Computer Animation

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History
Fundamentals
Animation (classic (cel) -> computer)
Motion Capture Technology
Software Tools *Movies: Geri's Game, MOTEK Motion Capture*

Computer Animation History

One of the early interests for using computer graphics for moving pictures creation.

Kenneth C. Knowlton

- the first publications describing experience & methods for computer movies
- <u>1964</u> the first programming language for computer animation

His animations simulated simple moving objects created from polylines, polygons or projecting 3D polyhedra to 2D plane

History reports chronology, events, ideas, ... to provide us with the shared experience with eventual prediction power.

Chronology/Timeline at

http://www.accad.ohio-state.edu/~waynec/history/timeline.html

Books:
A. Glassner, Nadia & Daniel Thalmann, J. Vince...

John Whitney Sr.

- Musician and film artist
- Computer Animation Father
- analogue computer
- <u>1966 67</u> the first computer film







- 1 440 frames
 24 f/s
- 1 minute
- huge "flip book"
- pages created by computer









William A. Fatter, Edward E. Zajec

Knowlton succesors

Animations that time had not removed the hidden lines

Ronald Baecker

 <u>1969</u> detailed specification of all unevitable steps for implementing the interactive animation graphics system.

The authors, in the following time, have focused to more matured modeling of human body, face, motion, surface materials, ... (Frederick Parke, John Halas, Charles Csuri, Nadia & Daniel Thalmann)

A. Ray Smith

- Institute of Technology, New York
- <u>1975</u> PAINT: prehistory of today's painting programs

Nadia & Daniel Thalmann

- Montreal University, Canada
- <u>1981</u> animation system for 3D objects MIRA (MIRANIM)
- important influence for animating systems



MIRALab-University of Geneva





- 1989, headed by Nadia Magnenat-Thalmann
- research group at "University of Geneva", SW







<u>1981</u> - TRON - sci-fi feature film (Disney Studios, E. Lisberger, production D. Kushner) computer assisted parts by: Information International Inc., Magi, Robert Abel Associates & Digital Systems

















TRON - trailer







TRON - Light Cycles With Music Score



TRON - Love Scene



<u> 1983</u> - Lucasfilm

- introduction of *Particle systems*
- Star Trek II: The Wrath of Kahn
- new effect "motion blur"
- W. Reeves " Particle Systems A Technique for Modeling a Class of Fuzzy Objects "







- <u>1984</u> Wavefront Technologies
 - the first large and marketed software: CG and CA
 - modeling of 3D scene
 - photorealistic rendering
 - scene objects choreography

Before, such programs available only in research centers/universities

John Lasseter

- computer animation artist
- Disney Studios -> PIXAR Animation Studios
- several Academy Awards for animations
- authored several short and commercial movies



<u>1984</u> - The Adventures of André and Wally B (J. Lasseter, the first

use of particle systems for grass



<u>1987</u> - Luxo Jr. (J. Lasseter)

- Nomination - Golden Nica - Ars Electronica (Linz)





<u>1988</u> - TIN TOY (J. Lasseter)

- The first Oscar for computer animation





■ <u>1988</u> - **Red´s Dream** (J. Lasseter)





<u> 1989</u> - Knickknack (J. Lasseter)

alternatively created as 3D stereoscopic version





<u>1991</u> - *Beauty and the Beast* (Walt Disney Pictures)

 hand drawn movie with extensive use of computer for coloring (complete animation) and 3D models, inhabited by hand drawn characters and creatures.



<u>1995</u> - **TOY STORY** - (Disney, PIXAR)

- J. Lasseter
- THE FIRST 3D animated movie
- No phasing, the complete model of fairy tale reality
- Golden Nica Ars Electronica
- Important milestone in cinematography right in the centenary celebrations year



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Chronology: <u>http://www.accad.ohio-state.edu/~waynec/history/timeline.html</u>
 1450 Guttenberg/press... Niepce/camera... Edison/many inventions... Ejzenstein/film cut... Chaplin/gag... sound... stereoscopy...

Technology timeline

Art language timeline

Computer graphics timeline (authoring tools, encoding standards, compression, women, Ars Electronica... points of view)

Future: home moving theatre, interactive TV...

<u>1992</u> - Terminator II (Industrial Light&Magic)

- Academy Award for Visual efects
- IMAGINA92 Monte Carlo









Computer animation uses:

- Ads, flying logos, TV, ...
- Visual effects
- Feature films, many roles:
- 1992 Death Becomes Her
- 1993 Jurassic Park
- 1994 Flinstone, Stargate, The Mask
- 1995 Judge Dredd, Batman Forever, Jumanji, *Casper*
- 1996 Independence Day, Twister, Dragonheart
- 1997 Star Wars, Titanic
- 1999 Star Wars: The Phantom Menace



<u>1997</u> - Geri´s Game - (PIXAR)

- Oscar, completely computer animated film
- Subdivision surfaces





<u>1998</u> - **Bug´s Life** - (Disney, PIXAR) – big commercial success





November 1999 - TOY STORY 2 - (Disney, PIXAR)





<u>2000</u> - For the Birds (PIXAR)



■ <u>2001</u> - Shrek





 $\overset{\wedge}{\bowtie}$

<u>2001</u> - Final Fantasy (The Spirits Within)

- all characters animated, photorealism, hair for millions dollars























November 2001 - Monsters, Inc.



