Computer Animation and Visualisation

Lecture 1

Introduction

Taku Komura
Today’s topics

• Overview of the lecture
• Introduction to Computer Animation
• Introduction to Visualisation
Introduction

Taku Komura
(PhD in Tokyo, 2000, Hong Kong 2002-6, Edinburgh 2006-now)
Royal Society Industry Fellow since 2015

Mainly working on character animation, geometry and control problems

http://homepages.inf.ed.ac.uk/tkomura
Collaborators (1)

Marza Animation Planet
(producing movies for SEGA)

https://www.youtube.com/watch?v=T1B8sAa9Oeg&feature=youtu.be
Collaborators (2)

Bandai Namco Games
Producing games like
• Pacman,
• Tekken

https://www.youtube.com/watch?v=2Fua5M8gbto#t=126
Collaborators (3)

Disney Research

I work half-time at Disney Research since 2015 for research about real-time character animation
Graduates:

Currently 4 PhD students

Finished 7 PhDs:

- Working at places like Disney Research, Rockstar, Northumbria University, Toshiba Medical, Xian Jiaotong University, NaturalMotion, etc.
Overview: What is taught in this course?

Algorithms for computer animation and visualisation

- Computer Animation: Algorithms to create scenes of moving images
  - Create animation of human characters
  - Simulation of various natural phenomena
  - Geometric modelling and processing

- Visualisation: Algorithms to extract important features from large-scale data and visualize them for analysis
  - CT, MRI, ultra-sound 3D volume data
  - Flows simulated on the computer
  - 3D surface data captured by laser scanners, computed by stereo vision techniques
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LOTs of MATH!!
What is computer animation?

• Creating moving images via the use of computers
• Subfield of computer graphics
• Applications:
  – Films
  – TV programs
  – Computer games
  – Web contents
Demo animation: Shrek 3 Trailer

http://www.youtube.com/watch?v=3aZXVzUQGA4
Topics of computer animation

- Character animation (3D animation)
  - Keyframe animation, motion capture, motion synthesis
  - Skinning, facial animation
  - Crowd simulation

- Physically-based animation
  - Rigid objects
  - Cloth, strands, deformable objects
  - Fluids (fire, water, smoke)
  - Finite Element Method (soft materials)

- Geometric modelling and editing
Character Animation

• Controlling characters
  – Humans / cartoon characters / animals
  – Using real human movements
  – Manually creating the movements
Motion capture

- Digitizing the human movements
- Tracking the movements of the markers
- Apply them to virtual characters
Skinning

• Need to decide how the surface deforms according to the movements of the skeleton
Motion Editing

- Making use of the captured motions for different scenes
- Adjust the movements so that they satisfy constraints
Motion Planning

• How to switch from one posture to another without colliding with other objects/characters
• How to control characters so that they behave smartly
Crowd simulation

• Simulating the pedestrians in the streets
• How does one's movement affect those of the others
• How do they avoid each other
Facial animation

• Animating the face by
  – Motion capture data
  – Using musculoskeletal models

- In computer graphics, the user input should be in low dimension
- But we expect high dimensional outputs (face models, 3D postures, scenes etc)
- Machine learning techniques such as
  - Dimensionality reduction
  - Nonlinear regression
- are helpful for such kind of problems
- Techniques:
  - Radial basis functions,
  - Gaussian Process, deep learning
Physically-based animation: Rigid Objects

- Simulating rigid objects flying, colliding, and bouncing
- Technical issues
  - Collision detection
  - Computing the repulsion forces
- Taking into account the friction etc.
Physically-based animation: Cloth simulation

- Simulating the movements of clothes when the body moves
- Technical issues:
  - Collisions, integration
Physically-based animation: Hair

• How the hair moves when the wind blows
• Need to take into account
  – the physical properties of the hair,
  – Collision between the hair
  – The lighting effects
Physically-based animation: Fluids

• Simulating liquid, mud, fire, bubbles
• How to efficiently simulate the motion of the fluids
• How to control the fluids so that the animator can get what s/he wants
Wrecks/Crashes/Destruction

- Simulate how/where the destruction starts and expands
Finite Element Method

Needed to simulate soft materials like jelly fish, human heart
FEM is used for analysis of hard objects like buildings, bridges, aircrafts etc

On courtesy of Dr. Takashi Ijiri
Shape Modelling and Editing

Designing shapes, editing shapes
Pattern Recognition of objects and scenes

• Recognizing 3D objects, classifying scenes and point clouds

• Classic but still an active topic in computer graphics and computer vision

• I will try to cover some techniques such as spin image, random forest, topology-based methods, etc.
Today’s topics

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What is visualisation?

