Computer Animation
0-Introduction
SS 15

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Overview

- Specifying motion [5 W]
  - History of animation, computer animation
  - Review splines
  - Keyframing parameterized models
  - Freeform deformations
  - Morphing
  - Review quaternions
  - Rigid bodies
  - Inverse kinematics
  - Character skinning
- 2D motion [2 W]
  - Interpolated motion
- Passive motion (physics-based and procedural methods) [4 W]
  - Particle systems
  - Rigid bodies
  - Contact and collision
  - Mass-spring systems
  - Noise and turbulence
- Active motion (controller and data-driven methods) [3 W]
  - Flocking behaviour
  - Motion optimization
  - Motion capture

Aim of the course

- To present techniques used in animations, i.e. “moving objects”
  - Algorithms
  - Mathematical methods
  - Movement studies

  - Not for the faint of heart
  - Lots of math, but also fun

Exercitations

- Final grades
  - 40% exercitations
  - 60% final exam.
- Exercitations:
  - Aline.Helmke[at]uni-weimar.de and Bernhard.Bittorf[at]uni-weimar.de

Literature

- Rick Parent: „Computer Animation. Algorithms and Techniques“, Morgan Kaufman 2002
- http://www.blender.org
- http://www.uni-weimar.de/medien/cg

Computer Animation
1-History
SS 13

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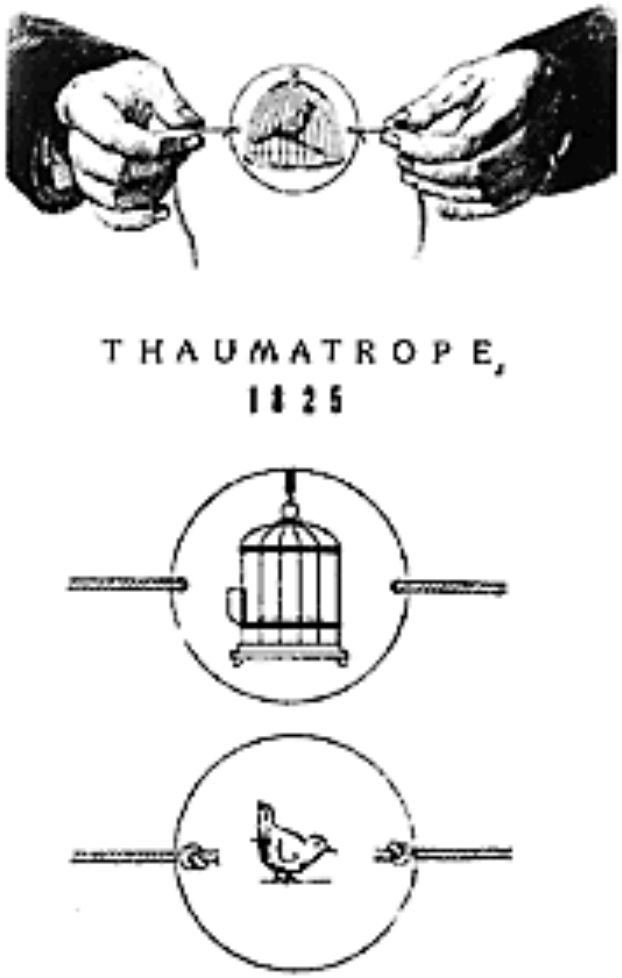
Early animation devices

- First experiments with persistence of vision done early 1800
- Animation existed before the camera
- Perhaps simplest device: thaumatrope
  - Flipping circle with two drawings



Early animation devices

- Flipbook
  - Very common, and survived till today
- Motion through page flipping

Early animation devices

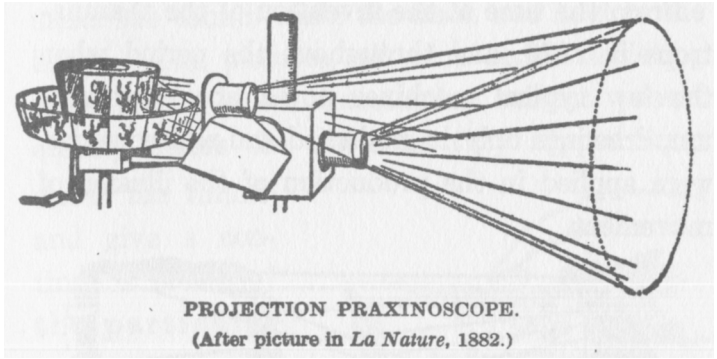
- Zoetrope: wheel of light
- Cylinder
  - Inside: drawings
  - Slits cut between frames on cylinder
  - Allow viewer to see only one frame
  - Illusion of movement

Early animation devices

- Phenakistoscope: greek for „spindle viewer“
- Two disks rotating in sync (or one at the mirror)
  - Back side: drawings
  - Slits cut between frames on cylinder
  - User can see only one small part of frame at a time
  - Illusion of movement

Early animation devices

- Praxinoscope: greek for „who knows?“
- Here rotating mirrors are used for allowing only the view on one frame at the back of the external cylinder



„Conventional“ animation

- Filming of two-dimensional handdrawings
- Georges Méliès (1896) used camera tricks (multiple cam exposures, stop motion) to make objects appear, disappear and change shape.
- Emile Cohl produced several vignettes
- J. Stuart Blackton animated smoke on a movie (1900) and created first animated cartoon in 1906.

