Computer Animation and Visualisation

Lecture 1

Introduction

Taku Komura

Introduction

Taku Komura
(PhD in Tokyo, 2000, Hong Kong 2002-6, Edinburgh 2006-now)

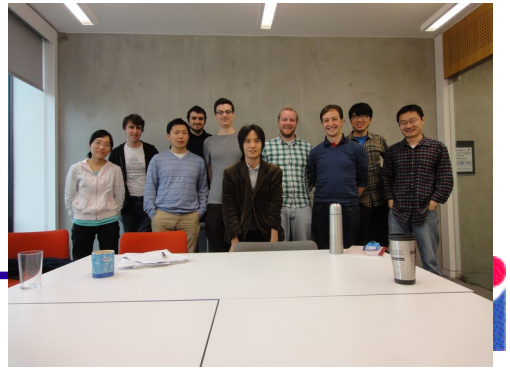
Mainly working on character animation, geometry and control problems

http://homepages.inf.ed.ac.uk/tkomura

Computer Animation Group

Currently 6 PhD students
4 visitors (from China, France, Japan)
Finished PhDs 9:

Working at places like Ubisoft, Rockstar, Leeds University, Northumbria University, Toshiba Medical, Xian Jiaotong University, NaturalMotion etc.

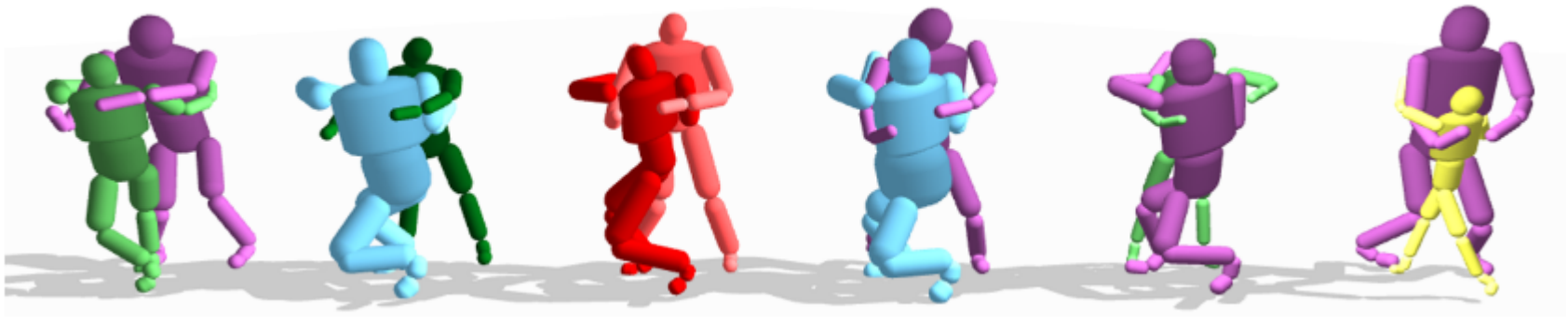


Collaboration with companies

Bandai Namco Entertainment

Interaction Mesh @Siggraph 2010

https://www.youtube.com/watch?v=2Fua5M8gbto



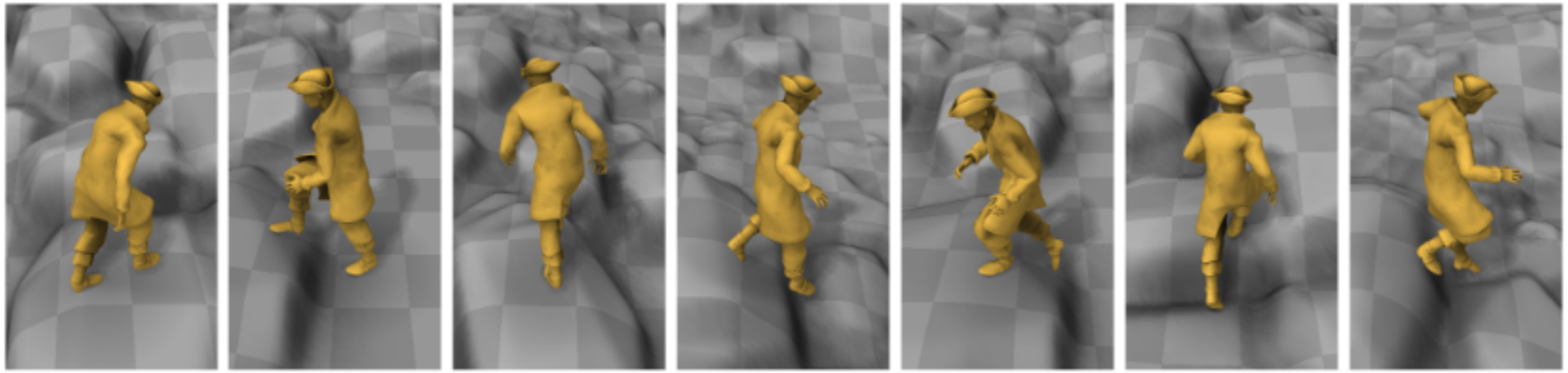
Collaboration with companies

Marza Animation Planet
(producing movies for SEGA)

