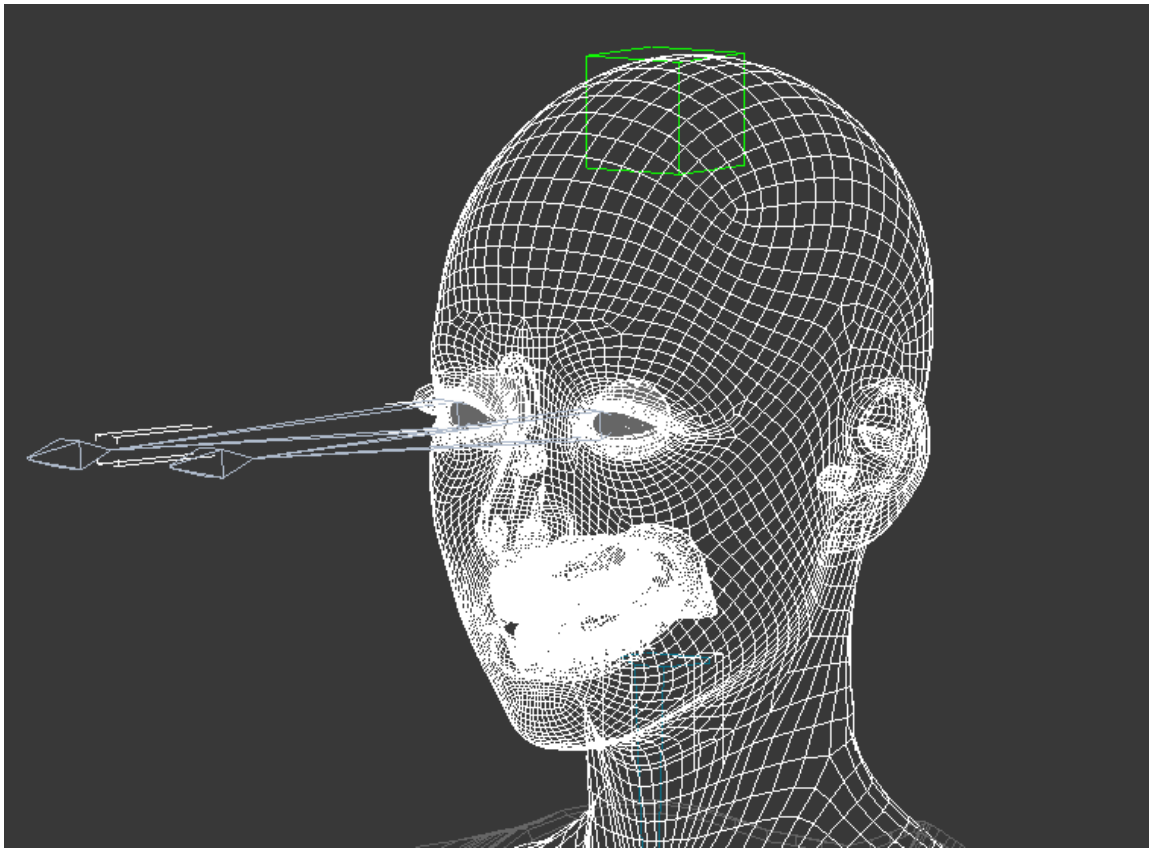
Multi-layered Methods

- The deformation of a human body does not only depend on the motion of the skeleton.
- The movement of muscle and fat also affect the appearance.
- Soft tissues need different techniques from rigid bones.



