



Topic 4

Animation Techniques

Carlos González Morcillo
 Carlos.Gonzalez@uclm.es
 Associate Professor
 Blender Foundation Certified Trainer
<http://www.blender.org/BFCT>



Topic 4
Computer Animation
School of Computer Science

UCLM

Contents

1. Introduction
2. Animation Methods
 - 2.1. High Level
Motion Capture
 - 2.2. Inverse Kinematics
CCD Method
 - 2.3. Keyframes

Visita Virtual ESI (2006)
Emiliano Salvador y Carlos Garcia

Recommended Readings

- Kerlow I. Victor. *The Art of 3-D Computer Animation and Imaging*. Wiley & Sons, 2000.
- Blair, P. *Cartoon Animation*. Ed. Walter Foster, 1994.

Carlos Gonzalez Morcillo [Slide 2]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Introduction

```

    graph LR
      A[anemos] --> B[animus]
      B --> C[animation]
      A --- A1[Greek]
      B --- B1[Latin]
      C --- C1[English]
    
```

Carlos Gonzalez Morcillo [Slide 3]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Introduction

```

    graph LR
      A[anemos] --> B[animus]
      B --> C[animation]
      A --- A1[Greek]
      B --- B1[Latin]
      C --- C1[English]
    
```

«Presentation of images on the computer screen repeatedly replaced by a new image produces illusion of movement»

Carlos Gonzalez Morcillo [Slide 4]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Introduction

```

    graph LR
      A[anemos] --> B[animus]
      B --> C[animation]
      A --- A1[Greek]
      B --- B1[Latin]
      C --- C1[English]
    
```

«Presentation of images on the computer screen repeatedly replaced by a new image produces illusion of movement»

How fast?

Peter Mark Roget (1824) : Persistence of Vision

- Human eye (brain) stores the images around 40ms.
- Illusion of smooth movement from 20Hz.

Carlos Gonzalez Morcillo [Slide 5]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Temporal Aliasing

- Major problem in **sampling video and audio**.
- In animation results from **limited frame rate**.
- Causes the "wagon-wheel effect" (change the apparent frequency of rotation).
 - Example: Animate a clock. What's happened if an image is stored every 2 seconds? And if it is stored every 30 sec? And every 59 sec?

Carlos Gonzalez Morcillo [Slide 6]


Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Temporal Aliasing

- Major problem in **sampling video and audio**.
- In animation results from **limited frame rate**.
- Causes the "wagon-wheel effect" (change the apparent frequency of rotation).
 - Example: Animate a clock. What's happened if an image is stored every 2 seconds? And if it is stored every 30 sec? And every 59 sec?
- Solution: **Motion Blur**.



Carlos Gonzalez Morcillo [Slide 7]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Animation Methods

```

    graph TD
      Methods --> LowLevel[Low Level]
      Methods --> MediumLevel[Medium Level]
      Methods --> HighLevel[High Level]
      LowLevel --> Scripts
      LowLevel --> Keyframing
      LowLevel --> Splines
      MediumLevel --> Kinematics
      MediumLevel --> Dynamics
      MediumLevel --> Procedural
      HighLevel --> MotionCapture
      HighLevel --> AutomSynthesis[Autom. Synthesis]
    
```

Carlos Gonzalez Morcillo [Slide 8]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM


Motion Capture

Motion Capture: process of recording a live motion event and translating it into usable mathematical terms by tracking a number of key points in space over time and combining them to obtain a single 3D representation of the performance.

Alberto Menache, "Understanding Motion Capture for Computer Animation and Video Games"

Advantages

- ☺ **Saves Time** (== Money).
- ☺ **Realism**.
- ☺ **Widely used** (Videogames, Film industry, Medical Applications, Virtual Reality, etc).



Carlos Gonzalez Morcillo [Slide 9]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Capture Systems


Magnetical Systems Vs **Optical Systems**

→ **Magnetic Fields & Aerials**

- ⊗ Low number of sensors
- ⊗ Low FrameRate
- ⊗ Usually only one actor.
- ⊗ Problems metallic surfaces
- ⊗ **Real Time**
- ⊗ **Cheaper***

→ **Cameras and Marks**

- ☺ High number of sensors
- ☺ High FrameRate
- ☺ Various Actors
- ⊗ Data clean is needed.
- ⊗ Occlusion, noise, interchange problems...
- ⊗ Light-sensitive
- ⊗ Only information about position is provided.
- ⊗ Expensive!



