Animation
Making Alive using Motion

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Creating Web Graphics

You and Andrej Ferko

Class and Individual Work

Agenda

- Project Specification: Your Project
- Computer Animation History & Workflow
- Human Perception of Motion
- Implications for Web Design

Architecture of Multimedia System

- A. Data bus for structured pictures
- B. Data bus for unstructured images
- C. Data bus for structured sounds
- D. Data bus for unstructured, natural sounds

- Input for A & C: model, data and functionality
- Input for B & D: scanner and microphone

- [Stuc91] STUCKI, P.: Graphics and Multimedia, tutorial at Eurographics Conference, Vienna 1991

Architecture of Multimedia System

- **A.** Data bus for structured pictures VRML, CGM, SVG
- **B.** Data bus for unstructured images JPG, GIF, PNG
- **C.** Data bus for structured sounds MIDI
- **D.** Data bus for unstructured, natural sounds MP3

- Input for A & C: model, data and functionality
- Input for B & D: scanner and microphone

- [Stuc91] STUCKI, P.: Graphics and Multimedia, tutorial at Eurographics Conference, Vienna 1991

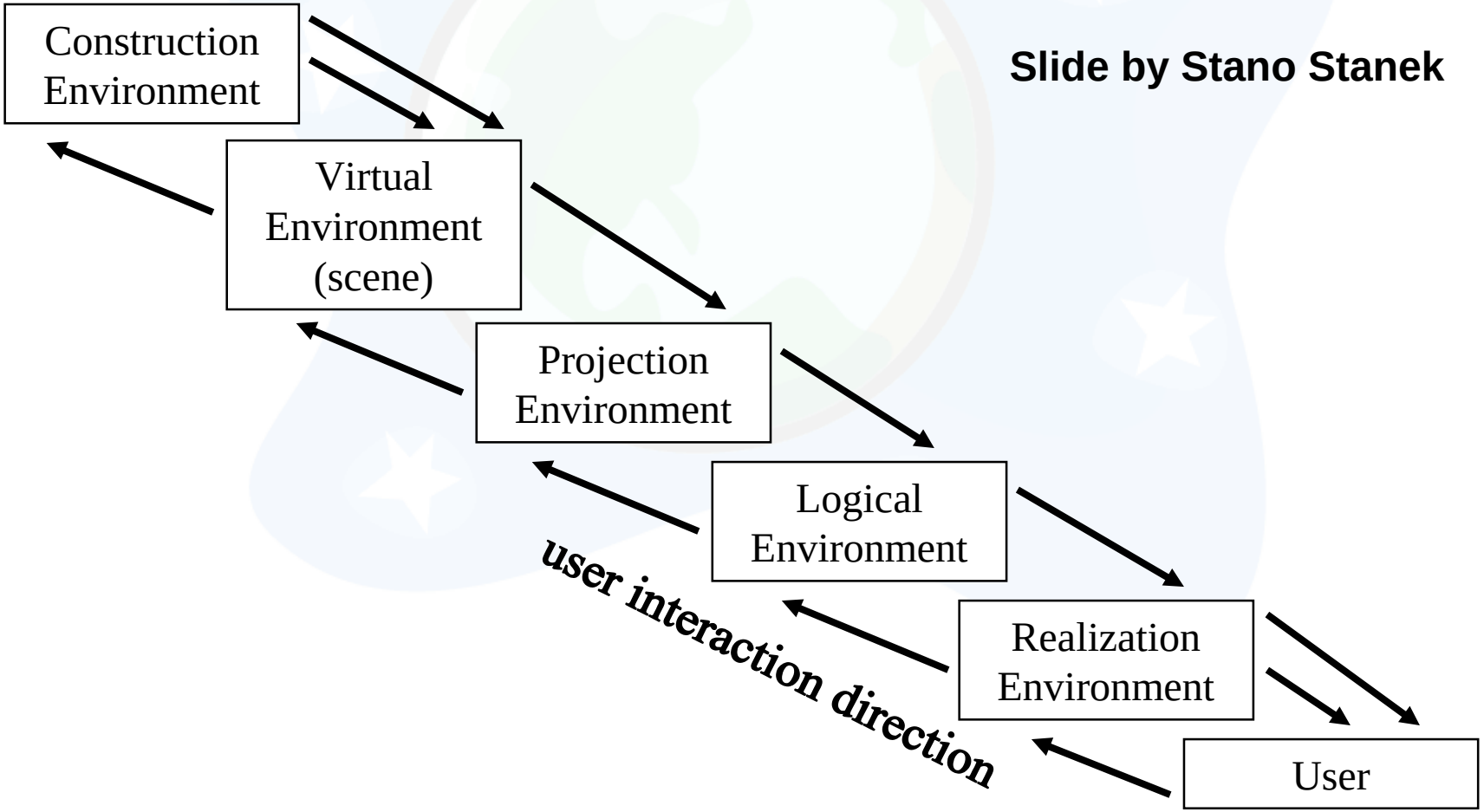
Architecture of MM System II

- A to B functional unit is Computer Graphics.
- B to A functional unit is Image Analysis.
- C to D functional unit is Sound Synthesis.
- D to C functional unit is Sound Analysis.

- No model cases:
- B to B is Image Processing: image to image.
- D to D is Sound Processing: sound to sound.

- [Stuc91] STUCKI, P.: Graphics and Multimedia, tutorial at Eurographics Conference, Vienna 1991

PREMO Environments



Slide by Stano Stanek

Oxymorons

Scientific Visualization

“The purpose of computing is insight not numbers“
Richard Hamming

Animation

- **"There is no particular mystery in animation… it's really very simple, and like anything that is simple, it is about the hardest thing in the world to do.”**
  - **Bill Tytla at the Walt Disney Studio, June 28, 1937.**

Defining Animation

- **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).**
- **Anima** - spirit, soul, life...

Animation (www.siggraph.org)

- Introduction
- Types of Animation Control Systems
- Low level Motion Control
- Camera Animation
- Character Animation
- Particle Systems
- Artificial Life
- Post - Production in Computer Animation

Animation

- Origins in film production
- Advantages against cel animation
  - Virtual models
  - No limits for camera (even multiperspective)
  - Costs
- Applications
  - Film Industry
  - Flight- / Military / NASA Simulation
  - Crash-Tests
  - ...

Categories Watt&Watt

- Procedural Animation
- Representation Animation
  - Animated articulated structures
  - Soft object animation
- Stochastic Animation
- Behavioural Animation
- Low-Level Motion Control

Authoring Tools

VRML case:

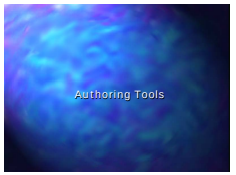
1) Modeling (3DS Max, Rhino 3D, Maya, Spazz 3D, Cosmo Worlds, trueSpace etc.)

2) Manual VRML editing, recommended "VrmlPad" (ParallelGraphics), by J. Zara

3) Animate

General case:

1) WWW, WWD, RenderMan, AutoCAD, HyperFun, Organica, VolVis, FractInt, ... freeware, dedicated software…



2) Combine/Animate

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*

Animation Control Systems

- Scripting Systems
- Procedural Animation
- Representational Animation
- Stochastic Animation
- Behavioral Animation

Scripting Systems

- earliest type of motion control systems
- animator writes a script in the animation language
- must learn animation language
- not interactive
- actors ~ OOP objects
- MAYA - MEL

Procedural Animation

- Procedures define movement over time: 1. **laws of physics** (Physically - based modeling)

- 2. **animator generated methods**:
- a motion that is the result of some other action (this is called a "secondary action"), for example throwing a ball which hits another object and causes the second object to move.