„Conventional“ animation

- Windsor Mc Cay, a newspaper cartoonist, produced first animated cartoons
  - *Little Nemo* (1911)
  - *Gertie the dinosaur* (1914).
- Technique used:
  - Draw each image on rice paper
  - Film them individually
- In many of his works, he interacted live with his characters

„Conventional“ animation

- John Bray started 1910 to work at patenting the animation processes.
- Was joined in 1914 by Earl Hurd, who patented the use of translucent *cels* to compositing multilayered images
- Bray patented also
  - The use of grayscale
  - He then enhanced overlaying to include a peg system for registration of the layers
  - Finally he patented drawing on long sheets to allow panning on the background

„Conventional“ animation

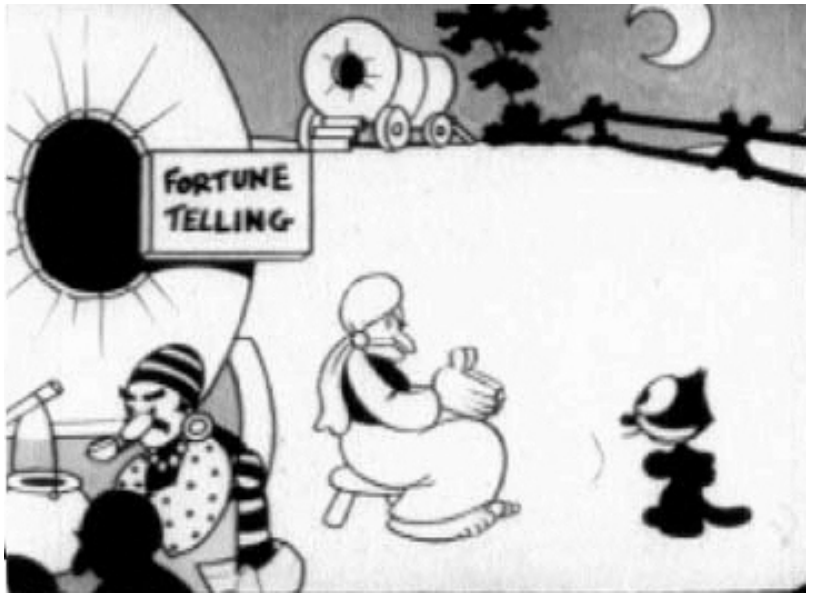
- Out of Bray ‘s studio came following authors:
  - Max Fleischer (*Betty Boop*)
  - Paul Terry (*Terrytoons*)
  - George Stallings (*Tom and Jerry*)
  - Walter Lanz (*Woody Woodpecker*)

„Conventional“ animation

- In 1915 Fleischer patented rotoscoping: draw images on cells by tracing previously recorded live actions
- Bray did experiment also with colour (1920) in the short „*The debut of Thomas Cat*“

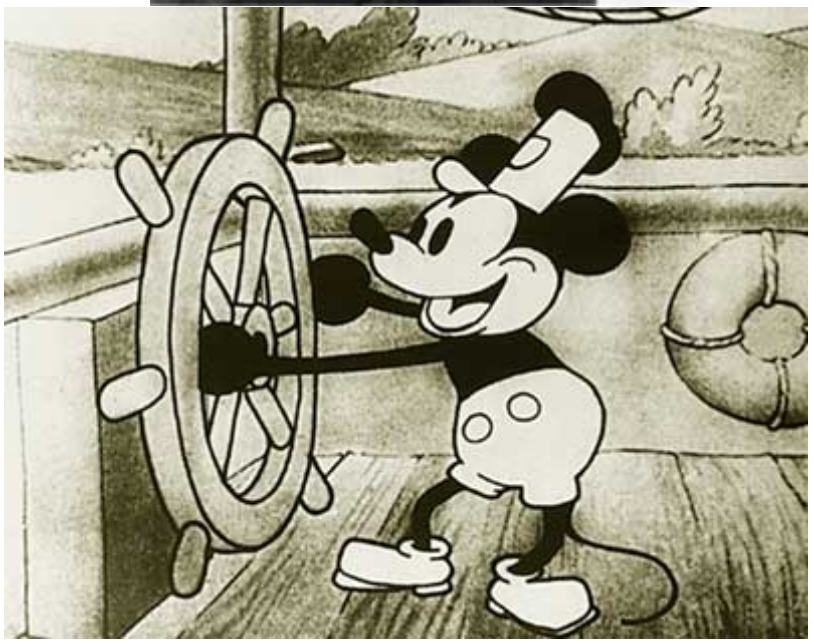
„Conventional“ animation: arts?

- Technology developed fast
- However, the artistic side struggled for long
- First complete character with personality:
  - *Felix the Cat* (Otto Messmer) very successful in mid 1920s



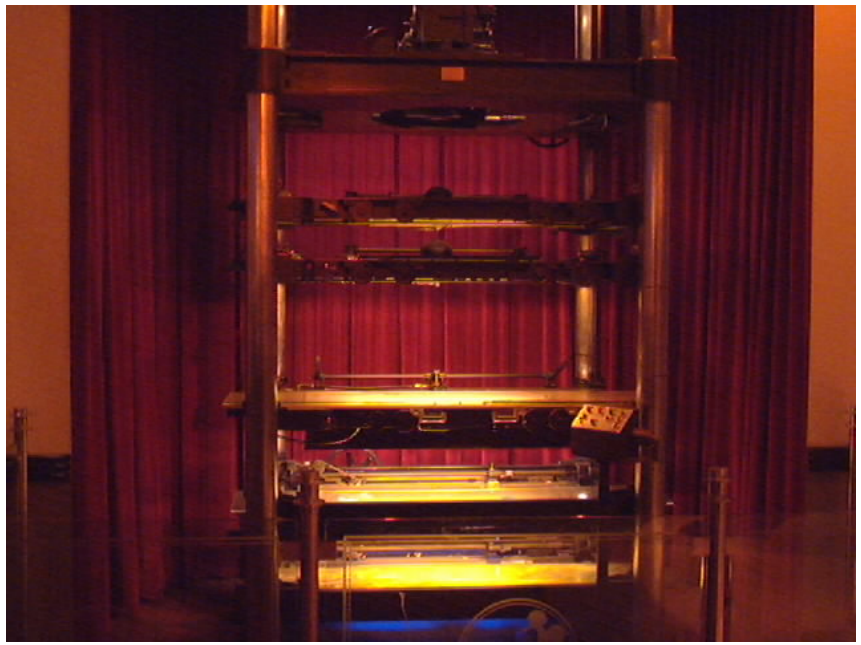
Walt Disney

- Walt Disney was the most successful conventional animator
- First to use storyboards for animations
- In 1928, he was the first to add sound to animations in „Steamboat Willie“