MARZA
ANIMATION PLANET

Phase-functioned Neural Networks

@SIGGRAPH 2017



https://www.youtube.com/watch?v=Ul0GiIv5wvY

Upcoming Collaborations

Oculus, Facebook
Google
IKEA
Adobe

Today's topics

- **Overview of the lecture**
- **Introduction to Computer Animation**
- Introduction to Visualisation

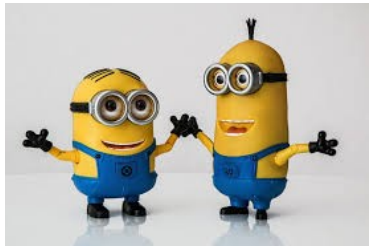
Overview: What is taught in this course?

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

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
  - Skinning, facial animation
  - Motion planning, motion editing
  - Crowd simulation
- Physically-based animation
  - Rigid objects
  - Cloth, strands, deformable objects
  - Fluids (fire, water, smoke)
  - Finite Element Method (soft materials)
- Geometric modelling and editing

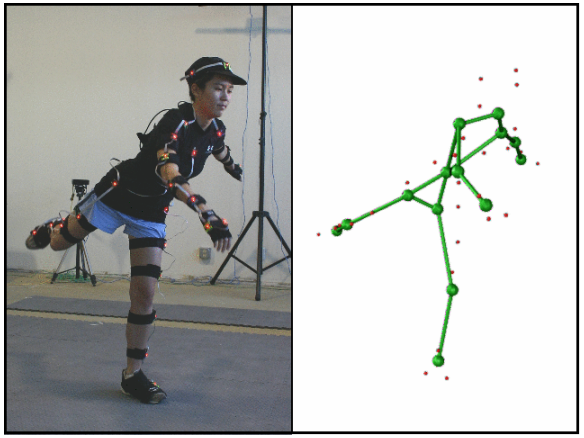
Character Animation

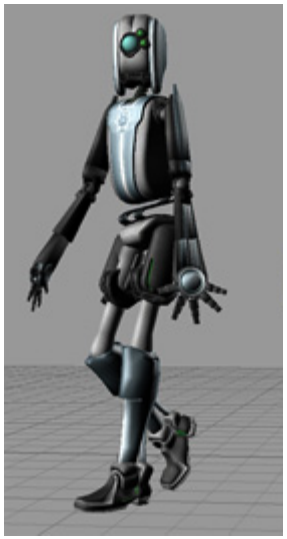
- Controlling characters
  - humans / cartoon characters / animals
  - Using real human movements
  - Manually creating the movements