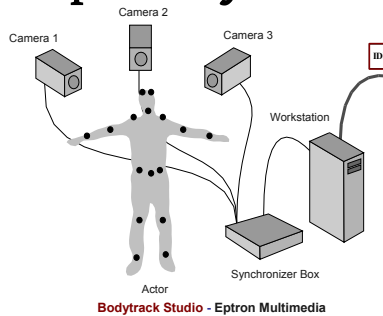
Carlos Gonzalez Morcillo [Slide 10]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Optical Systems



Problems

- ⊗ Lost Marks
- ⊗ Erroneous Trajectories
- ⊗ Channels Interchange
- ⊗ Precision Errors

Bodytrack Studio - Epron Multimedia

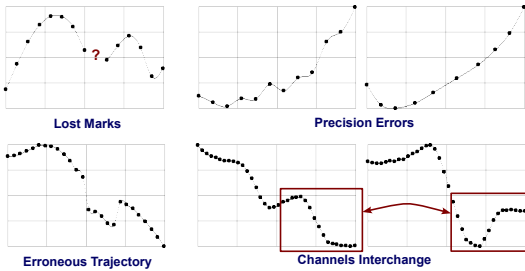
Carlos Gonzalez Morcillo [Slide 11]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Problems Optical Systems



These identification and cleaning are **very expensive**

Carlos Gonzalez Morcillo [Slide 12]

Topic 4
Computer Animation
School of Computer Science

Introduction Methods Principles (Rules) Character Design

UCLM

Error Resolution Methods

Interpolation Curves

Natural Cubic Splines

- No Local Control.
- Automatically calculated. No extra parameter is needed.

Hermite

$P(u) = (x(u), y(u), z(u))$

- Local Control is allowed.
- The tangent of every control point must be specified by the user.

Cardinal

- Tangent of every control point is automatically calculated.
- Tension Parameter is required.

Carlos Gonzalez Morcillo [Slide 13]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

Direct/Inverse Kinematics

Used to specify **key poses** in hierarchical structures.

- **Direct Kinematics:** The final position of the actuator is determined specifying the angles of the joints.
- **Inverse Kinematics:** The final position of the actuator is directly specified. The angles between joints are automatically calculated.

Carlos Gonzalez Morcillo [Slide 14]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

Inverse Kinematics

- The **Inverse Kinematics** problem can be solved by means of **different methods**: Inverse Transformation, Dual Quaternions, Iterative Methods...
- An approximated and general approach is the **Iterative Method**. **Constraints** can be easily defined.
- Sometimes, the animation using IK requires final tuning with FK.

Carlos Gonzalez Morcillo [Slide 15]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

Inverse Kinematics

- The **Kinematics** are defined in relation to its neighbours.
- **4 parameters** are required:
(a_p, α) Link Parameters
(d_p, θ) Joint Parameters

Carlos Gonzalez Morcillo [Slide 16]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

Analytical Inverse Kinem.

$$\theta_1 = \arctan \left(\frac{y(L_2 \cos(\theta_2) + L_1) - x(L_2 \sin(\theta_2))}{x(L_2 \cos(\theta_2) + L_1) + y(L_2 \sin(\theta_2))} \right)$$

$$\theta_2 = \arccos \frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}$$

- **Analytical Computation** is good because of its **speed** and **exactness**.
- It's **very complex** with huge descriptions (i.e. Human armatures).
- A general method is needed.

Carlos Gonzalez Morcillo [Slide 17]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

CCD Iterative Method

Cyclic-Coordinate Descent. Error is minimized in each joint of the chain.

Repeat the cycle on every element of the chain. Stop the process when the effector is enough close to the final position D or the algorithm has iterated a defined number.

Carlos Gonzalez Morcillo [Slide 18]

Topic 4
Computer Animation
School of Computer Science

Introduction **Methods** Principles (Rules) Character Design

UCLM

Key Frame Animation

- **Key positions** are defined \rightarrow In Between positions are interpolated.
- **Other properties** can be defined (not only positions).
- The interpolation is represented using curves ("**Curves of Parameters**" or "**Curves of Functions**"). Time is usually represented in horizontal axis.

Carlos Gonzalez Morcillo [Slide 19]