Representational Animation

- Allows an object to change its shape during the animation:
- 1. **animation of articulated objects**,
- **i.e., complex objects composed of connected rigid segments**
- 2. **soft object animation**
- **deforming and animating the deformation of objects, e. g. skin over a body or facial muscles**
- 3. **morphing** 2D, 3D (5D? – Homotopic Fun)

Stochastic Animation

- Using stochastic processes to control groups of objects, such as in particle systems.
- Examples are fireworks, fire, water falls, etc. – cloth simulation by M. Teschner
- Dragon Fireball in Shrek

Behavioral Animation

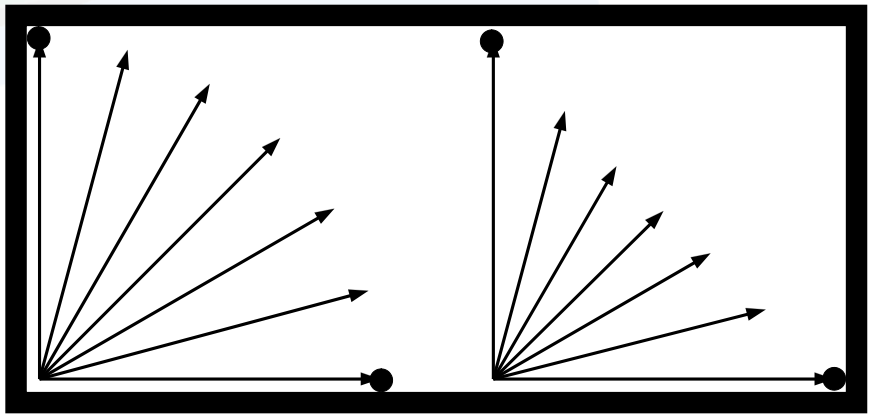
- **Objects or "actors" are given rules about how they react to their environment.**

- Examples: schools of fish or flocks of birds where each individual behaves according to a set of rules defined by the animator
- Mass scenes: hair, vegetables in soup, crowds of people (Titanic, Star Wars, Gladiator…)

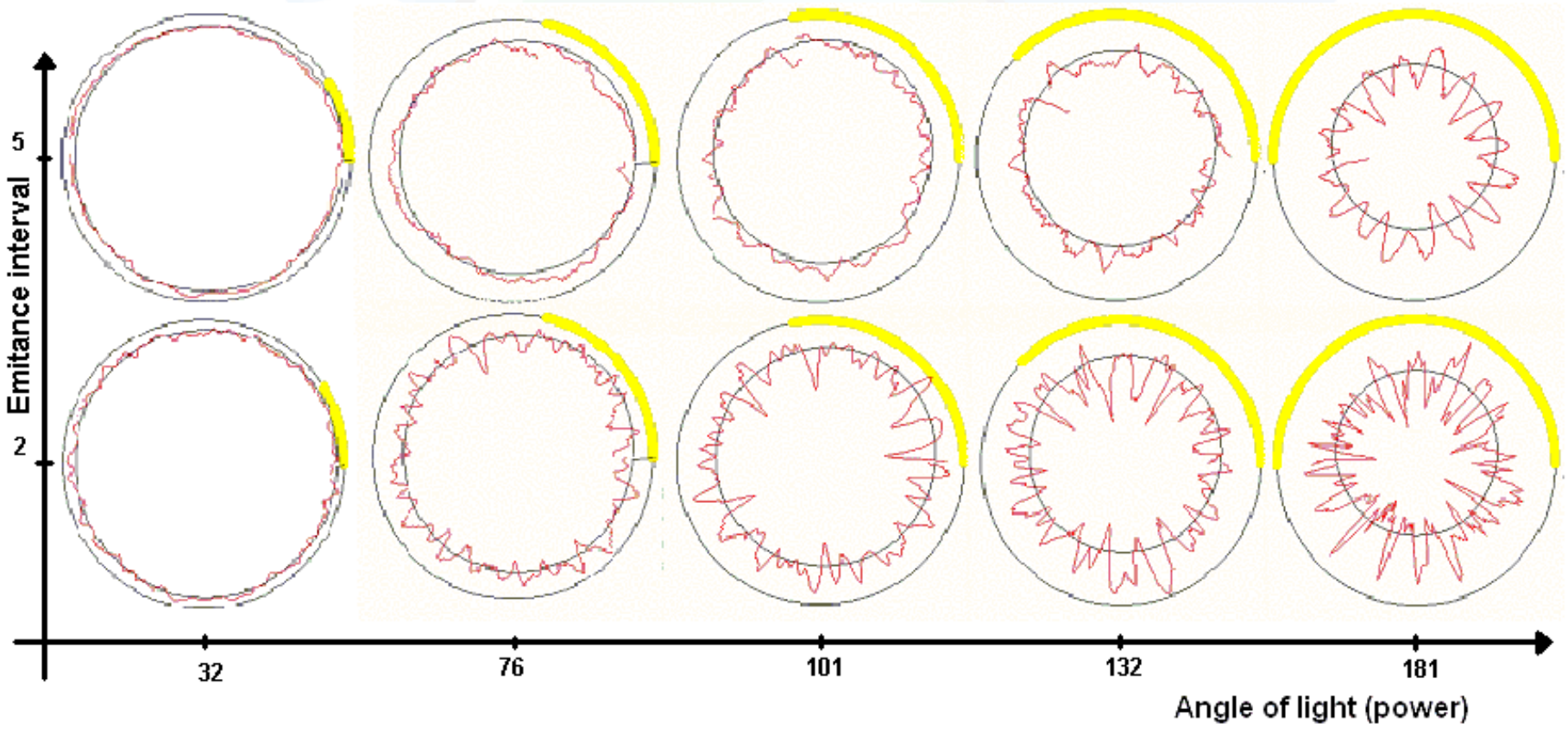
Key Framing

- Named after hierarchic production system by Disney
- Artist creates key frame sequence (3D!)
- Interpolation of inbetweens (MPEG)
- In computer animation:
  - What (xyz, k_d, k_s, ...)
  - How (t, s, v, ...)

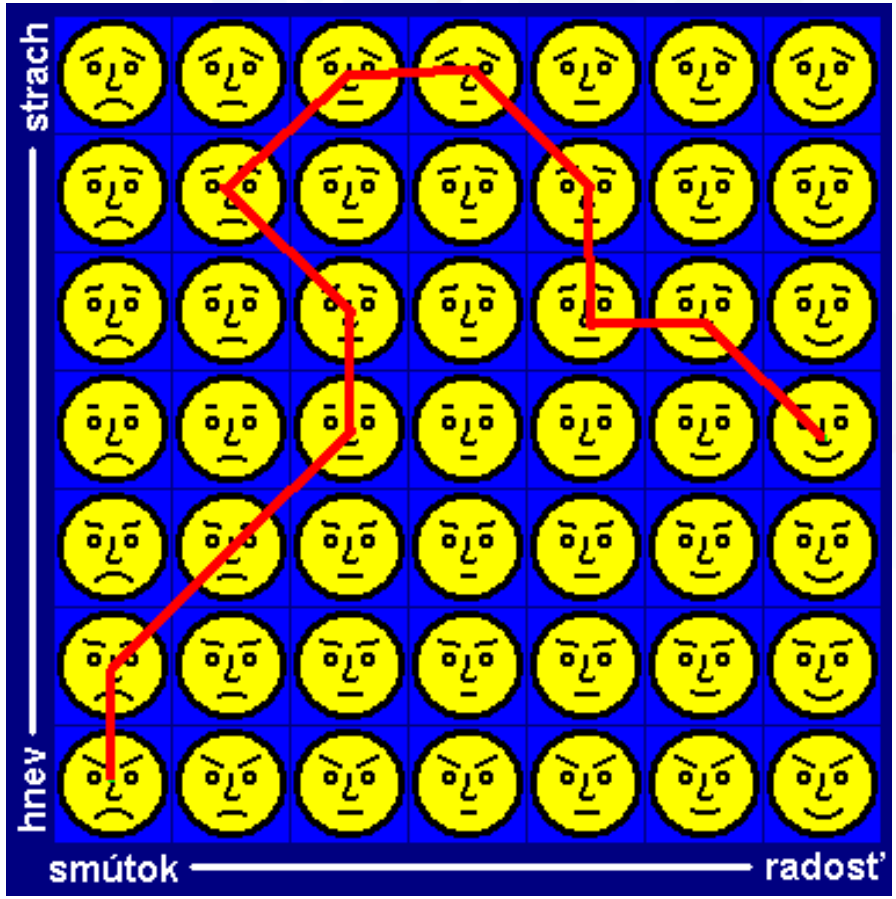
  to interpolate ?