Weber 2007

Facial Animation



Facial Animation

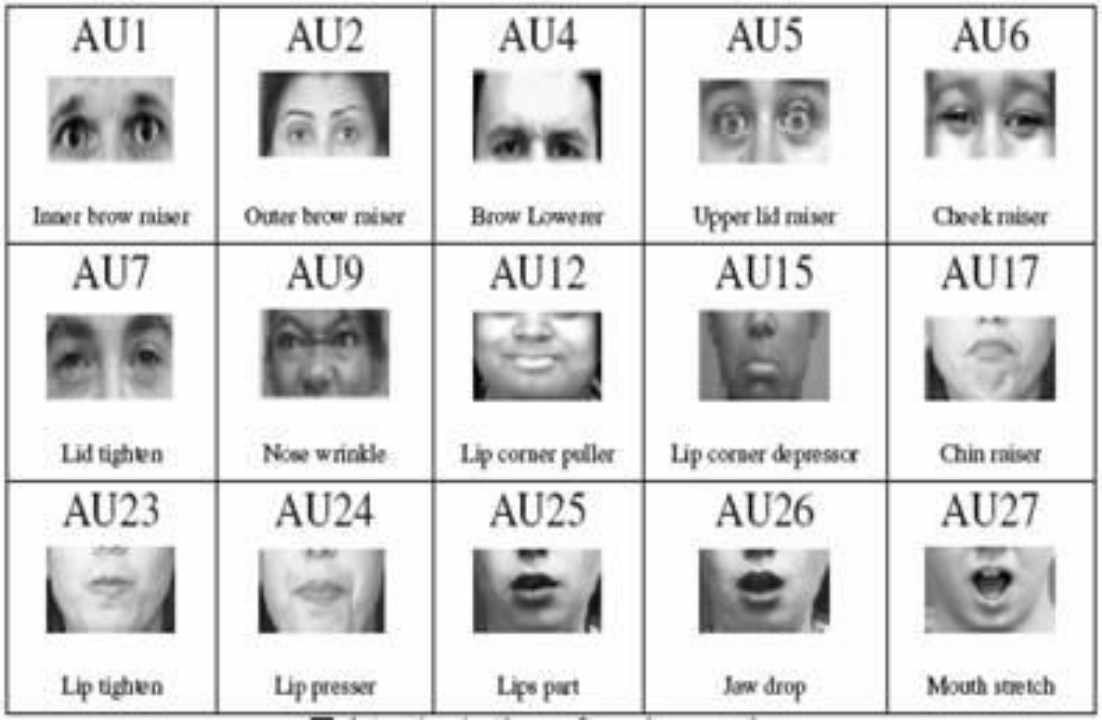
- The face is the most observed area on human body during interpersonal interactions
- A face is capable of producing about twenty thousand different facial expressions
- We are extremely sensitive to even very subtle changes on the face!

Facial Expressions

- Describing Facial Movements
- Facial Animation Techniques
  - Key frame systems
    - Morph Targets
    - Facial Bones
    - Muscle Models
  - Facial Motion Capture

Describing Facial Movements: Facial Action Coding System (FACS)

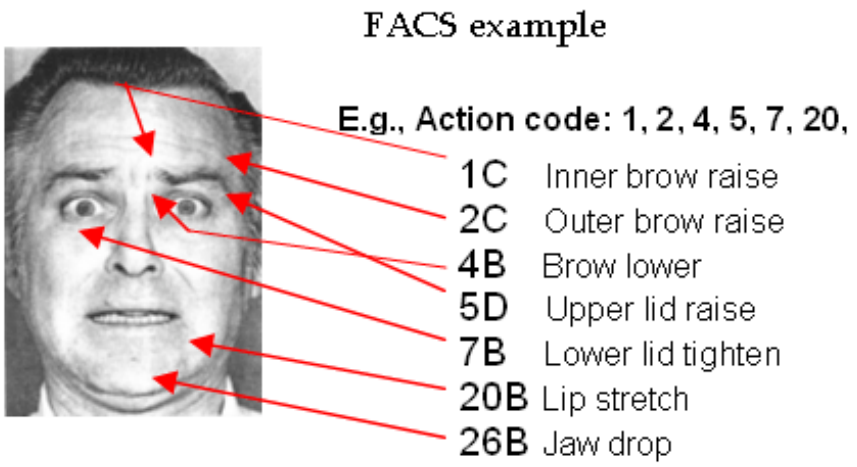
- Deconstruct any facial expressions into Facial Action Units



Ekman 78’

Describing Facial Movements: Facial Action Coding System (FACS)

- Another example, with intensity



- A Trace
- B Slight
- C Marked or Pronounced
- D Severe or Extreme
- E Maximum

Describing Facial Movements: Facial Action Coding System (FACS)

- Problems:
  - Describes only symmetric facial expressions
  - Does not provide any information about the meaning communicated through facial expressions