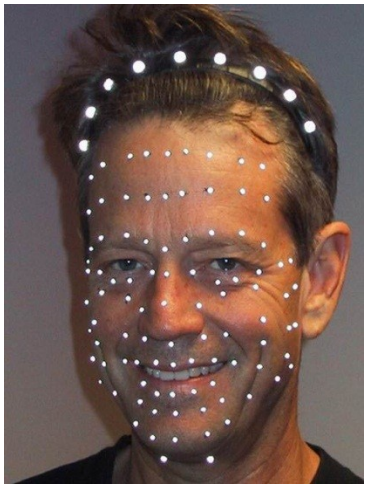


Motion capture

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

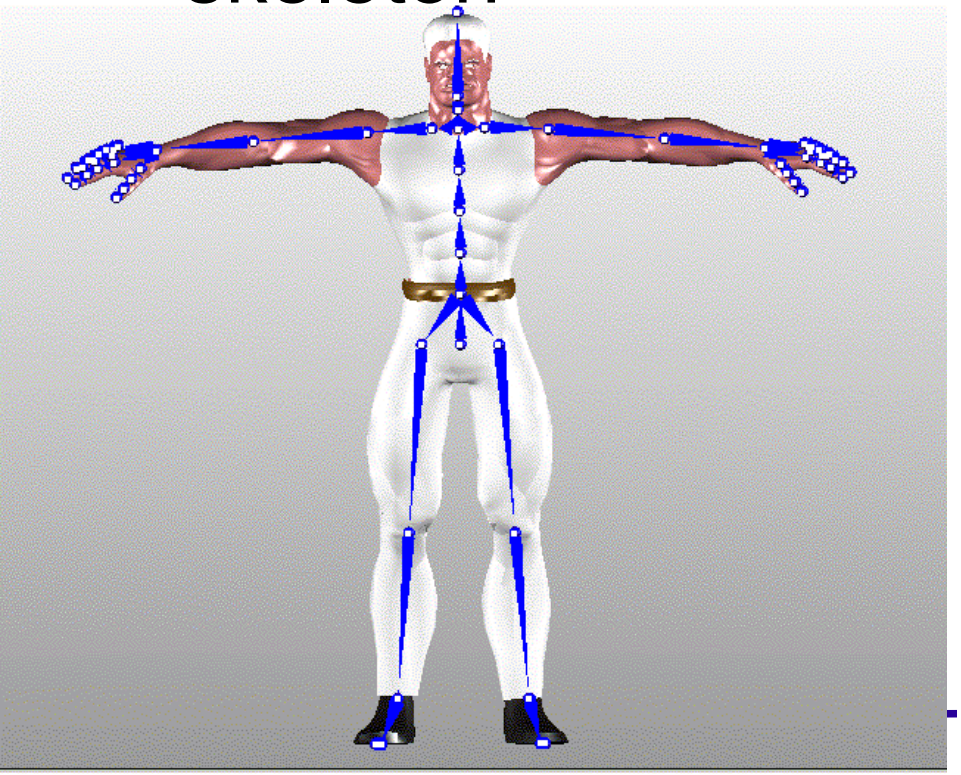






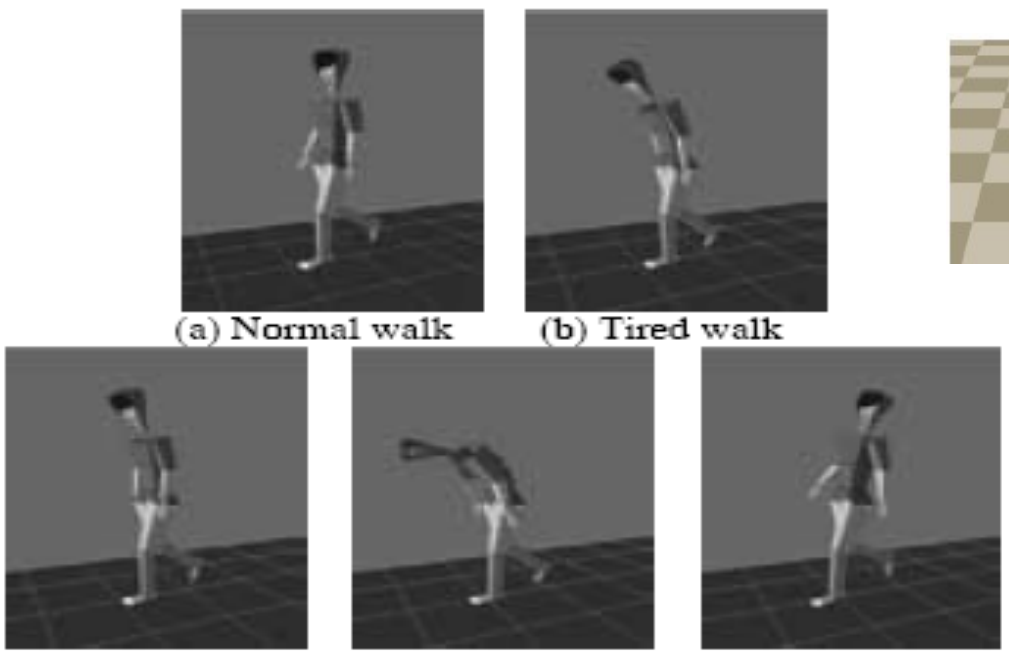
Skinning

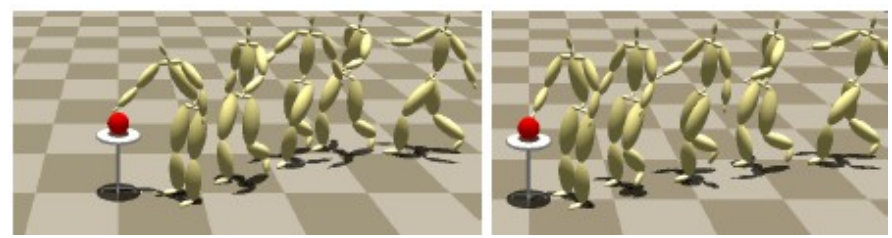
- Need to decide how the surface deforms according to the movements of the skeleton