Walt Disney

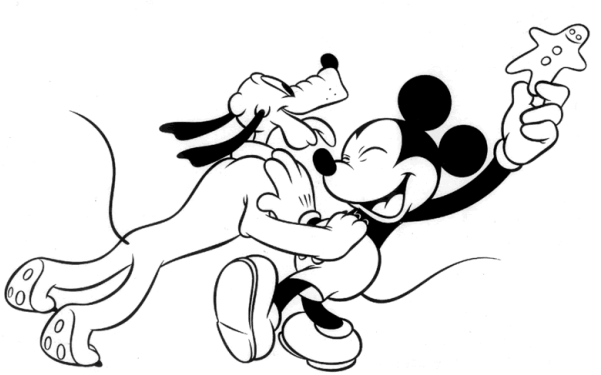
- Major technical innovation of Walt Disney:
  - Multiplane camera
  - Camera mounted on top
  - Each plane holds an animation cell
  - Planes move along 3 axes
- Allows parallax motion (multiplane backgrounds)



Courtesy Sébastien Barthe

Walt Disney: arts

- Disney preferred to give characters a long lasting personalities
- Focus on character, build stories around it
- Major characters: Mickey Mouse, Pluto, Goofy, Donald Duck
- Studied intensively real life motion
- Developed first „mood pieces“
  - *Skeleton Dance* in 1929
  - *Fantasia* in 1940



Animation studios

- The success of Walt Disney pushed others to initiate animation studios
- Well known animation studios: Fleischer, Iwerks, Van Beuren, Universal Pictures, Paramount, MGM, Warner Brothers.

Alternative techniques

- Stop motion
- techniques have been
- also very popular:
  - Clay animation
  - Puppet animation
- Here figures are
- moved one frame
- at a time, and snapshots are tak
- Father of these techniques:
  Willis O ‘Brian *(King Kong)*
- Ray Harryshausen (Mighty Joe Young)
- In Europe: Fusako Yusaki (Fernet Branca)

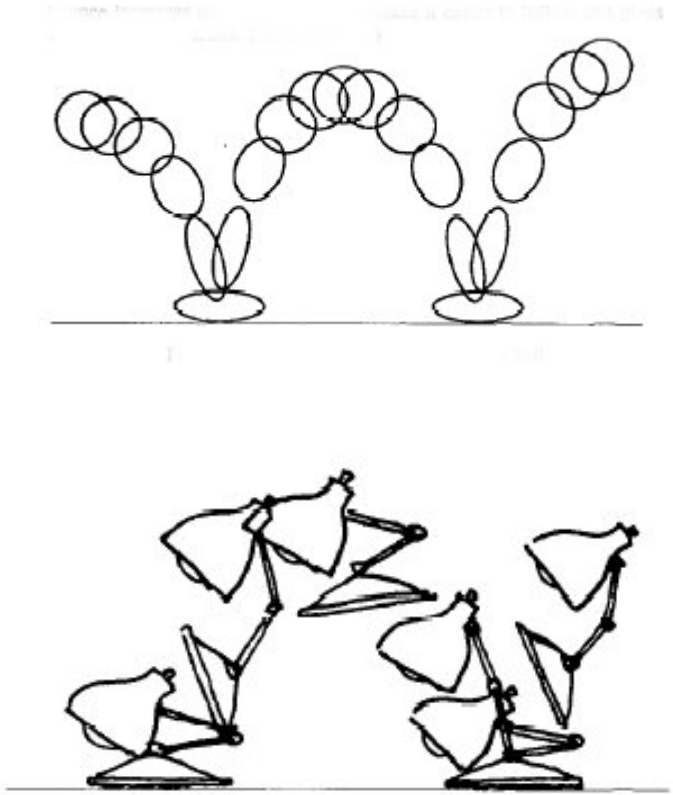
Computer animation: the principles

- Animation has its roots in 2D animation, and rules of course have been found out for 2D animation (the grammar of animation)
- These principles are nowadays quite well known. John Lassater (Pixar) outlined these principles in a nice article at Siggraph 87

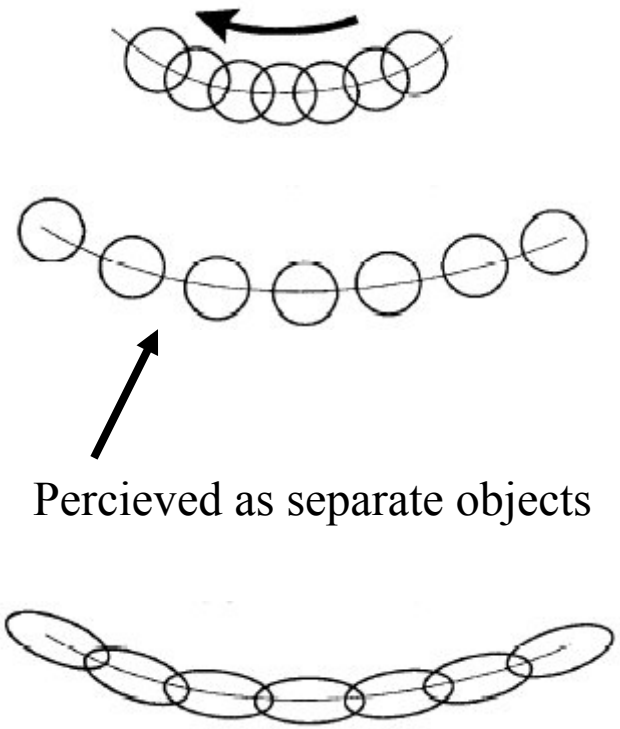
1. Squash and stretch
2. Timing
3. Anticipation
4. Staging
5. Followthrough and overlapping action
6. Straight ahead action and pose-to-pose action
7. Slow in and slow out
8. Arcs
9. Exaggeration
10. Secondary action
11. Appeal