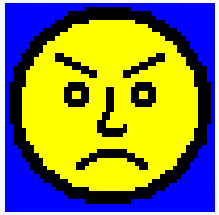


2D Time, M. Hyben, M. Procházka



Matrix of Animations (Simulations)



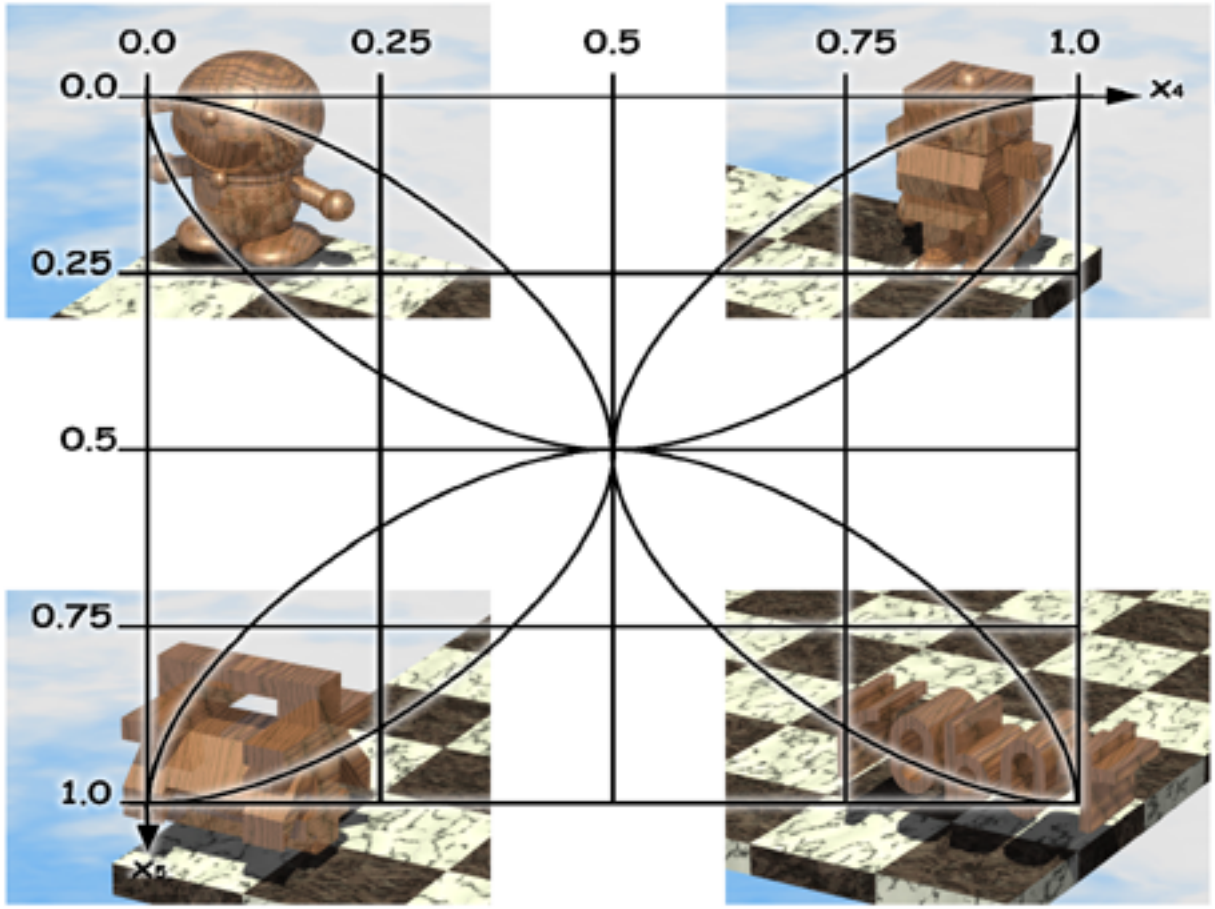


Spreadsheet Rendering

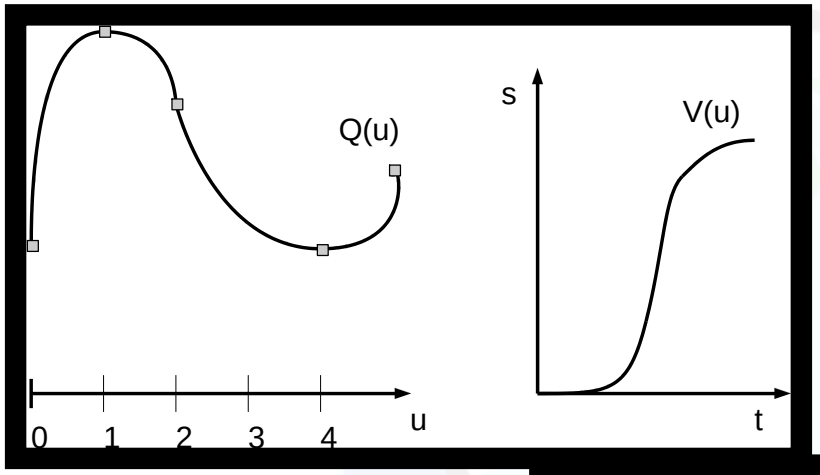
by Alexander PASKO, www.hyperfun.org

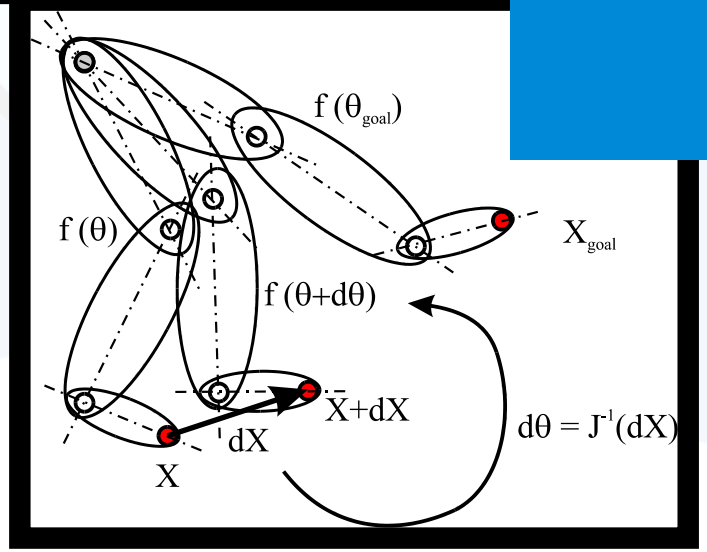
Animation Path in t_1t_2 Plane

by Alexander PASKO, www.hyperfun.org



Mathematics for Computer Animation (Watt)





Key Framing Workflow

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

Key Framing Steps

Chief animator (choreographer) designs and depicts objects.