Motion Editing

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

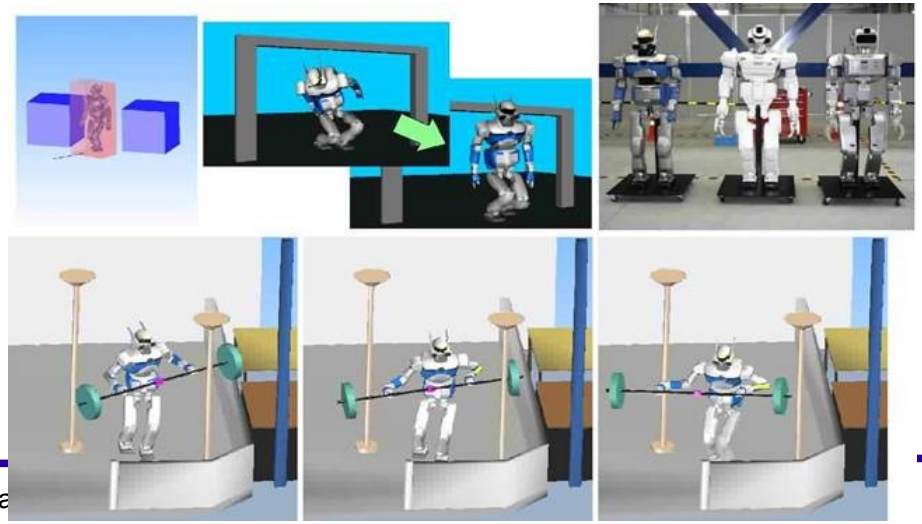


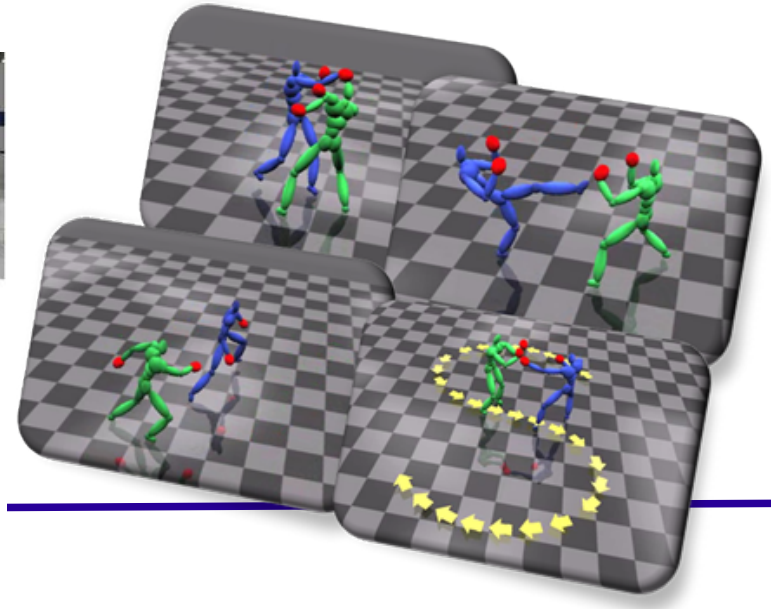


https://youtu.be/NbHVkVPwrlg

Motion Planning

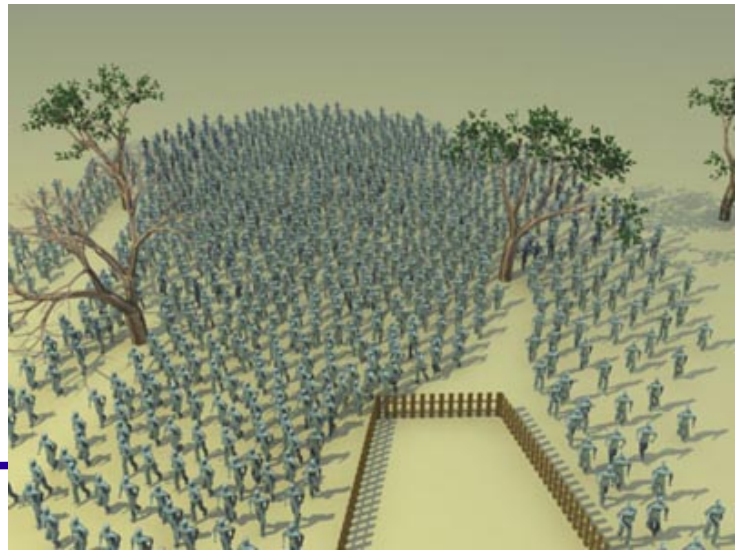
- How to switch from one posture to another without colliding with other objects / characters
- How to control characters so that they behave smartly





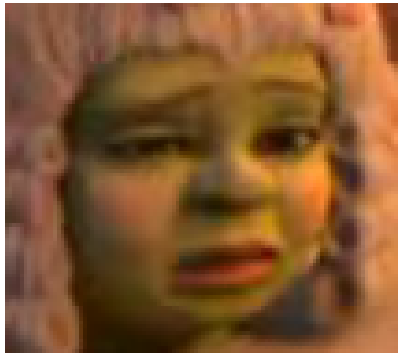
Crowd simulation

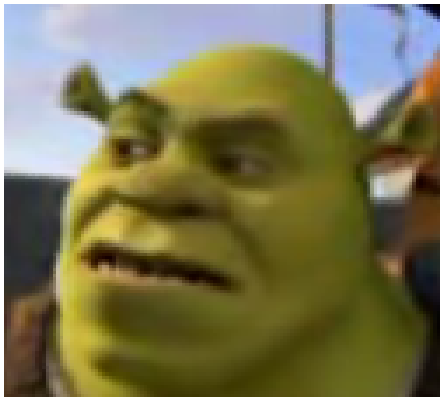
- Simulating the pedestrians in the streets
- How does one's movement affect those of the others