Principles: squash and stretch

- Example



– Used also to avoid strobing in fast movement



Principles: timing

- Timing: the speed of an action
  - Not too long (boring)
  - Not too short (one sees nothing)
  - Weight of object is defined by timing
    - the heavier, the slower it accelerates
    - The lighter, the faster they accelerate
    - Big and heavy objects move slooooowwww
- Emotions can be also expressed through different timings:
  - Tilting a head with one inbetween may indicate it has been hit by a bat
  - But with seven inbetweens it tries to get a better look at something

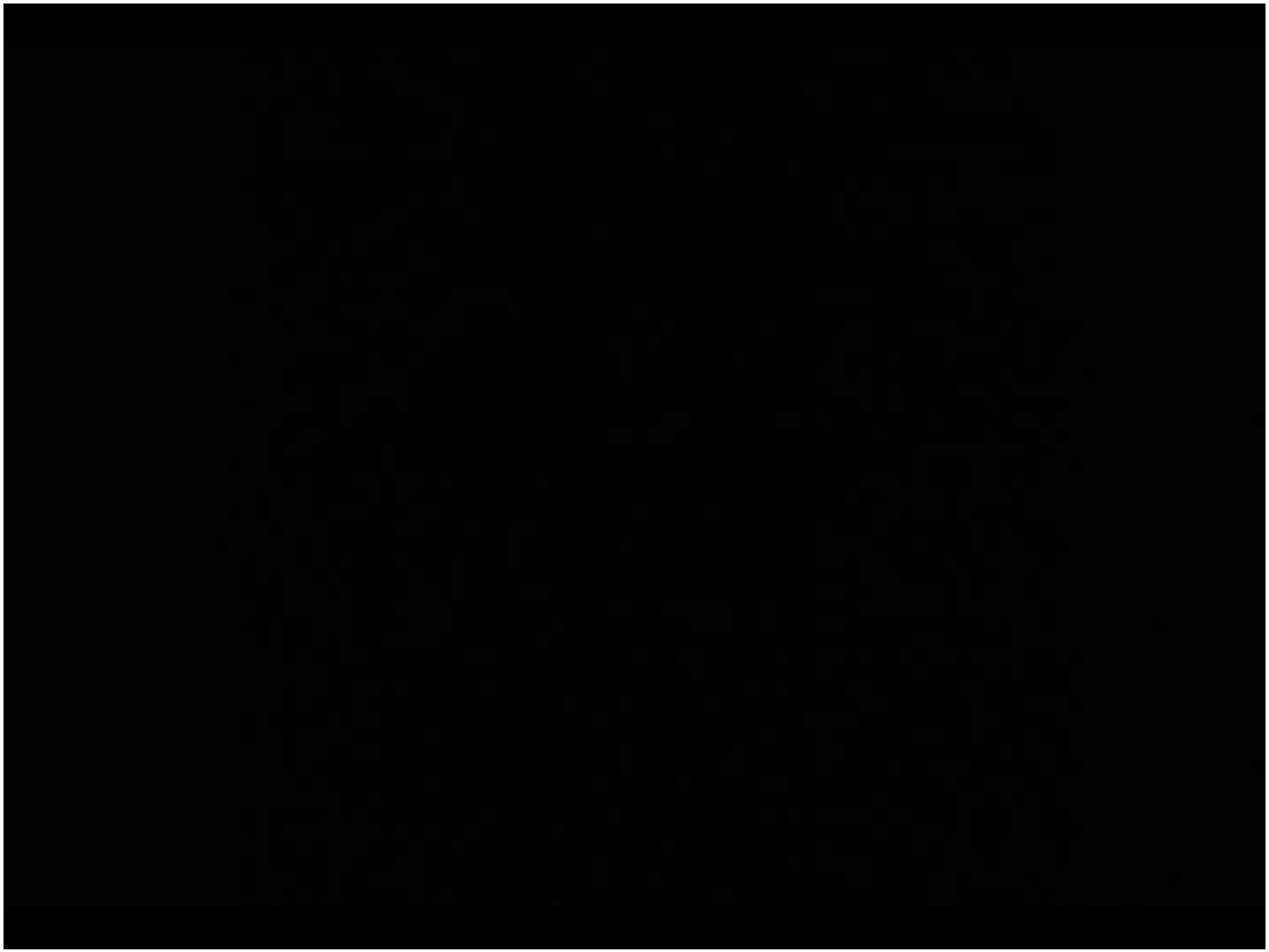
Principles: Anticipation

- Actions are subdivided in 3 parts:
  - Preparation (anticipation)
  - the action itself (staging)
  - its termination.
- Anticipation prepares the action and notifies the viewer something is going to happen
- In nature, it is the same: you can't kick unless you pull the leg backwards
- Anticipation aims at making the viewer look at the right part of the image
- If the viewer knows what to expect, then action itself can be faster
- Exaggerated anticipation can be used to emphasize heavy weights (bending back to lift one)

Principles: Anticipation

- Actions are subdivided in 3 parts:
  - Preparation (anticipation)
  - the action itself
  - its termination.
- Anticipation prepares the action and notifies the viewer something is going to happen
- In nature, it is the same: you can't kick unless you pull the leg backwards
- Let us make an example

Principles: Anticipation



Principles: Staging

- Staging is the presentation of an idea so it is unmistakably clear.
- This can be an action, a personality, an expression, or even a mood
- Staging, anticipation and timing are all integral part to directing the eye.
- Very important is to allow users to see only one thing at a time

- Animators in fact tell a story saying „look at this, then this“
- Staging is mostly done in silhoutte: actions are done outside of the body so as to make them pop out more clearly (e.g. Scratching is done on side)

Principles: Follow-through and overlapping action

- Follow through is the termination of an action
- Actions usually last longer than their end. Ex: hand throwing ball goes on after
- Actions of parts of an object are not simultaneous. Some parts start before (the *lead*).
- For example, hips move before legs for walking
- Similarly, appendices would „follow“ the action, and do this according to their weight
- Slight variations are added to loose parts to make action look more interesting (overlapping)
- Actions themselves overlap, just as we curve not by turning promptly but on smooth curves