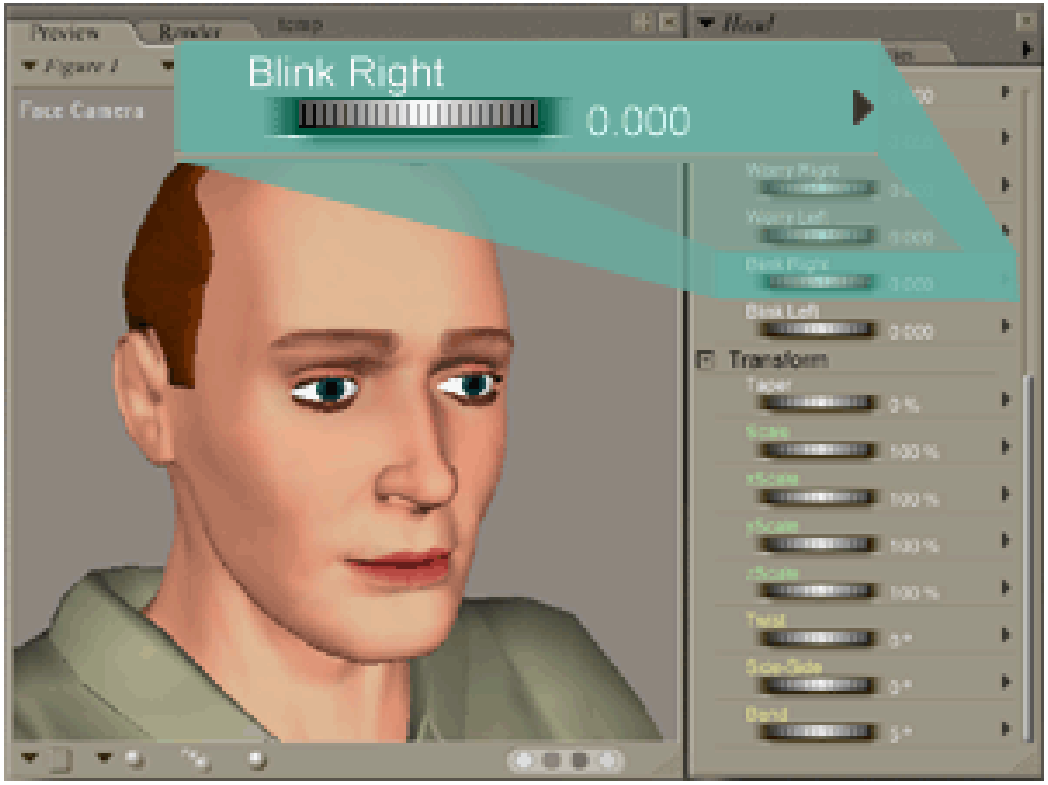
Facial Expressions

- Describing Facial Movements
- Facial Animation Techniques
  - Key frame systems
    - Morph Targets
    - Facial Bones
    - Muscle Models
  - Facial Motion Capture

Morph Targets

- Start with a base (neutral expression)
- Have a number of basic expressions, each represented by a separate mesh.
- Build new facial expressions out of these basic expressions.

Morph Targets



Morph Targets

Lip-Sync Animation

- An important problem is how to animate people talking.
- In particular how to animate appropriate mouth shapes for what is being said.
- videos\miki-1-b.flv

Visemes and Lip-sync

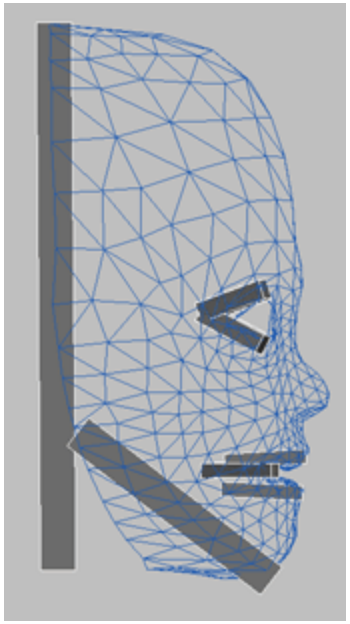
- Each sound (phoneme) has a distinctive mouth shape
- Can create a morph target for each sound (visemes)
- Analyse the speech or text into phonemes
- Match phonemes to visemes and generate morph target weights

Visemes and Lip-sync

- Very hard to make it perfect
- Speech and mouth shapes are more complex than phonemes and visemes
  - e.g. running one word into another
- Easy to get something reasonable