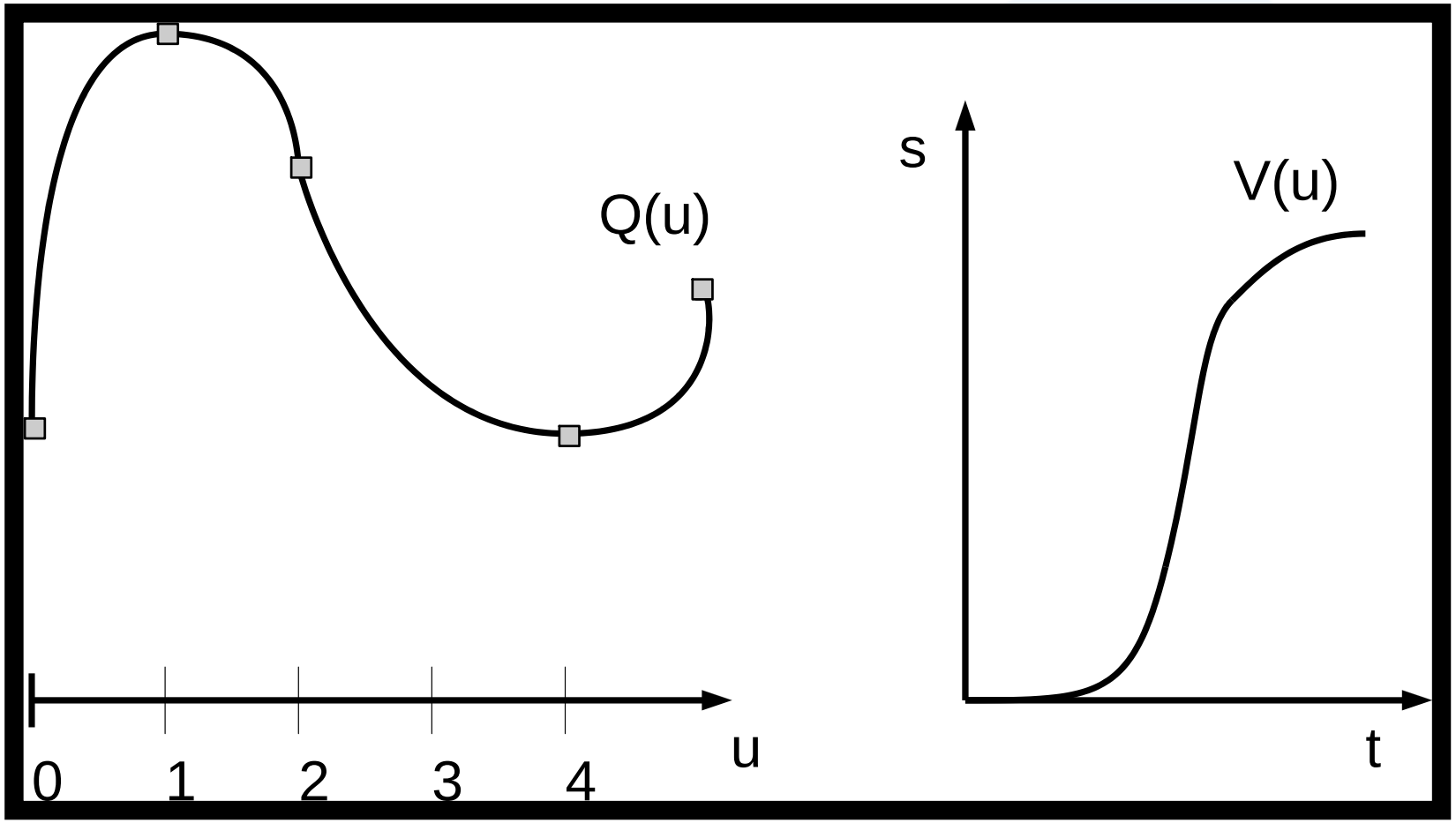
Phasing of the complete animation is too complex, therefore she completes the key-framing.

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

Time: 12 fps slow, 120 fps - super.

Spline Parameterisation

- Arc length parameterisation
  - Parameter ≠ arc length interpolation
  - Reparameterisation with $u = A^{-1}(s)$
- Speed-up parameterisation
  - V(u) = (t, s)
  - Double reparameterisation
- Interpolating rotations
  - Problem with Euler angles $R(\theta_x,\theta_y,\theta_z)$
  - Shortest arc lengths using quaternions

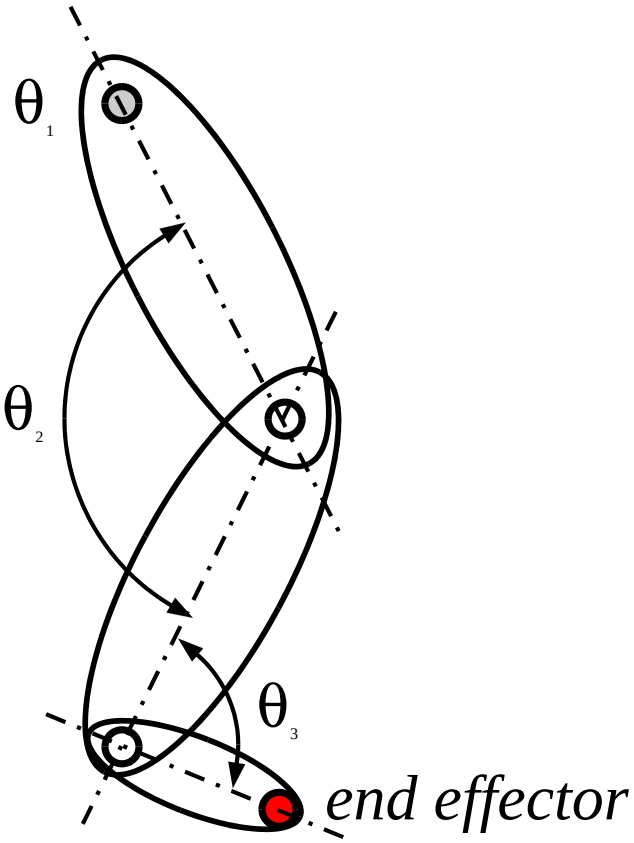

Q(u)
s
V(u)
0
1
2
3
4
u
t

Kinematics

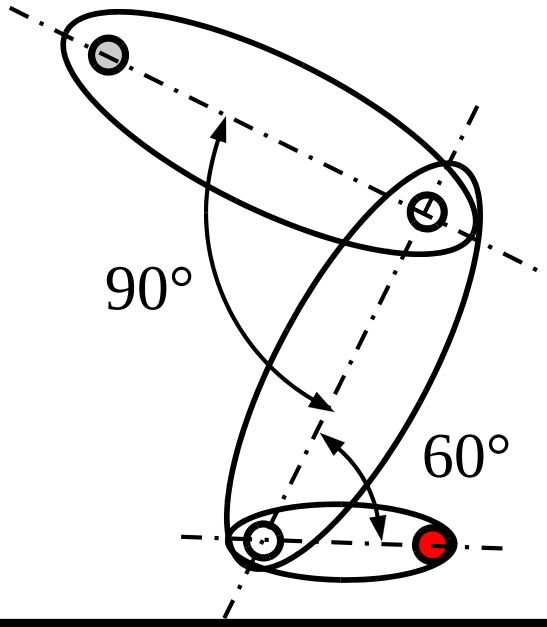
- **Notions:**
  - Articulated figures (Gliederstrukturen)
  - Degrees of freedom (DOF)
  - End effector X (freies Ende der Struktur)
  - State vector θ (Status der Zustandsvariablen)
- **Techniques:**
  - Forward Kinematics: $X = f(\theta)$
  - Inverse Kinematics: $\theta = f^{-1}(X)$