PIXAR Charleters Nov.2 Charleters Nov.2

DISNEP · PIXAR ONSTERS, INC. In Theaters Nov. 2 WE SCARE BECAUSE WE CARE © 2001 Disney/Pixar

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Computer Graphics Fundamentals

Analogy of photography and computer graphics



ISO: Computer graphics: methods & techniques for construction, manipulation, storage and displaying pictures using computer.

Picture

- Graphics display created by computer graphics (known model).
- Structured <--> Non-structured (given by image points)
- Natural <--> Synthetic
- Continuous image photography, poster, painting
 Digital image matrix m x n (m-rows, n-columns)
 - PIXEL (Picture Element) digital image atom
 - Resolution: m x n x color depth
- Continuous image ----- digitization ----> Digital image (Photo ----> Scanner ----> Display)
- **2D Graphics** modeling in the plane
- **3D Graphics** modeling in 3D space (projection to 2D)

Picture Creation:

- 1. Geometric modeling and object representation (2D or 3D)
- 2. Defining physical properties of the object (color, material, ...)
- 3. Defining physical properties of the scene scény and composition of objects
- 4. Display the scene (camera parameters, projection type, realistic or stylised photorealism or NPR, visibility...)

Animation (Anima - spirit, soul, life...)

ISO: Animation: image sequence ordered in time for video display. This covers all changes which cause visual effect (position, shape, color, transparency, object structure and texture, lighting, camera parameters, even the rendering technique).

Classic (cel) animation (handmade)

Script (storyboard layout)

action sketch and fabula description

Object definition

defining shape and properties of objects, synthetic actors

Key-frame specifications

discrete timing - draw significant frames

Generation of in-between frames

interpolating frames in time, between the keyframes

Chief animator (choreographer) designs and depicts objects.

Phasing of the complete animation is too complex, therefore she completes the key-framing.

Help animators do the phasing, coloring, etc. (in-between frames).

Use of computers for work automation.

<u>Computer animation</u>

Computer supported animation

a) computer creates primitives (polylines, polygons, ...)

b) inbetweening (interpolations, morphing, warping ...)

- c) coloring (area fill, texturing ...)
- d) visual effects (fade out, dissolve, transition, wipe ...)

Computer modeled animation

- Making scene objects alive object autonomy
- Display of time-dependent scene
- Image generation, change object attributes and camera parameters in time
- Simulation cretaing highly realistic animation
- Change any parameter (color, size, ...)

Creating Computer Animation



<u>Storyboards</u>
 sketch the story
 give the message



<u>Shading</u>
 colors, surfaces,
 materials,
 textures



<u>Modelling</u>
 2D/3D models
 (e)motion
 specification





Lighting
 lightsources
 in the scene

<u>Rendering</u>
 transform the
 images into
 the animation



 Animation
 Choreography
 of motion in the scene
Storytelling

- Story, oral history
- Myth (past time)
- Fairy tale (two times)
- Sci-fi
- (past, present, future)

~ SOUND SPACES

Performed stories

~ GAGMAN

Theatre

- Written stories
- Novel/travelling
- Drama/agora
- Script/street

Cinema, TV WWW

Storytelling patterns: joke, folktale & Propp morphology, drama...

The First Department of Digital Storytelling...

- Interactive storytelling for GUI
- New artwork
- For WWW and at WWW: http://www.animationlibrary.com/a-l/ - Over 13,754 free Animations Online!
- Storytelling as a profession, authoring tools at:
- http://www.clramatica.com/,
- http://home.click2learn.com/en/toolbook/index.asp,
- http://www.macromedia.com/software/director/
- http://www.macromedia.com/software/authorware/ free demo

The level of abstraction in motion parameters representation divides computer animation:

- Low-level computer animation
- High-level computer animation
- High level operations are composed from the low level ones

Low level animation

- the motion is defined using parameters, which is necessary to set manually (speed, orientation, direction, speeding up, ...)
- key-framing
- key-parameter

- animation curves
 - define object trajectory (key frame interpolation)
 - define parameter value change
 - interpolating curves determine the whole of animation (continuity, shape changes between intepolated points, smoothness, speed changes ...)
 - Bézier curves,
 - Kochanek-Bartels (TCB),
 - Catmul-Rom spline (C²-continuous),