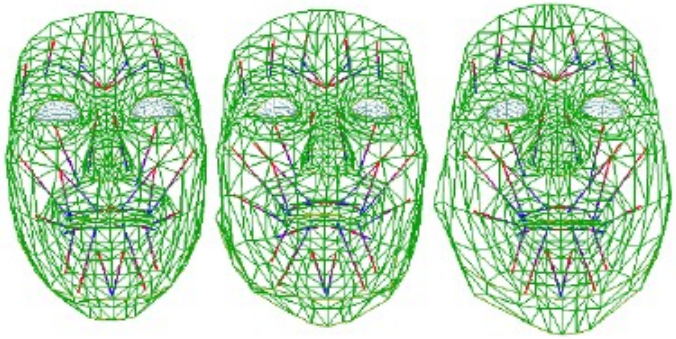


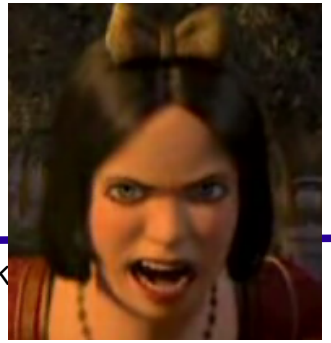
Facial animation

- Animating the face by
  - Motion capture data
  - Using musculoskeletal models



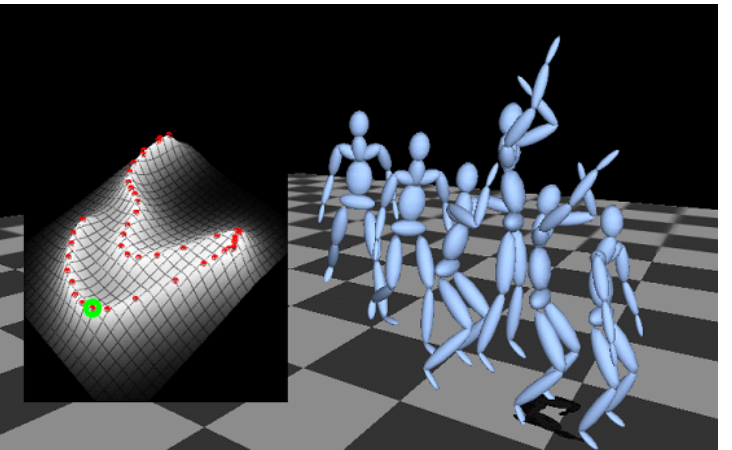






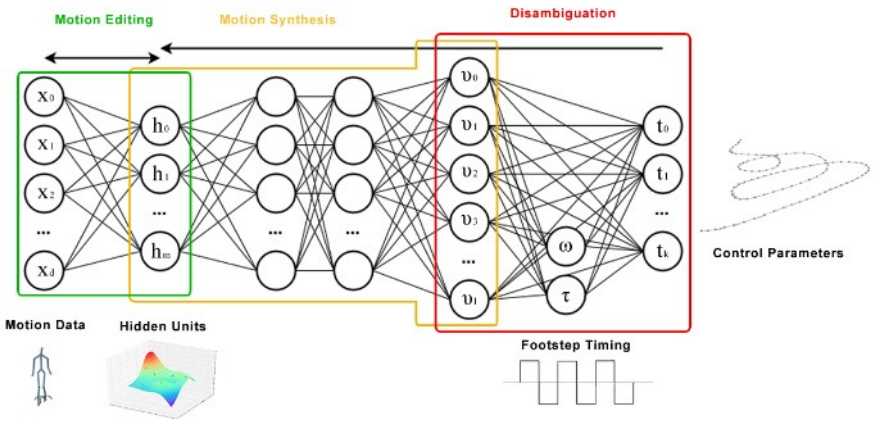
Machine Learning Techniques for Computer Graphics

- In computer graphics, we expect high dimensional outputs (face models, 3D postures, scenes etc)
- But the user inputs should be in low dimension
- Machine learning techniques such as
  - Dimensionality reduction
  - Nonlinear regression
- are helpful for such kind of problems



Regressing the User Input to Full Body Motion

https://www.youtube.com/watch?v=urf-AAIwNYk



Physically-based animation: Cloth simulation

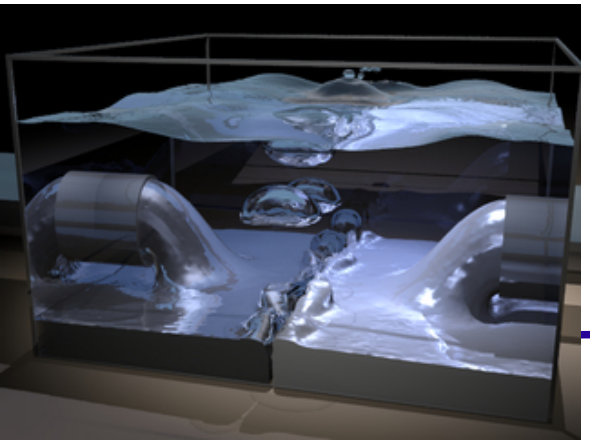
- Simulating the movements of clothes when the body moves
- How the wind affects the shape

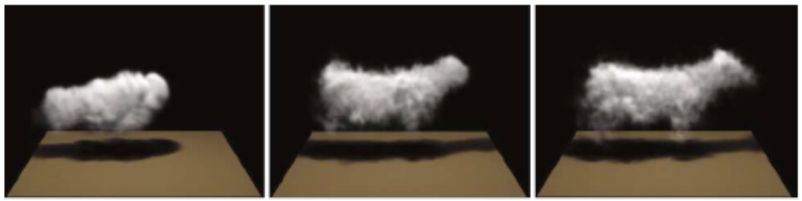
Physically-based animation: Hair

- How the hair moves when the wind blows
- Need to take into account
  - the physical properties of the hair,
  - Collisions between the hair
  - The lighting effects