Forward Kinematics

state vector $\theta = (\theta_1, \theta_2, \theta_3)$



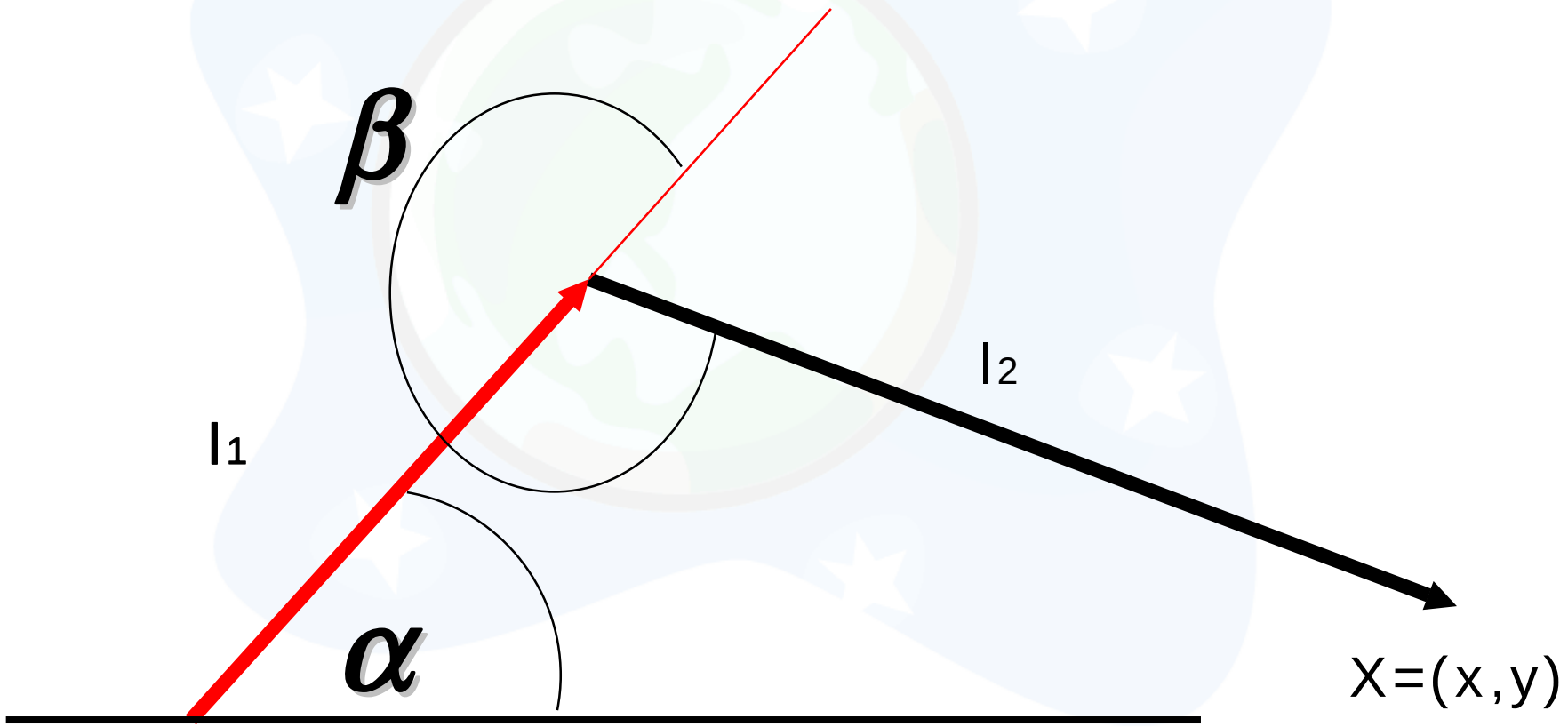
$\theta = ([x,y,z],90°,60°)$



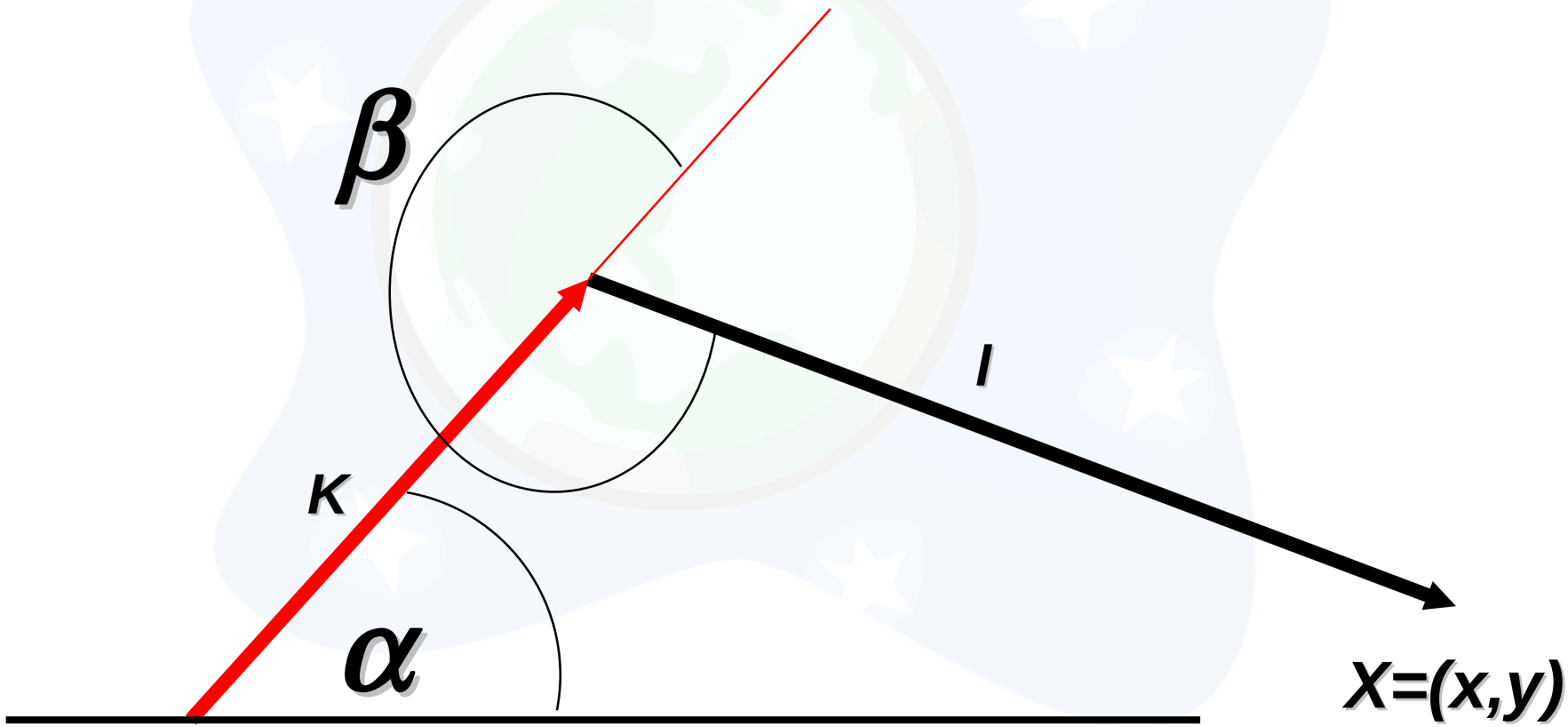
Inverse Kinematics

- Inverse function $\theta = f^{-1}(X)$ analytically too complex for practical instances
- Iterative solution:
  - Start point: $X = f(\theta)$
  - Jacobian matrix: $dX = J(\theta)\, d\theta$
  - through $d\theta = J^{-1}(dX)$ partial state vector changes computed
  - next iteration step

