

CENG 732 Computer Animation

Spring 2006-2007

<http://www.ceng.metu.edu.tr/~tcan/ceng732/>

metu.ceng.course.732

Course Description

- Main techniques covered in this course include:
 - Keyframing, story-boarding,
 - Kinematics, physically based dynamics modeling,
 - Motion capture,
 - Scene composition, lighting, and sound track generation
- Advanced topics such as dynamic simulation of flexible and rigid objects, facial animation, and behavioral/AI based animation are also studied.

Lecture Time/Place

- **Mondays - 13:40 to 16:30 in A-101.**

Course Objectives

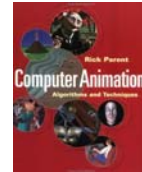
- This course will teach the students about current techniques in computer animation. By the end of the course, the students should:
 - have learned the computational methods for modeling of motions in the physical and virtual world,
 - be able to storyboard, light, compose, and render an animated sequence,
 - and be able to read and critically evaluate the current literature in computer animation.

Prerequisites

- No formal prerequisites. However, CENG 477 Introduction to Computer Graphics is a prerequisite of the proposed course, which introduces the fundamental concepts of computer graphics which are essential in such an advanced computer animation course.

Textbook

- Computer Animation: Algorithms and Techniques, by Rick Parent, Morgan & Kaufmann, 2001



- Online version:
http://www.siggraph.org/education/materials/HyperGraph/animation/rick_parent/Outline.html

Reference Material

- The Art of 3-D: Computer Animation and Imaging, 2nd Edition by Isaac Victor Kerlow.
- Advanced Animation & Rendering Techniques by Watt and Watt.
- Computer Facial Animation by Parke and Waters.
- Principles of Three-Dimensional Computer Animation by Michael O'Rourke, Revised Edition.
- SIGGRAPH papers on Computer Animation.

Grading Policy

- Reading/written assignments (paper critics, short quizzes, or short presentations) : 20%
- Class project (teams of 2-3 students) : 50%
- Final exam : 30%

Instructor

- Tolga Can
- Office: B-109
- E-mail: tcan@ceng.metu.edu.tr
- Office Hours: Monday 10:30 - 12:00

Schedule

- **Week 1:** Introduction and overview of animation
- **Week 2:** Introduction to keyframing
- **Week 3-4:** Animating articulated structures, kinematics and inverse kinematics
- **Week 5-6:** Physically based modeling and simulation, particle system dynamics
- **Week 7:** Facial animation
- **Week 8:** Processing motion capture data, motion synthesis, motion recognition
- **Week 9:** Behavioral-AI based animation, crowd animation
- **Week 10-12:** Paper presentations
- **Week 13-14:** Project presentations

Computer Animation

- What is computer animation?
- What is animated?

Computer Animation

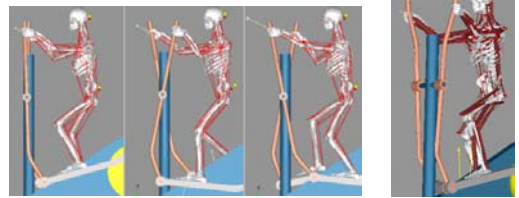
- What is computer animation?
 - Computer animation is the art of creating moving images via the use of computers
 - A technique in which the illusion of movement is created by displaying on a screen, or recording on a recording device a series of individual states of a dynamic scene
- What is animated?
 - Object position, orientation, shape
 - Light position, orientation, parameters
 - Object texture
 - Camera Parameters

Today

- Motion perception
- Technical evolution of animation
- Animation production
- Examples

Perception

- How do you perceive a rapid sequence of still images?
 - As a series of images or as a continuous single moving image?



Positive afterimage

- A single image presented to a viewer for a short time will leave an imprint of itself in the visual system for a short time after it is removed

Persistence of vision

- When a person is presented with a sequence of closely related still images at a fast enough rate, *persistence of vision* induces the sensation of continuous imagery.
- What if the rate is not fast enough?