Physically-based animation: Fluids

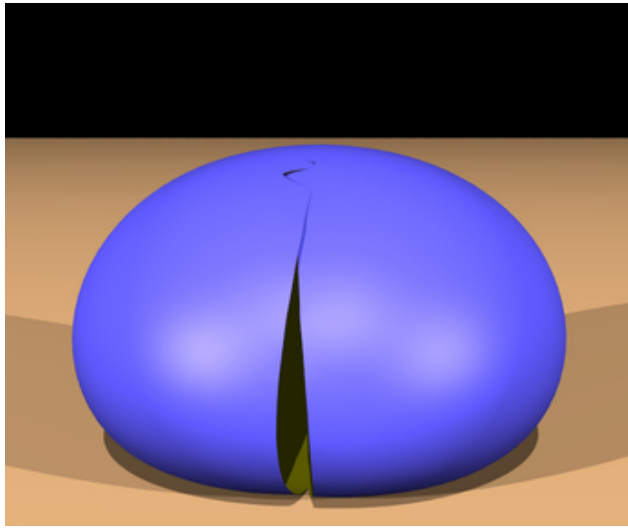
- Simulating liquid, mud, fire, bubbles
- How to efficiently simulate the motion of the fluids
- How to control the fluids so that the animator can get what s/he wants

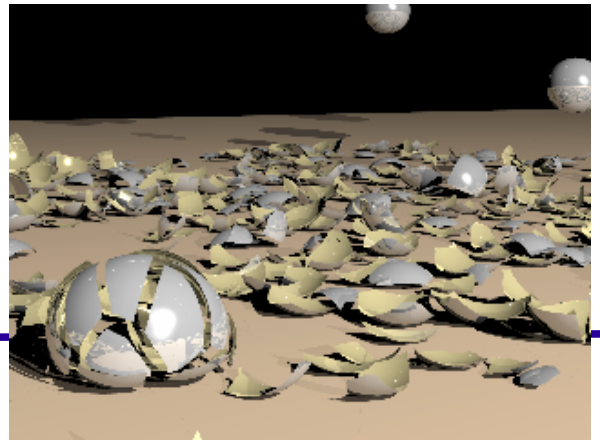


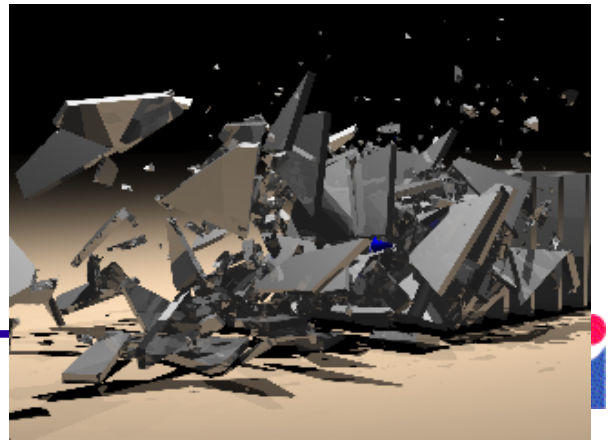


Wrecks/Crashes/Destruction

- Simulate how / where the destruction starts and expands



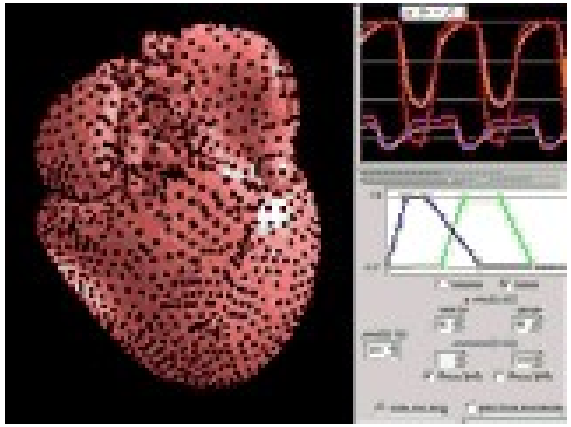




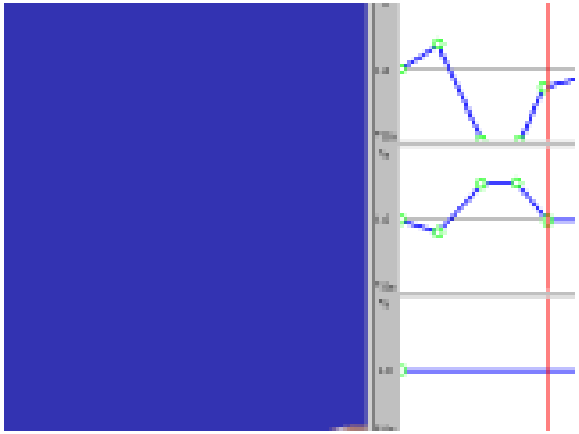
Finite Element Method

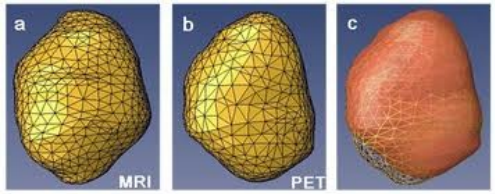
Needed to simulate soft materials like jelly fish, human heart