Both Kinematics in 2D



FWD Kinematics in 2D



- $X = (k \cos a + l \cos (a + b), k \sin a + l \sin (a + b))$

Inverse Kinematics

- Inverse function $\theta = f^{-1}(X)$ analytically too complex for practical instances
- Iterative solution:
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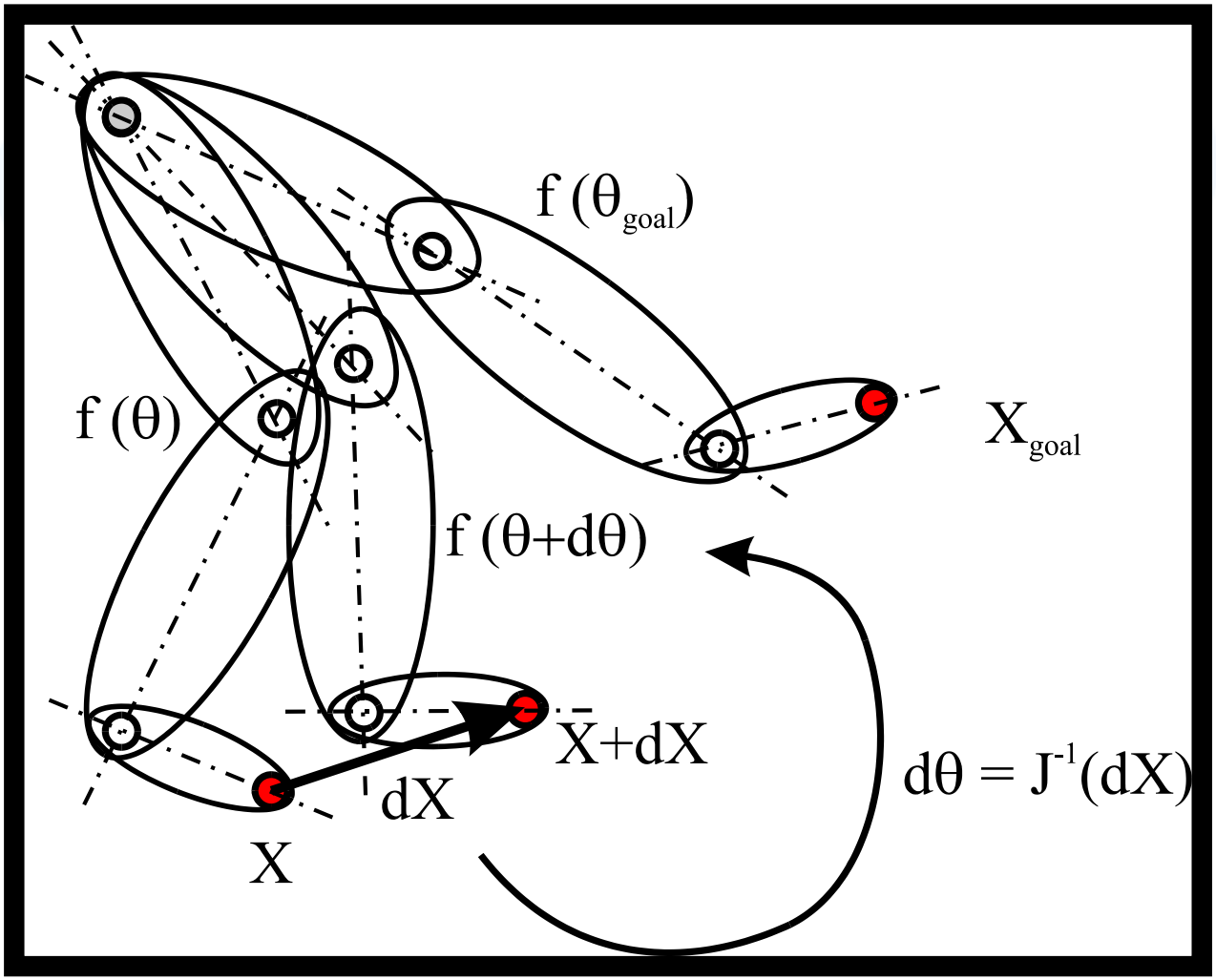

f (θgoal)
f (θ)
Xgoal
f (θ+dθ)
X+dX
dθ = J-1(dX)
dX
X

Quaternions

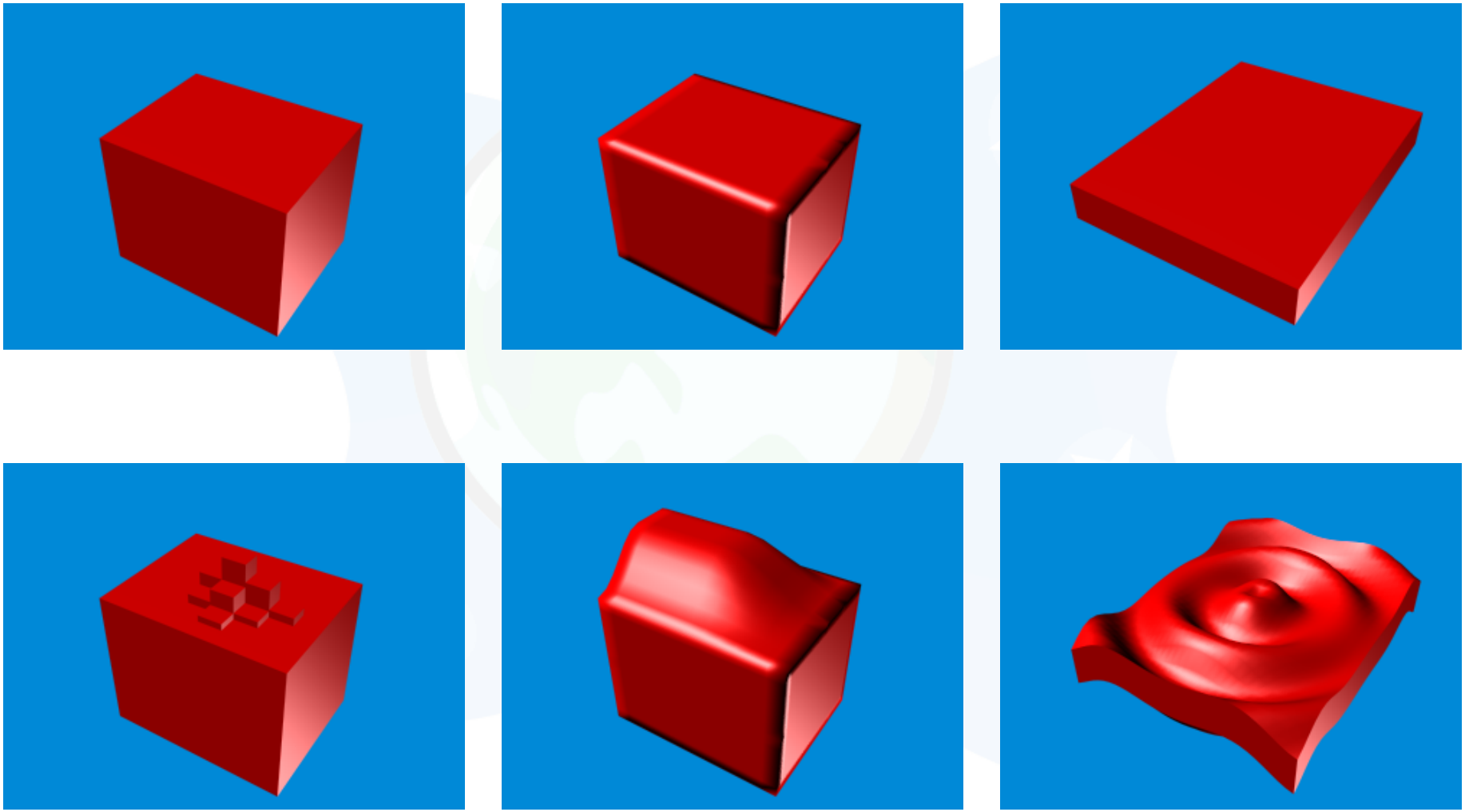
- http://www.cs.berkeley.edu/~laura/cs184/quat/quaternion.html
  - **Problem with Euler angles $R(\theta_x,\theta_y,\theta_z)$**
- Any rotation can be broken down into a series of three rotations about the major axes. We can represent any pose, e. g. for rotation of a space shuttle, by
- the "roll" about the x-axis along the plane,
- the "pitch" about the y-axis which extends along the wings of the plane,
- and the "yaw" or "heading" about the z-axis
- as a vector (roll,pitch,yaw).
- Useful, intuitive, but:
- 1. No universal standard for Euler rotations. Different fields use different sequences of Euler angles, for example some physicists use z-y-z as opposed to the x-y-z system described above.
- 2. Since any rotation can be represented by either a set of Euler angles or a matrix, we should be able to convert between them. However, computing the required angles is expensive and can introduce errors.
- 3. Interpolation between two poses represented in this system does not follow the great arc between the rotations, but involves wild swings about the canonical axes.