Facial Bones

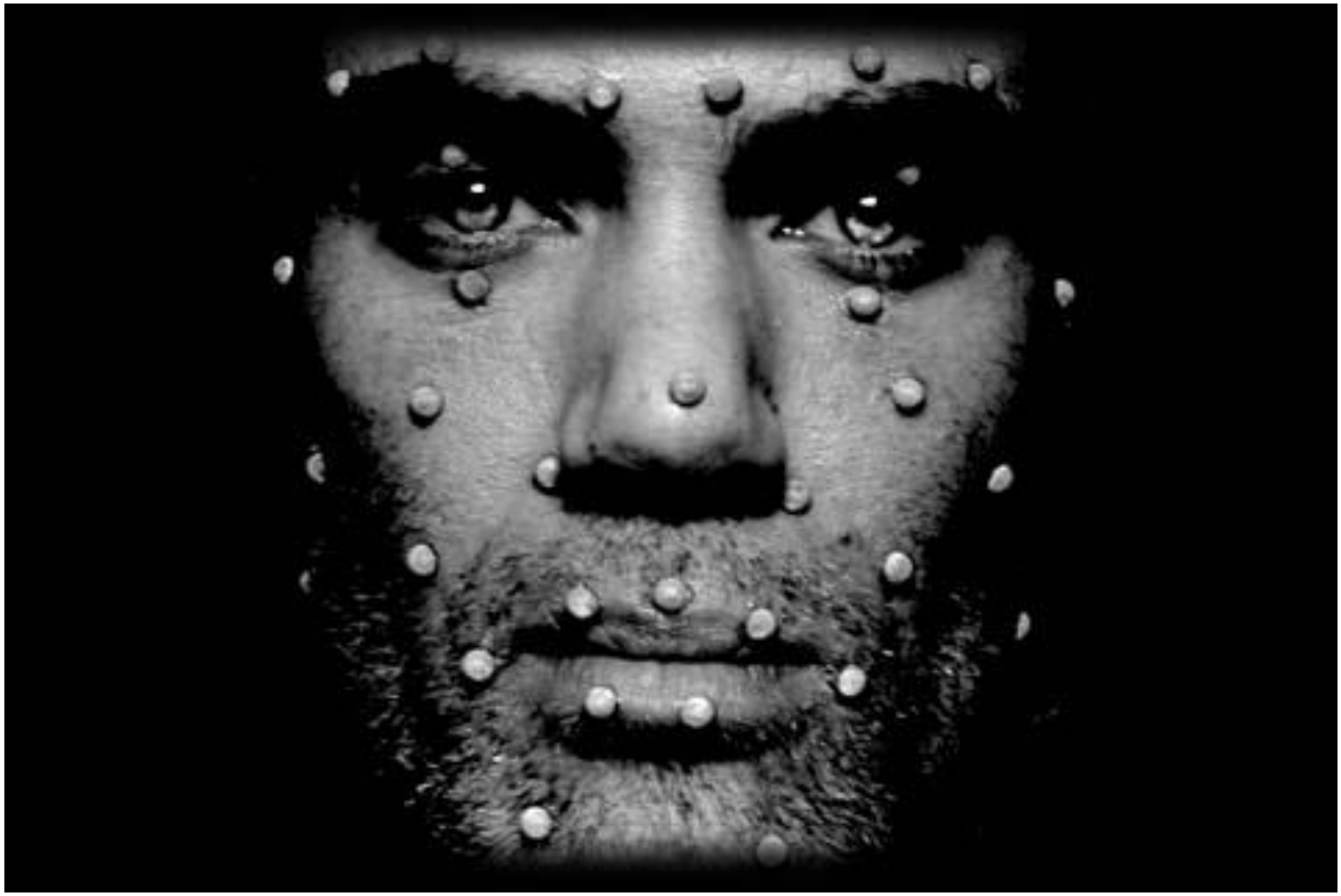
- Similar to bones in body animation
- Each bone affects a number of vertices with weights in a similar way to smooth skinning for body animation.



Muscle Models

- Model each of the muscles of the face.
- There could be a more complex physical simulation as mentioned for multi-layered body animation.

Facial Motion Capture



Facial Motion Capture

- Actors' performance
- Similar to body motion capture
  - More challenging as the changes are more subtle
  - The motion capture data is then mapped to the mesh, not to a set of bones
- Markerless motion capture techniques is also possible
  - Use features on the face to track the face

Finally…

- http://www.youtube.com/watch?v=xvkjcDq5zqM
- videos\Avatar Motion Capture Mirrors Emotions.mp4