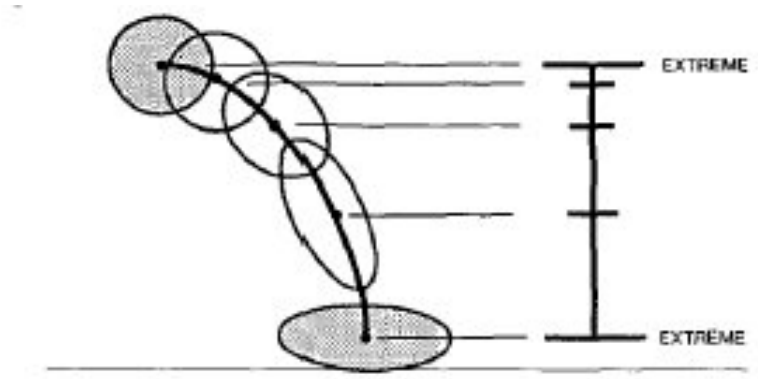
Principles: Follow-through and overlapping action

- There are mainly two approaches to hand drawn animation
  - The animator can produce one pic at a time in sequence (*straight ahead*)
  - The animator can produce key poses and then draw the inbetweens (*pose to pose*)
  - Inbetweens are done knowing the timing necessary for action
  - For complex shapes they are difficult to do
- Automatical inbetweening becomes therefore difficult to do
- Moreover, parts of figures may require different keyframe timings

Principles: Slow in, slow out

- This deals with the spacing of the inbetween drawings between the extreme poses
- Mathematically it means controlling acceleration
- The animator indicates the inbetweens with a timing chart drawn to the side to specify where the inbetween drawings are placed in the timescale

- Here is an example of a timegraph of a ball bounce:



Principles: Arcs

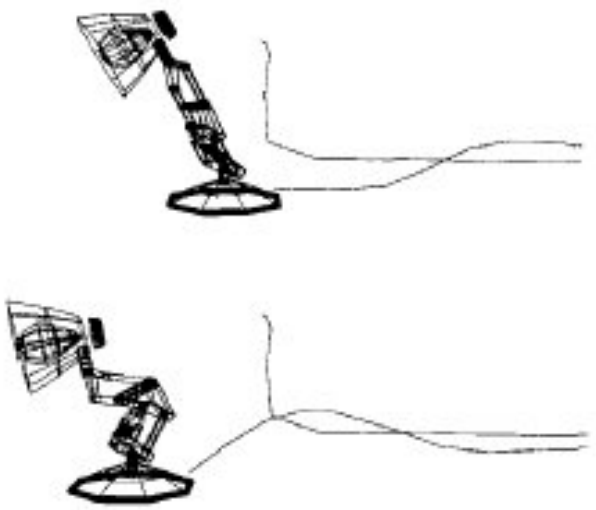
- The visual path of action is described by an arc
- All movements follow an arc
- Sometimes, they are on a straight line, but mostly they are on an arc
- Even if characters move on a straight line, they usually rotate on themselves

- Arcs are usually done on 3rd order splines, to be able to control velocity and acceleration

Principles: Exaggeration and secondary action

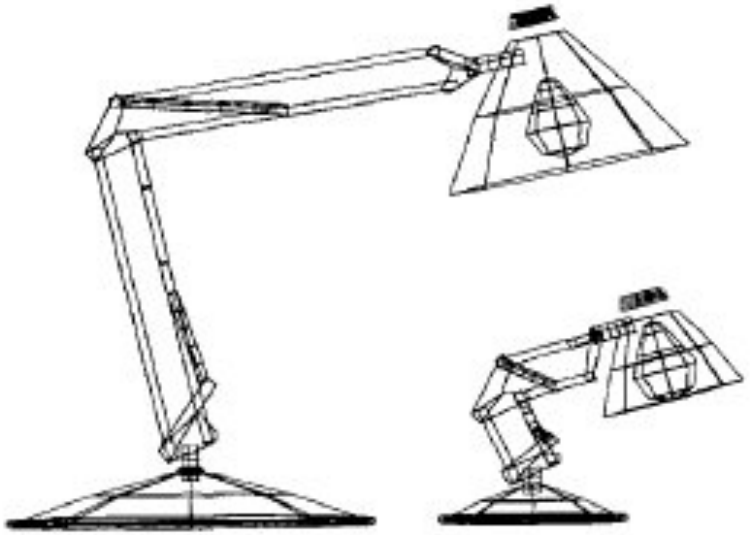
- Exaggeration in animation does not mean distorting, just accentuating
- Make sad characters sadder, wild characters frantic
- Balance exaggeration in the scene so all looks „equally exaggerated“
- Do not overdo exaggeration, and keep it „natural“

- Secondary actions are actions resulting directly from another one
- Example: a power chord of a device has its own secondary movement if you move the device itself



Principles: Appeal

- Appeal is anything the viewer likes to see, or would look at:
  - Weak drawing
  - Too complicated drawing
  - Akward moves
- Simple rules to avoid flatness of design:
  - Do not make characters symmertic: they would look dull
  - Think of detail when you develop a character



Principles: Personality

- Personality is given by the successful application of the above principles
- A story is good when viewers look at the character and at the story
- Animators have full control of every move, but they are good at animating when a character becomes a character