Quaternions 2

- q = s + ia + jb + kc
- i, j, k are imaginary units
- q = (s, v)
- v denotes the vector (a, b, c)
- addition q1 + q2 = (s1 + s2, v1 + v2)
- multiplication can be expressed in terms of vector dot and cross products
- q1*q2 = (s1s2-v1.v2, s1v2 + s2v1 + v1xv2)
- inverse quaternion is (1/abs(q*q))*(s,-v)

Soft Object Animation

- Animating surface
- Representation-dependent methods
  - Deforming of B-Reps
  - Deforming parametric objects
- Representation independent methods
  - Non-linear global deformation
  - Free Form Deformation (FFD)



SIGGRAPH Animation

SIGGRAPH Animation Course:

http://www.siggraph.org/education/materials/HyperGraph/animation/anim0.htm

SIGGRAPH Course Notes:

- http://www.siggraph.org/education/materials/siggraph_courses/s96_course30.pdf
- http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/principles/prin_trad_anim.htm
- http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/principles/lasseter_s94.htm
- http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/motion_capture/motion.htm

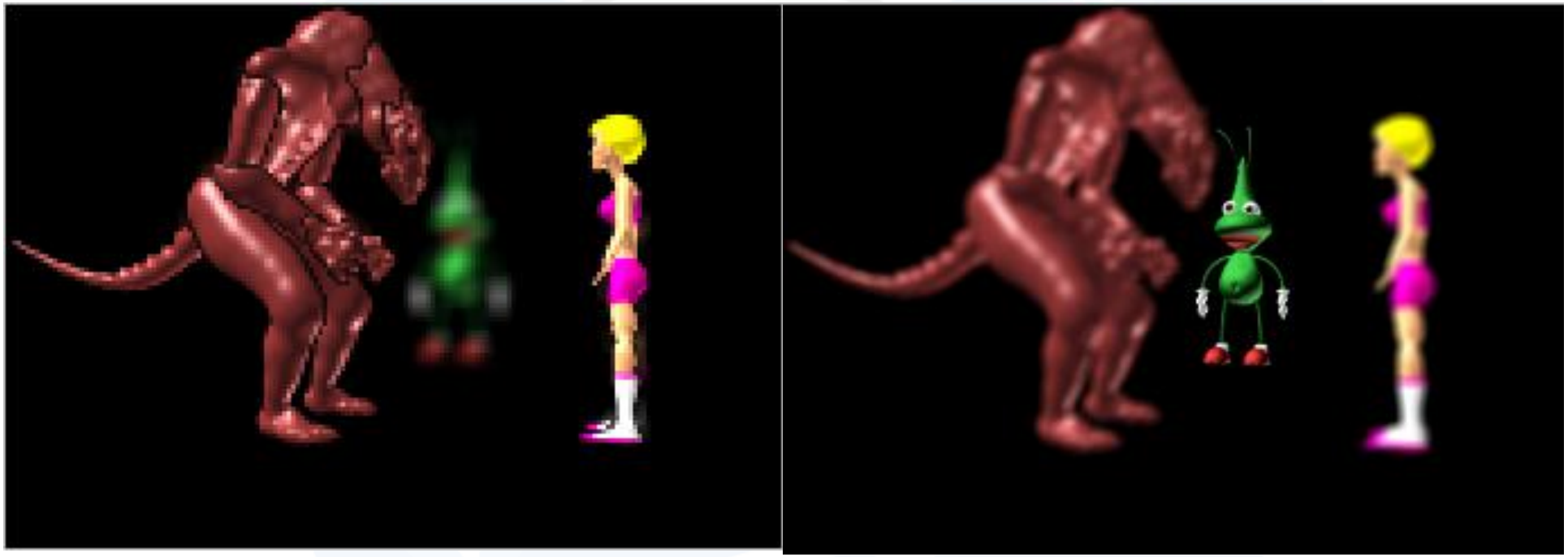
Key-frame Animation Workflow

- 1. Develop a script or story for the animation
- 2. Lay out a storyboard, that is a sequence of informal drawings that shows the form, structure, and story of the animation.
- 3. Record a soundtrack
- 4. Produce a detailed layout of the action.
- 5. Correlate the layout with the soundtrack.
- 6. Create the "keyframes" of the animation. The keyframes are those where the entities to be animated are in positions such that intermediate positions can be easily inferred.
- 7. Fill in the intermediate frames ("inbetweening", "tweening").
- 8. Make a trial "film" called a "pencil test"
- 9. Transfer the pencil test frames to sheets of acetate film, called "cels". These may have multiple planes, e.g., a static background with an animated foreground.
- 10. The cels are then assembled into a sequence and filmed

Camera Elements in any Scene

- Field of View
- Transitions
- Camera Angle
- Camera moves
- Panning
- Dolly shot
- Crane shot
- Lenses
- Zoom Lenses and the Vertigo Effect
- Depth of Field Effects

Field of View (fov)



- http://www.siggraph.org/education/materials/HyperGraph/animation/cameras/movies/vertigo.avi

Walt Disney‘s Principles

- In the 1930's... principles were developed to make animation, especially character animation, more realistic and entertaining... can & should be applied to 3D computer animation…
- 1. **Squash and Stretch** - defining the rigidity & mass of an object by distorting its shape during an action
- 2. **Timing and Motion** - spacing actions to define the weight and size of objects and the personality of characters
- 3. **Anticipation** - the preparation for an action
- 4. **Staging** - presenting an idea so that it is unmistakably clear
- 5. **Follow Through and Overlapping Action** - the termination of an action and establishing its relationship to the next action
- 6. **Straight Ahead Action and Pose-to-Pose Action** - The two contrasting approaches to the creation of movement
- 7. **Slow In and Out** - the spacing of the in-between frames to achieve subtlety of timing and movement
- 8. **Arcs** - the visual path of action for natural movement
- 9. **Exaggeration** - Accentuating the essence of an idea via the design and the action
- 10. **Secondary Action** - the action of an object resulting from another action
- 11. **Appeal** - creating a design or an action that the audience enjoys watching
    - **=> Personality** in character animation is the goal of all of the above.