Flicker

- The rate at which single images must be played back in order to maintain the persistence of vision is called the *flicker rate*.
- It depends on viewing distances, lighting conditions, etc.

What about the upper limits?

- What if an object moves too quickly with respect to the viewer?
 - Motion blur occurs (as in still cameras if the shutter speed is not fast enough)
- However, in computer graphics motion blur will not occur because each produced images is sampled at a precise instant in time. What will happen if an object is moving too fast (i.e., faster than the sampling rate?)

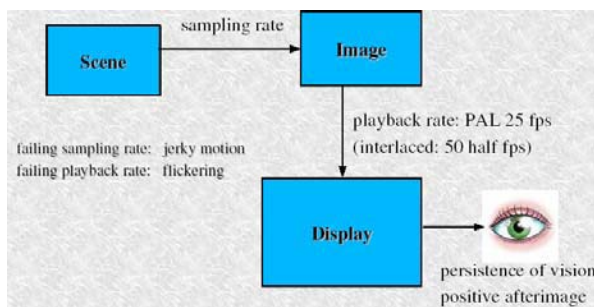
Strobing

- The images of a fast moving object can appear disjointed and the motion becomes jerky, if the sampling rate is not fast enough.
- In hand-drawn animation, fast moving objects are typically stretched in the direction of travel so that the object's images overlap, reducing the strobing effect.

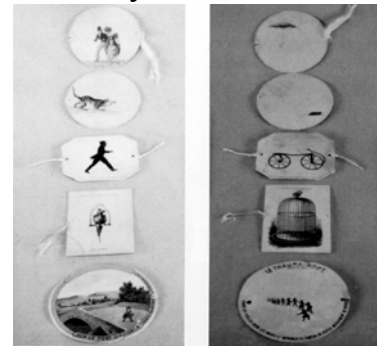
Playback rate vs. Sampling rate

- Playback rate: the number of images per second displayed in the viewing process
- The number of different images that occur per second.
- For example a hand drawn animation may be created at 6 frames per second; however it may be displayed on TV at 30 fps. (Each image displayed 5 times repeatedly.)

Playback rate vs. Sampling rate



History of Animation



A thaumatrope developed in the 1800s.

History of Animation



A zoetrope.

History of Animation

- 1891: Thomas Edison invented the motion picture projector
- 1896: Georges Melies made objects appear, disappear, change shape using camera tricks
- 1900: smoke is animated in a scene (J. Stuart Blackton)
- 1906: first animated cartoon (J. Stuart Blackton)

History of Animation

- Winsor McCay is the first celebrated animator
 - [Little Nemo](#) (1911)
 - Gertie the Dinosaur (1914)
- 1914: translucent cels (currently made from acetate) were patented (John Bray and Earl Hurd)
- Drawing of the background on long sheets of paper so that *panning* could be performed easily

History of Animation

- 1915: Max Fleischer patented *rotoscoping* (drawing images on cels by tracing over previously recorded live action)
- First popular animated character:
 - Felix the Cat (by Otto Messmer)



History of Animation

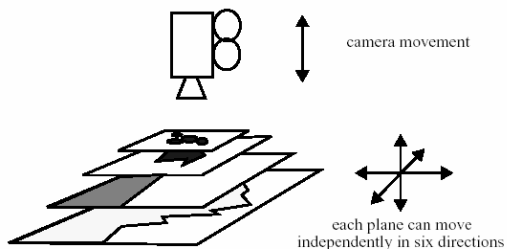
- Walt Disney
 - Use of storyboard to review the story
 - Pencil sketches to review motion
 - Sound and color in animation
 - First use of sound in animation: [Steamboat Willie](#) (1928)

History of Animation

- Multiplane camera
- Camera mounted above multiple planes (animation cels)
- Each plane can move in six directions
- The camera can move closer and farther away.