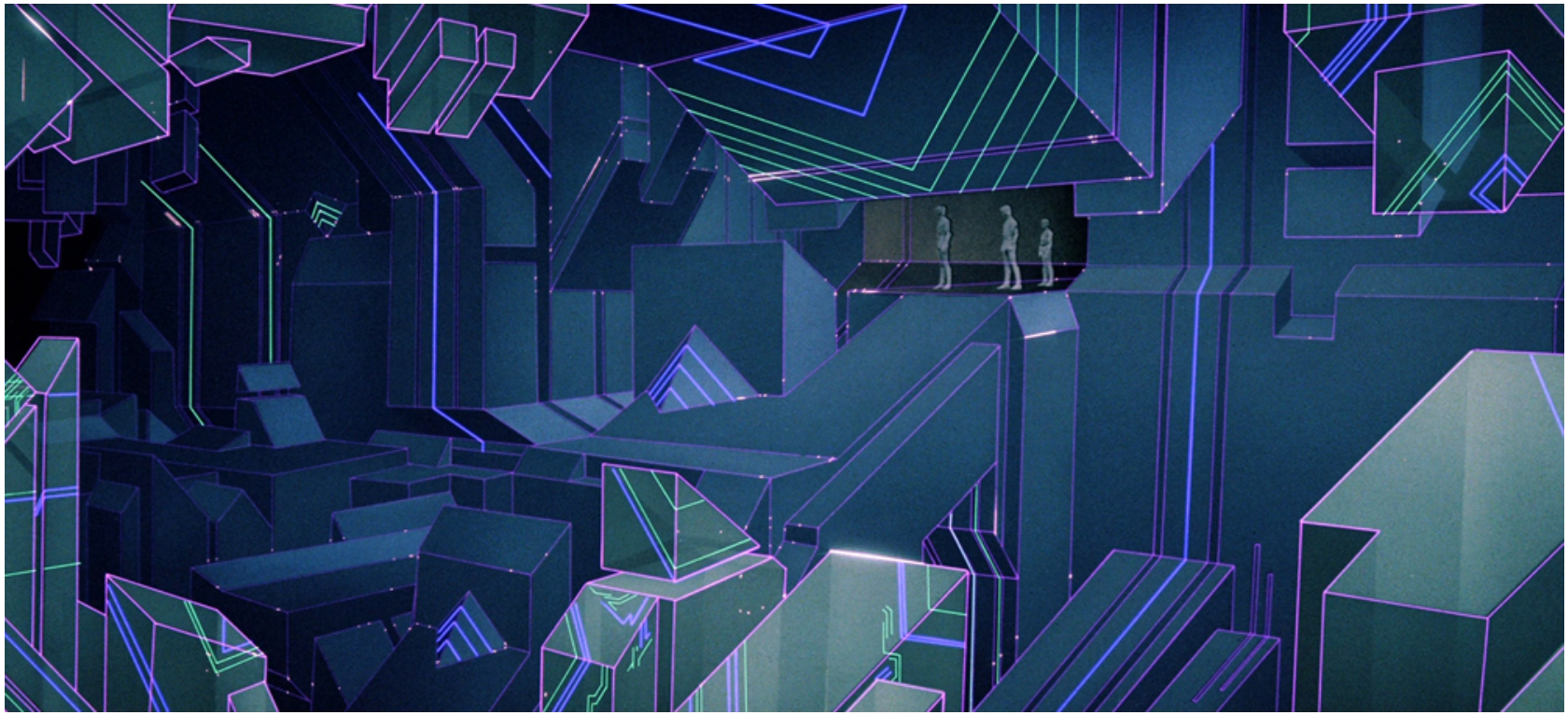
- Questions animators have always present to express a characters personality are:
  - What mood is the character in?
  - How would he move to perform this action?
- No two characters would do an action the same way
- AND the personality of the character should be familiar to the audience

Computer Animation: examples

- First movie to make extensive use of animation?

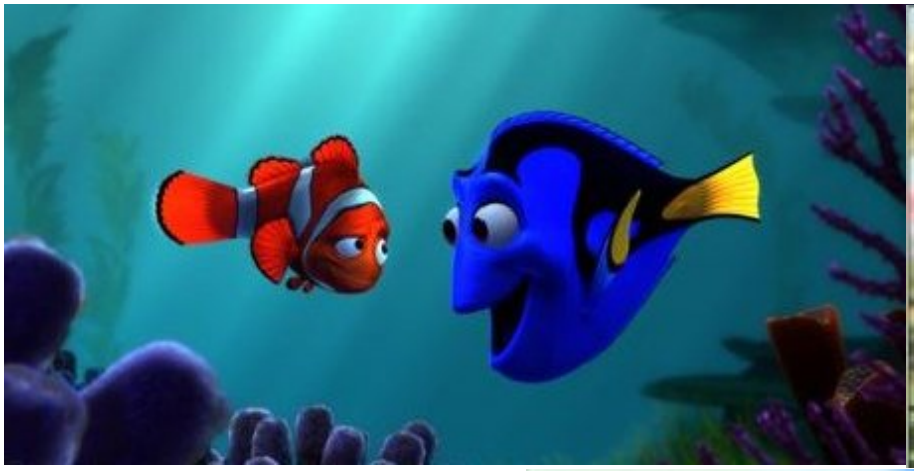
Computer Animation: examples

- First movie to make extensive use of animation?
- Tron, Disney, 1982



Computer Animation: examples

- Finding Nemo: Copyright Pixar (2003)

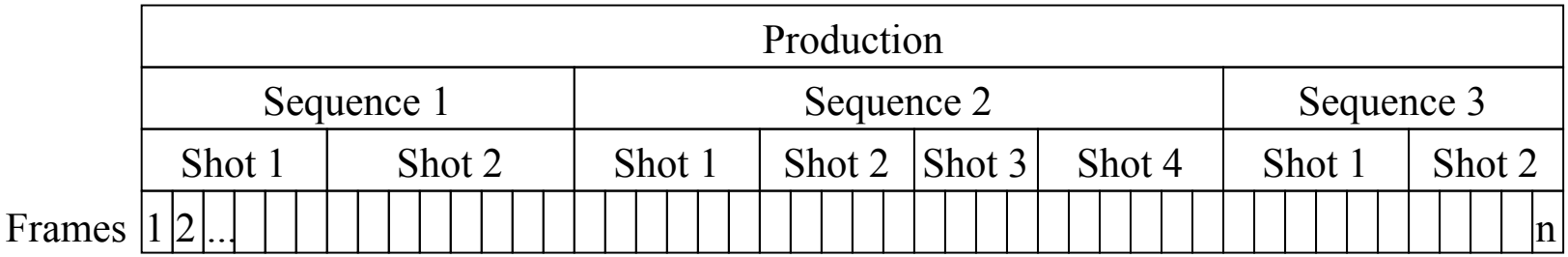


Geri ‘s Game: Copyright Pixar (1999)