FEM is used for analysis of hard objects like buildings, bridges, aircrafts etc



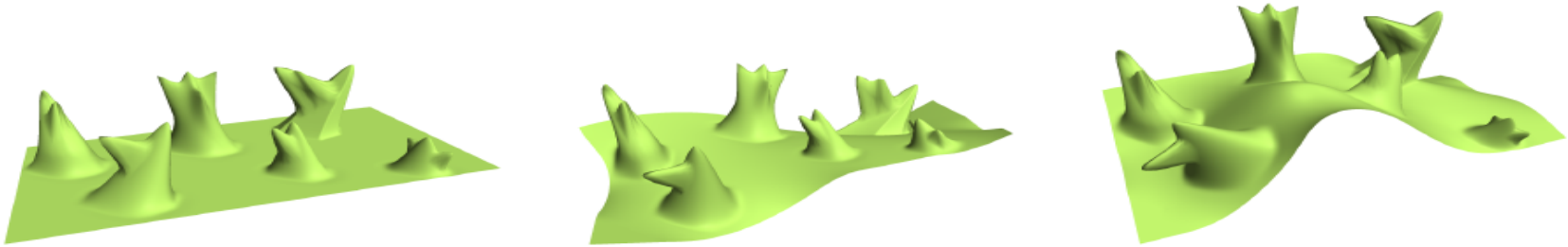
On courtesy of Dr. Takashi Ijiri





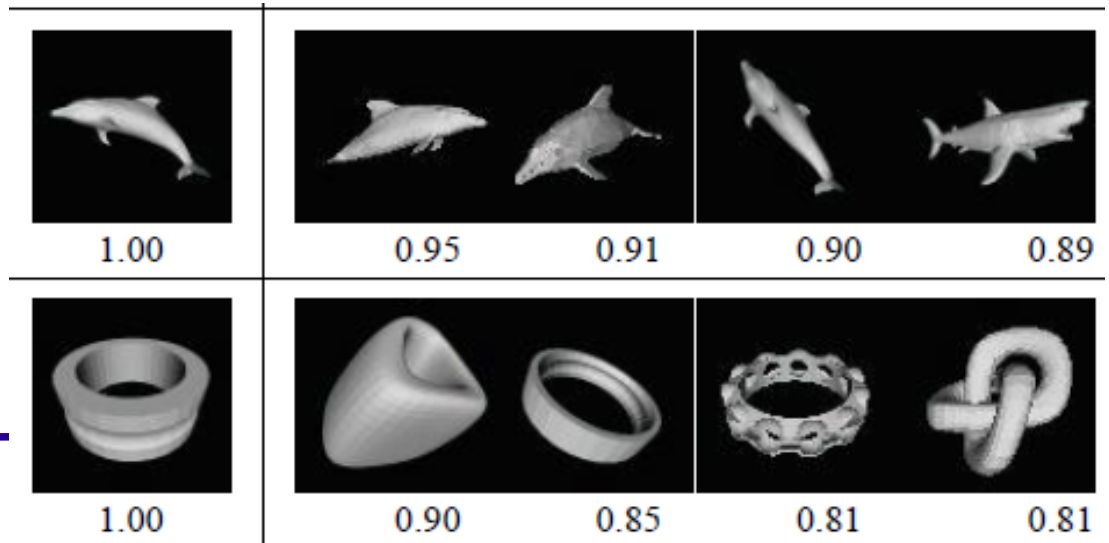
Shape Modelling and Editing

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



Today's topics

- Overview of the lecture
- Introduction to Computer Animation
- **Introduction to Visualisation**

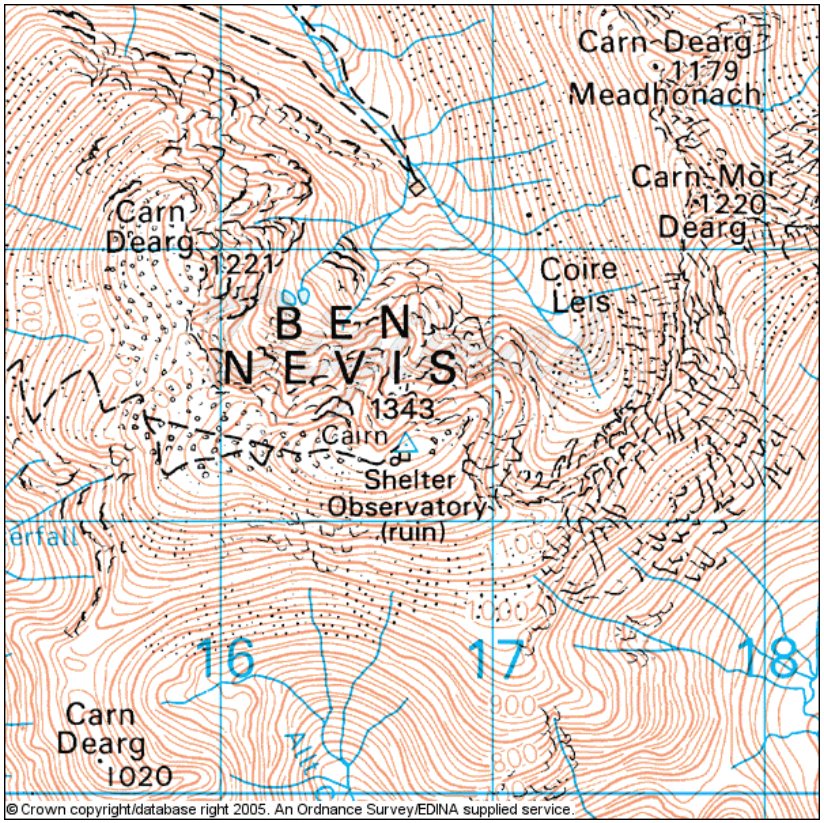
What is visualisation?