• Application of interactive 3D computer graphics to the understanding of data.
  – interactive viewing, understanding and reasoning process
• Conversion of numbers → images
  – humans are generally poor at raw numerical data analysis
  – human visual reasoning allows robust analysis of visual stimuli
→ convert numerical analysis into visual analysis
Simple Example : Maps

- Numbers represent height on a 2D map
- so what is the shape of this famous mountain?
Simple Example: Maps

with 3D graphics we can represent the shape of the mountain directly - we can improve the visualisation of this height data by viewing it in 3D

Ben Nevis Fly Through: http://www.ordnancesurvey.co.uk

Ben Nevis – visualisation of 3D satellite data http://earth.google.com
The ‘scientific’ process
- the *creation* of knowledge

**Knowledge**
(Scientific papers, business strategy, a medical diagnosis etc).

**Observations**
(could be scientific, medical or business sales figures etc).

**Human ‘expert’**

Some analysis?

**Numbers**
The visualisation process
- the effective presentation of knowledge

Knowledge
(Scientific papers, business strategy, a medical diagnosis etc).

Observations
(could be scientific, medical or business sales figures etc).

Visualisation algorithms

Human ‘expert’

Interaction

3D Computer Graphics

Numbers
Computer Visualisation

• Strengths of computing as a visualisation tool:
  - **3D computer graphics**
    - multi-dimensional data
    - temporal data (suitable for animation)
  - **human computer interaction**
    - visualisation is an interactive process
  - **Data storage / processing**
    - large amounts of data (fast, random access)
    - data transformation (from point clouds to meshes, or volume data)

• This course:
  - data representation & transformation for visualisation
What's in this course?

• Data representation
  – Surface data, volume data, point clouds, flows, vector fields

• Data conversion
  – Volume -> surface
  – Point clouds -> surface
  – Volume -> image
  – Flow data -> surface, image

• Techniques to handle 3D data
  – Practical problems of visualising and acquiring 3D data
Example: Flow Visualization

• Flow of data
  - e.g. weather, financial prices, air flow
  - time varying (temporal) data
  - visualisation of flow
  - Can use animation
  - Vector fields (many flows)

http://www.paraview.org/
Example: Medical Imaging

• Computer imaging in medicine:
  - *Computed Tomography (CT)* imaging uses pencil thin X-ray beams
    - *Computer Aided Tomography (CAT)*
  • *Magnetic Resonance Imaging (MRI)* uses large magnetic fields with pulsed radio waves
Example: 3D surfaces from CT slices

- Many planar slices (2D) can be combined (in topological order) to form a 3D volume of data
  - i.e. stack of 2D images

- Volume can be processed and rendered to reveal complete anatomical structures
Information Visualization

- Visualization of abstract data
  - Book contents
  - Graphs, Networks (social networks, train routes)
  - Transaction data
Syllabus for Visualisation

• **Data Representation**
  - Data geometry and topology
  - Data dimensionality
  - Surface and volume representations

• **Fundamental algorithms**
  - 2 & 3D Contouring, Colour-mapping
  - Volume rendering

• **Advanced algorithms**
  - Flow visualisation
  - Vector visualisation
  - Tensor visualisation
  - Dimensionality reduction

• **Information visualisation**
  - Networks and trees, documents

• **Real-world visualization**
  - Visualisation of real objects & environments
  - Acquisition of 3D data
  - Mesh editing techniques, data conversion of 3D data
Course Outline

• 18 Lectures
  - lecture notes on-line (http://homepages.inf.ed.ac.uk/tkomura/cav/)
  - background reading (mainly on-line)

• 2 Assessed Practicals
  - 2 programming tasks
  - One for Computer animation, another for Visualisation
  - Both to be done by OpenGL and C or C++
  - Deadlines: 22nd Feb 2016, 21st March 2016

• Assessment
  - 1.75 hour examination (70%)
  - Practical assignments (15% each)
    - (variation between UG4 and M.Sc. requirements)
PhD in Pervasive Parallelism

http://pervasiveparallelism.inf.ed.ac.uk
Centre for Doctoral Training in Robotics & Autonomous Systems

Funded by EPSRC

http://www.inf.ed.ac.uk/student-services/robotics-cdt

4 year studentship available for robot control about close interactions

• Manipulating objects

• Moving through constrained environments

• Let me know if you are interested
PROJECT : Distro

“Distributed 3D Object Design” (DISTRO)


ETH Zurich / STUDIO GOBO

Another slot for

Edinburgh Napier University

with Disney Research