Computer Animation?

- **http://cawww.miralab.unige.ch//**
- **THE 15TH INTERNATIONAL CONFERENCE ON COMPUTER ANIMATION**
- **(Geneva-Switzerland: June 19-21, 2002)**
- **Facial Animation, Virtual Heritage and Natural Phenomena, Virtual Reality, Image-based Modelling and Animation, Database systems for animation, Standards for human animation, Autonomous Characters and Behavioural Animation, Digital media communication, Simulation of clothes, Medical Applications , Facial Animation II, Motion retargeting, Virtual Pompeii Show**

Tricks to Animating Characters

by John Lasetter

- Keyframes
- 2D vs. 3D
- Weight & Size
- The Thinking Character
- Moving Holds
- Emotion
- Readability of Actions
- A Story Trick
- Ask Why
- Animation Notes from Ollie Johnston

Motion Capture

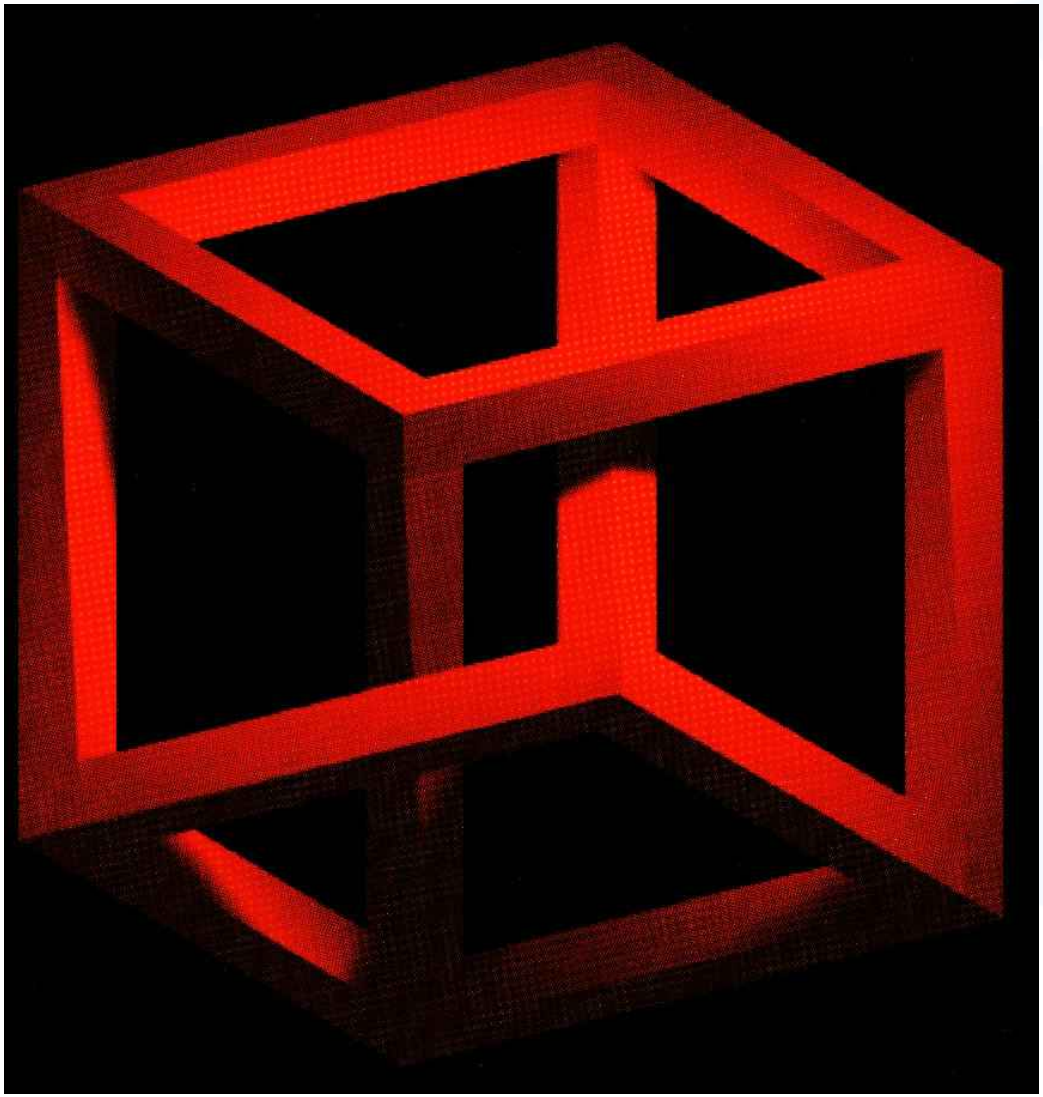
- MOTEK short tutorial video
- notice the
- morphing,
- skeletons, and
- metaballs techniques

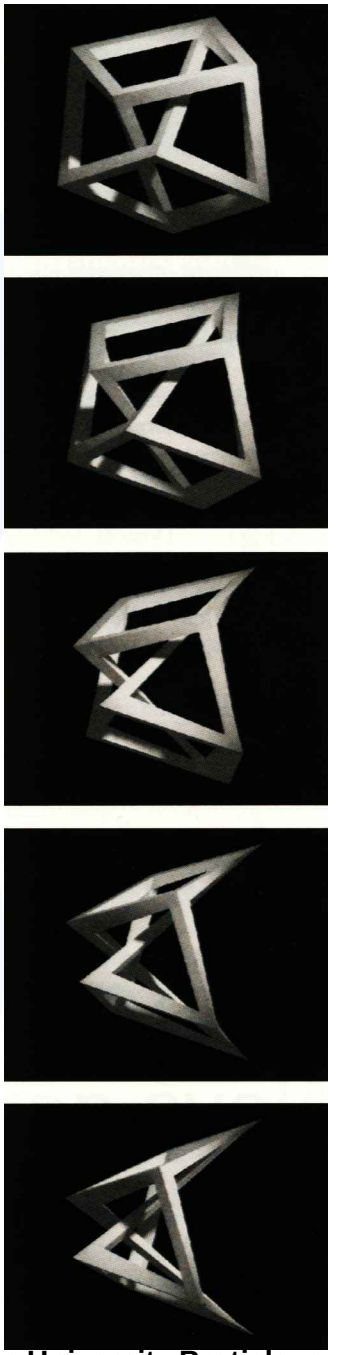
Facial Expressions

- Geri's Game
- subdivision surfaces
- sound space construction

- 22,5 MB in .mov encoding

KUBOID by P. Eliáš





Algorithm Animation

- Book by M. Brown
- Historical survey by Hausner&Dobkin
- Algorithm: static-written, dynamic-runtime, default values, initialisation, profiling, history of each variable, ...
- Multiple views: global & local zoom, visual output, ...
- Speed: step by step, normal run
- Prepared input data for demos
- Error behavior, interactivity
- Automatic algorithm animation, input: C code, output: animation

Maya & MEL

- MAYA API in addition to MEL scripts
- Alternative: Blender
- 2D Alternative – StripMaker
- Storyboard: PowerPoint / Battle of V.

Animation On-Line 1

E-book: WWW Animation Book

http://www.cis.ohio-state.edu/~parent/book/outline.html

Entertainment and New Media Guide (Careers)

http://www.skillsnet.net/core.cfm

Computer Animation annual conference

Animation On-Line 2

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- http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/motion_capture/motion.htm

Video - Examples

http://www.zvonov.ru/FahrSchule-Crap.SWF

Computer Animation

Thank You

For Your Attention

Animation
Making Alive using Motion

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www.sccg.sk/~wega