Multiplane camera



Stop-motion Animation

- With clay or puppets



Principles of Computer Animation

- Simulating Physics
- Designing Aesthetic Actions
- Effective Presentation of Actions
- Production Technique

Simulating Physics

- Squash & Stretch
 - Object rigidity, mass should be consistent during squash & stretch.
- Timing
 - Weight, size, and personality of an object should determine how the actions are spaced through time
- Movement in arcs. Inertia, friction, and viscosity should be taken into account
 - Slow in & slow out, arcs
- Secondary actions should support main action
 - Example: If a character collides with boxes, the boxes should also move

Designing Aesthetic Actions

- Exaggeration
 - To draw attention to an action
- Appeal
 - The action should be enjoyable to watch
- Follow through/overlapping action
 - Actions should flow into one another (instead of looking like disjoint movements)

Effective Presentation of Actions

- Anticipation
 - An upcoming action should be set up so that audience knows it is coming
- Staging
 - The action environment has to be set up so that it is not missed by the audience
- Timing
 - Appropriate duration for the action should be given so that the intended effect reaches the audience

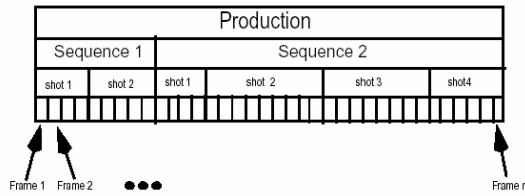
Production Technique

- Straight ahead
 - Progressing from a starting point and developing the motion continually along the way
 - Example: physically based animation
- Pose to pose
 - Identifying key frames and then interpolating intermediate frames

Animation Production

- Four-level hierarchy:
 - **Production**: The entire animation
 - **Sequence**: A major episode with an associated staging area
 - **Shot**: A continuous camera recording
 - **Individual frames**: A single recorded image
- A production usually consists of one to dozen sequences

Animation Hierarchy



Animation Production Steps

- A *preliminary* story with a *script* is decided on
- A *storyboard* is developed
 - It lays out the action scenes by sketching representative frames
- A *model sheet* is developed that lists the characters in various poses
- The *exposure sheet* records information for each frame such as camera moves, sound track cues
- The *route sheet* records the statistics and responsibility of each scene

Animatic

- Also called a *story reel*. A prototype animation that helps to work on timing, revise storyboard, etc.

Animation Production Steps

- Once the storyboard has been decided on a *detailed story* is developed.
- *Key frames* are produced by master animators
- Associate and assistant animators produce the frames between the keys
 - This is called in-betweening
- Test shots, pencil test
 - [Example](#)

Animation Production Steps

- Inking
 - Transferring the penciled frames to cels
- Opaquing or painting
 - Application of color to the cels

Sound

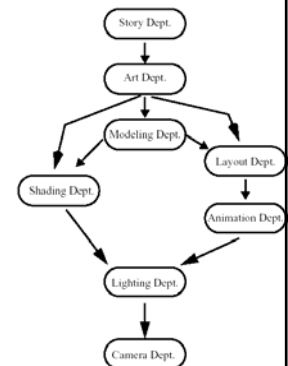
- Music
- Special effects
- Voice
- In lip-synched animation, sound-track is created first and then animation is produced to fit the sound-track.

Computer vs. Conventional Animation

- Computer animation borrows a lot of ideas from conventional animation in terms of production approaches.
- However, there are differences:
 - The lighting, camera models, motion can be reused easily in computer animation
 - Multiple detailed models can be used in computer animation
- Test shot: short high quality rendering
- Pencil test: low quality models and approximate motions

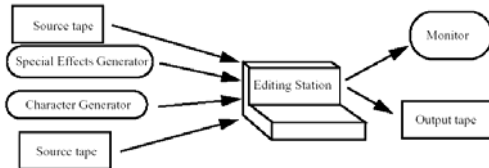
Computer Animation Production Tasks

- The pipeline used by Pixar to produce Toy Story

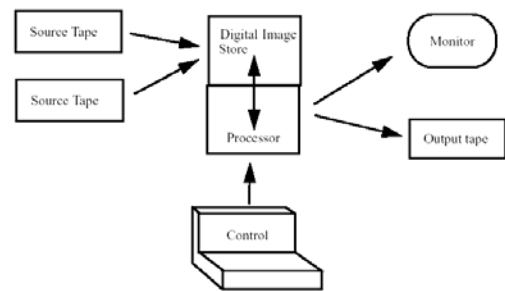


Editing

- Non-linear editing
 - Sequence can be inserted at any order
- A linear electronic editing system