High level animation

- motion defined by abstract commands: collide, follow, explore, go ahead, ...
 - (collision detection, forward / inverse kinematics, hierarchies, structures, state space, ...)
- Kinematics study of motion independently on forces influence (location, speed, acceleration)
- Dynamika study of mutual interaction of forces and objects
- Segment structure (articulated structure)
- Open segment strukture end effector
- DOF-degree of freedom

State space - state vector ($v = (v_0, v_1, ..., v_N) \# DOF = N-1$)



Animating the motion of segment structure is searching the path in its state space (sequential travelling through given states)

Forward kinematics

- hierarchy
- the change of a part causes changing of all succesors
- end effector position P = f(v)
- model control is not intuitive and is tedious
- **Inverse kinematics** (goal directed motion)
 - inverse forward kinematics
 - $v = f^{-1}(P)$
 - !!! 1. *f*⁻¹ may not exist for particular *P* underestimated
 - 2. Icleas (approximation theory methodology, e.g. limit the state space)



Collision detection

- Virtual Reality real time imprecise
- Computer Animation exact computations out of real time
- Collision detection and reaction
- Algorithms
 - Sphere hierarchy
 - OBB trees

(Oriented Bounding Box)





Power and benefits of computer graphics and animation

NO NEED OF PHYSICALLY EXISTING MODEL (INTERIER, EXTERIER, ...)

- FREE CAMERA POSITIONING IN THE SCENE
- SIMULATIONS, VISUALIZATIONS AND RECONSTRUCTION OF PHENOMENA OR EVENTS
- SAVES & MAKES MONEY

Problems of computer graphics and animation

- Realistic image
 - photorealism (Ray-Tracing, Radiosity)
- Realistic motion
 - Motion Capture technology
- Modeling of natural phenomena
 - special modeling (vegetation Fractal Modeling, waterfalls -Stochastic Modeling)

Motion Capture Technology

Motion Capture, MC

create realistic looking motion of complex objects and structures

Methods:

- Optic sensors
- Elektromagnetic field
- Potenciometric approach
- Combinations of the previous ones

Application areas:

- Body motion capture
- Facial motion
- Hand and fingers motion

Optic method

- cameras
- 31 markers joints
- capturing in various environments
- analyse marker trajectories
- absolute location





Electromagnetic MC

- electromagnetic field
- markers objects sensible to motion in the field
- analyse the markers placement
- relative location change







Potentiometric method mechanic principle









Body motion (moving body recording)







Facial motion (facial mimics capture)



Hand motion (capturing of hands/fingers movements)





















MoTek

Capturing various movements data (in a plethora of environments)



Real-time MC



Movie industry





Realistic appearance of a human

<u>Appearance</u>

- photorealism methods
- texture mapping (skin, clothes)
- deformations (muscles)
- material imitation and simulation

– <u>Motion</u>

- Motion Capture complete body motion
- collision detection
- simulated clothes properties

■ Face - 3D Model





Face - 3D Model





Face

- realistic maps (texture map, bump map, specular map)
- layered maps onto the 3D model

Bump map





Texture map



Specular map

Wrinkles/Falten

- Reality smoothing
- Here creating
- Increase believability
- Location influenced by mimics or movement
- Detailising of eyes expression







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Hair

 Sophisticated techniques





Plenty of individuals (~ 120 000)
 Each individual connected to scull surface
 Styles - fluid flow simulation or air blowing



Barb

- influences expression
- hair/nohair
- influenced by mimics
- shadows casting more compex
- more details







Muscles

- body movement influence
- simple muscle structure
- muscle deformations
- mapping the skin texture





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Motion

- realistic motion: Motion Capture technology
- actors acting all movements for all characters in each act





Clothes

- simulation of properties
- collision detection





Authoring Tools

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<u>VRML case:</u> 1) Modeling (3DS Max, Rhino 3D, Maya, Spazz 3D, Cosmo Worlds, trueSpace etc.) 2) Manual VRML editing, recommended "VrmlPad" (ParallelGraphics), by J. Zara 3) Animate

<u>General case:</u>

 WWW, WWD, RenderMan, AutoCAD, HyperFun, Organica, VolVis, FractInt, ... freeware, dedicated software...
 Combine/Animate

Authoring Tools

trueSpace (Caligari Corporation) www.caligari.com







Loft

3D Studio MAX (Kinetix, Inc.) www.discreet.com


Using Maya Animation

- Animation development environment
- Keyframe animation
- Nonlinear animation
- Path Animation
- Motion capture animation

Animation development environment

- Animation controls
- Time slider
- Range slider
- Playback controls
- Animation controls menu
- Current character settings
- Editing animation preferences
- Frame rate heads up display

Live computer animated demos...