For the Birds: Copyright Pixar (2001)

Traditional animation: production

- *Production* indicates the whole film
- Productions are split in *sequences*: each sequence is usually identified by an associated staging area. There are 1 to 12 sequences in a production
- A sequence is broken in one or more *shots*. Each shot is a continuous camera recording
- A shot is broken down into individual *frames*. A frame is a single image



Traditional animation: production steps

- First a *preliminary story* is decided
- This includes a *script*
- A *storyboard* is developed: it lays out action scenes by sketching representative frames and writing text to it
  - A storyboard is used for discussing action

- For each character, *model sheets* are done. They are drawings of the character in different poses for keeping the characters consistency across animation
- The *exposure sheet* records all info of each frame (camera moves, sound cues, composing elements)
- The *route sheet* records stats and responsibility for each scene
- A *story reel* may be produced: a recording of the keyframes, each for as long as the scene it represents. It helps reviewing the timing of movie

Traditional animation: production steps

- Once storyboard is decided, work on the *detailed story* is done (detail in action)
- *Keyframes* (or *extremes*) are identified and drawn by master animators
- Assistant animators draw the inbetweens between the keys (*inbetweening*)
- Test shots are done on short sequences to check rendering and movement
- Sometimes movement can be checked on pencil drawings
- Once sequence is fixed
  - *Inking* is done (transferring contours to the cels)
  - *Opaquing* is done (filling with colour)

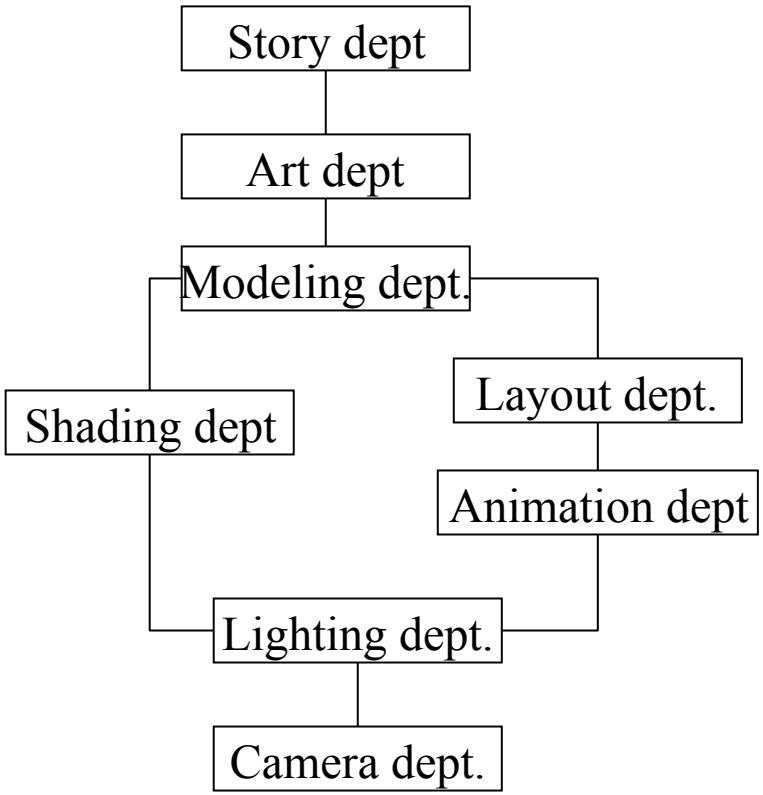
Traditional animation: sound

- Sound is extremely important in animation
- Contrary to regular movies, precise timing is possible
- Depending on importance of sound, either
  - Animation is done first :
    here a *scratch track* (or rough sound track) can be built while storyboard is developed
  - Sound track is done first
    e.g. for lipsyncing

And in Computer Animation?

- Many of the tasks and tools before are used here too: storyboarding, model sheets, keyframing....
- However, computer animation allows more flexibility
- Moreover, animators can turn on/off effects to concentrate on partial aspects
- They can even simplify rendering to check for particular aspects
- Moreover, even at rendering time certain aspects can be turned on/off to speed up the process
  e.g. Which objects cast shadows to where

Producing a Computer Animation



- **Story Dept**: Converts screenplay to storyboard and to story reel
- **Art Dept**: Creates design and color studies, including detailed model description and lighting scenarios
- **Modeling Dept**: Creates the characters and the world they live. Often parametrizes figures to control movement of figures
- **Layout Dept**: Implements staging and blocking. Is responsible for taking the film from 2D to 3D
- **Shading dept**: Adds textures, displace-ment shaders and lighting models
- **Animation dept**: Responsible for character „life“. Produce gestures and subtle animation detail
- **Lighting dept**: Assigns teams to each sequence so that lighting is done as the arts department wishes
- **Camera dept**: renders the frames

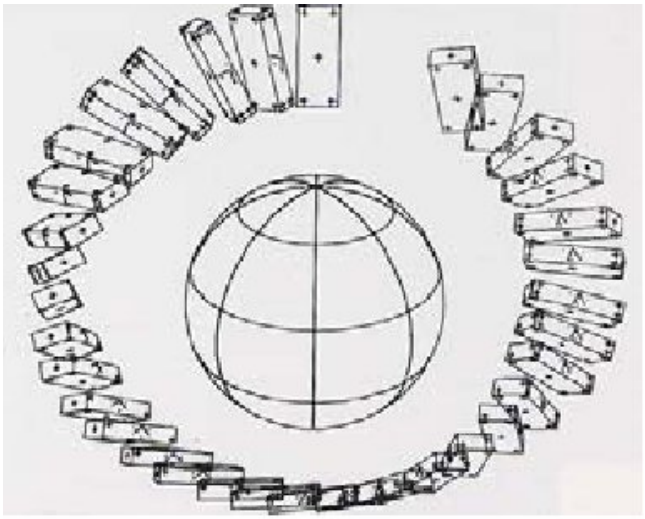
Editing

- Once images are produced, they have to be assembled into the final movie
- Originally, sequences got mixed one after the other linearly in time (the output was linear)
- Later, timestamps were added so that some non linear editing was possible