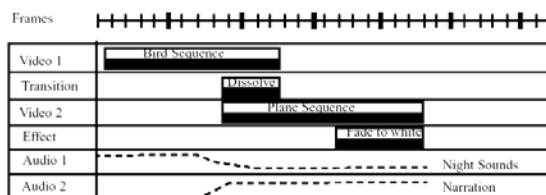


Digital On-line Nonlinear Editing



Non-linear Editing

- An example time-line used for nonlinear digital editing



Digital Video

- With digital video all the non-linear editing tasks are easily done
- Other issues:
 - Compression?
 - Storage: An hour of uncompressed video is 76 Gb
 - Playback

History of Computer Animation

- Evans and Sutherland: '60s and '70s first interactive computer graphics programs
- University of Utah
 - 1972: Animated hand and face by Ed Catmull
 - 1973: Walking, talking human figure by Barry Wessler
 - 1974: Talking face by Fred Parke

History of Computer Animation

- At the end of 1970s, a project titled *The Works* was started to produce a wholly computer generated feature film (but never completed)
 - The used BBOP: a three-dimensional key-frame articulated figure animation system
- 1974: *Hunger*, the first computer animation nominated for an Academy Award
 - Object shape modification and line interpolation (2 ½ D)

<http://www.nfb.ca/animation/objanim/en/films/film.php?sort=director&director=Fold%E8s%2C+Peter&id=10443>



History of Computer Animation

- 1971: Architectural walk-throughs of the Cornell University campus by Don Greenberg
- 1979: Ed Emshwiller demonstrated moving texture maps in Sunstone
- 1979: Voyager flyby animations by Jim Blinn

History of Computer Animation

- 1976: Graphical Symbiosis System (GRASS) was developed a derivative of which was used in the first Star Wars film.

History of Computer Animation

- The Middle Years (1980s):
 - Companies start to emerge
 - Hardware z-buffers were produced
 - Flight simulators developed
 - Animation of waves (Carla's Island, 1981)
 - Flyby of fractal terrain (Vol Libre, 1980)
- The movie TRON (1982) is a landmark movie in its extensive use of computer-generated imagery

History of Computer Animation

- 3D animations emerge in 1980s and 1990s
- Award winning animations by Lucasfilm and Pixar
 - The Adventures of Andre and Wally B. (1984)
 - Luxo Jr. (1986)
 - Red's Dream (1987)
 - [Tin Toy \(1988\)](#) – First computer animation to win an Oscar
 - Knick Knack (1989)
 - [Geri's Game \(1999\)](#) – Won an Oscar

History of Computer Animation

- In 1984, 20 minutes of realistic computer animation was used in the movie *The Last Starfighter*. The action takes place in space as well as on planets.

History of Computer Animation

- 1986: First time a synthetic character appeared in a live-action feature film (Young Sherlock Holmes)
- 1989: An alien creature that appears to be made from water is created for the movie *The Abyss*
- 1991: *Terminator 2*
- 1988: First digital blue screen matte extraction (*Willow*)
- 1994: A digital ping-pong ball is inserted into the movie in *Forrest Gump*

History of Computer Animation

- Use of particle systems
 - *Star Trek II: The Wrath of Khan* (1982)
 - *Lawnmower Man* (1992)
 - *Twister* (1996)

History of Computer Animation

- *Toy Story*
 - First full-length, fully computer generated 3D animated feature film
- High quality rendering
 - [Bunny](#) (Blue Sky Productions – 1999) uses ray tracing and radiosity
 - Winner of the 1998 Academy Award for Best Animated Short Film

Computer Animation

- Holy grail of computer animation
 - To produce a synthetic human character indistinguishable from a real person