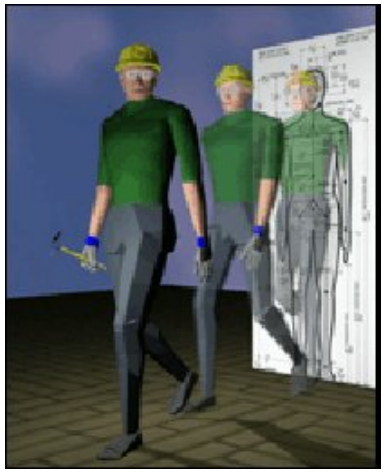
- Nowadays, almost every PC is capable of non-linear editing
- Here, tracks can be mixed, inserted, overlayed, sound can be added to them at will

History: early days (60s-70s)

- It all started from Ivan Sutherland ‘s interactive machine (MIT 63)
- First animated computer sequence: Ed Jazzac (Bell Labs)



- Early 70s: Univ. of Utah established program of CG (Catmull)



- Early Labs (late 70s):
  - U. Pennsylvania (N. Badler)
  - NYIT (Catmull)
  - Ohio State (De Fanti, Csuri)
  - U. Montreal (D. And N. Thalmann)
- Animation mostly in Labs

History: towards maturity (80s)

- Three major events:
  - Development of graphics capable hardware (SGI) and rendering
  - Development of complex algorithms for modeling
  - Appearance of first animation studios and first complex films
- First animated computer film: Tron (Disney 1982)

- Big animation studios at that time:
  - Digital Pictures
  - Image West
  - Cranston-Csuri
  - Pacific Data Film
  - Lucasfilm (who became Pixar)
- First animation Oscars won: Tin Toy (1988)

History: maturity(?) (90s-today)

- Major productions of
  - Complex special effects
  - Whole productions
  - Digital characters in movies
- Two real big players:
  - Pixar (Star Trek II, Toy Story, Monsters.....)
  - ILM (Terminator II, The Abyss, Casper, Jurassic Park, ...)
- Animation big in commercials
  - Here smaller studios work

- Software available nowadays off the shelf
- Hardware too (despite Pixar ‘s Renderfarms)
- Modeling possible at home

History: maturity(?) (90s-today)

- 3D movies: Avatar.

Courtesy 20th Century Fox © 2009

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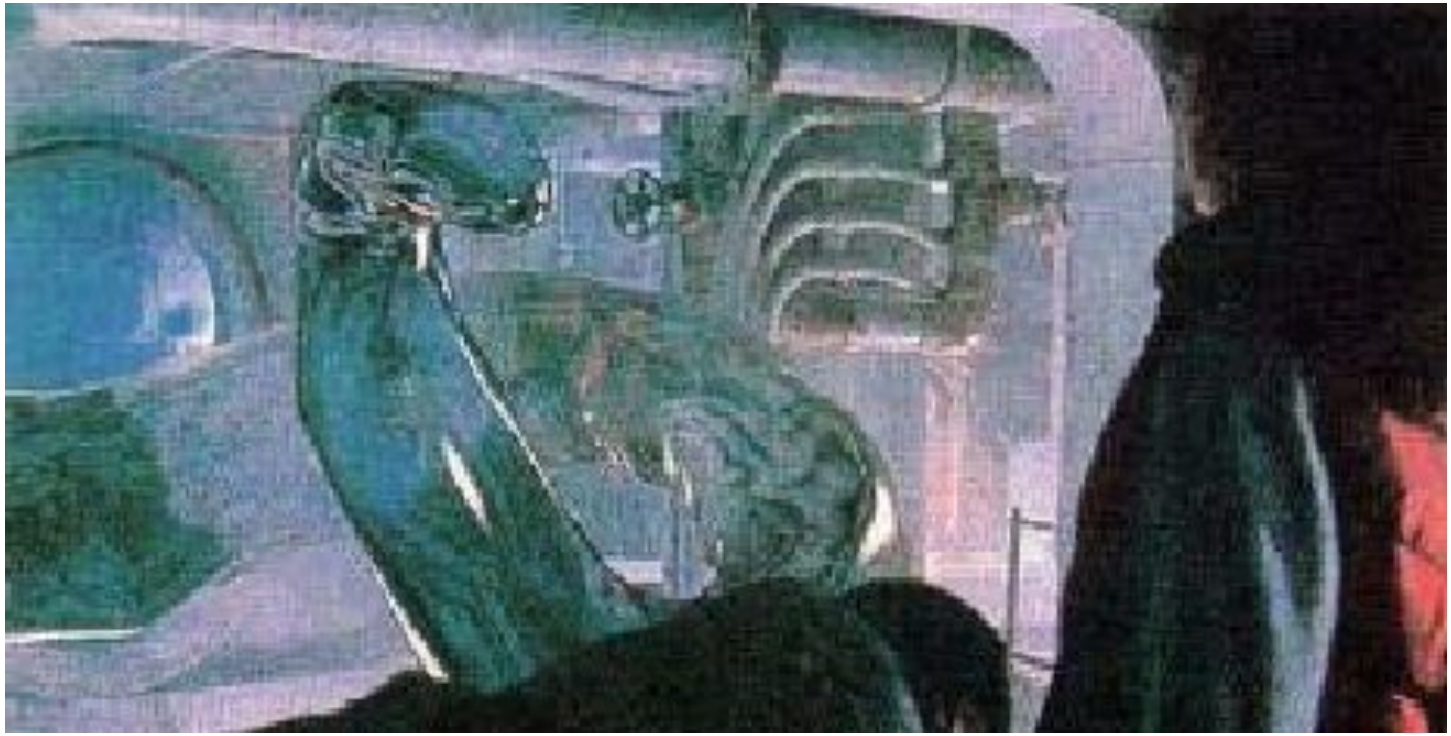

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