- **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*

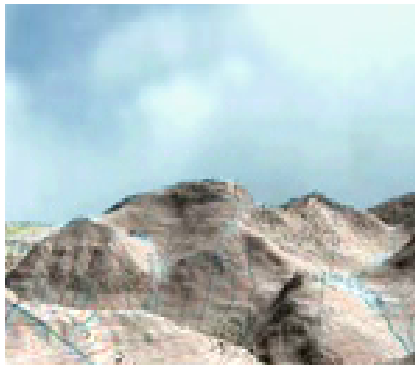
Simple Example : Maps

16	0	82	66	50	155	158	55	158	129	72	134	122
145	105	99	85	46	56	35	0	222	201	146	229	213
170	108	227	220	165	89	86	41	33	34	3	24	27
2	0	11	15	14	17	18	20	1	0	0	65	56
0	0	14	0	0	59	43	27	24	12	0	8	0
2	0	106	89	61	202	181	138	209	184	128	208	181
181	108	235	207	134	226	202	130	190	167	97	164	145
185	119	184	170	109	162	146	94	135	119	68	151	130
155	105	137	118	76	93	78	39	98	84	39	114	101
99	44	148	132	81	109	95	56	30	21	0	6	1
46	32	0	3	0	0	5	0	0	1	0	3	0
21	6	34	21	2	41	33	10	32	24	3	12	0
46	25	166	147	105	174	156	108	97	82	41	11	0
0	0	1	1	0	11	9	0	63	59	32	106	93
89	52	74	67	39	29	21	0	25	11	0	76	59
74	49	116	98	78	30	16	5	34	25	18	66	66
21	13	7	7	0	83	80	63	162	150	124	226	208
176	128	196	174	117	251	237	176	255	251	192	255	255
238	195	219	208	163	216	203	158	245	231	182	190	177
73	21	180	165	110	248	233	176	225	210	153	230	214

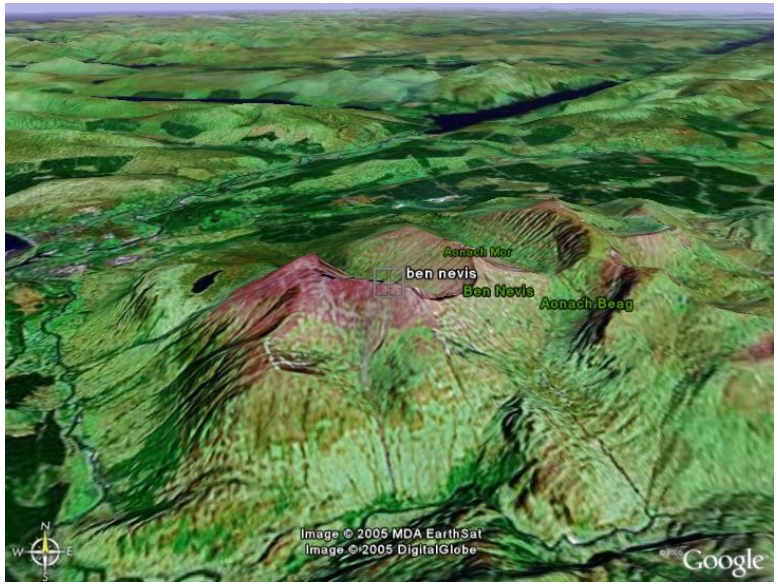


- Numbers represent height on a 2D map
- *– so what is the shape of this famous mountain?*

Simple Example : Maps



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



Ben Nevis – visualisation of 3D satellite data http://earth.google.com

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

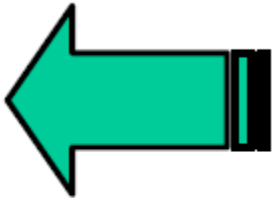
The 'scientific' process
- the *creation* of knowledge

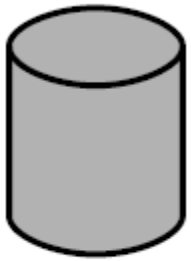
Knowledge
(Scientific papers, business strategy, a medical diagnosis etc).

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

Some analysis?

Human 'expert'

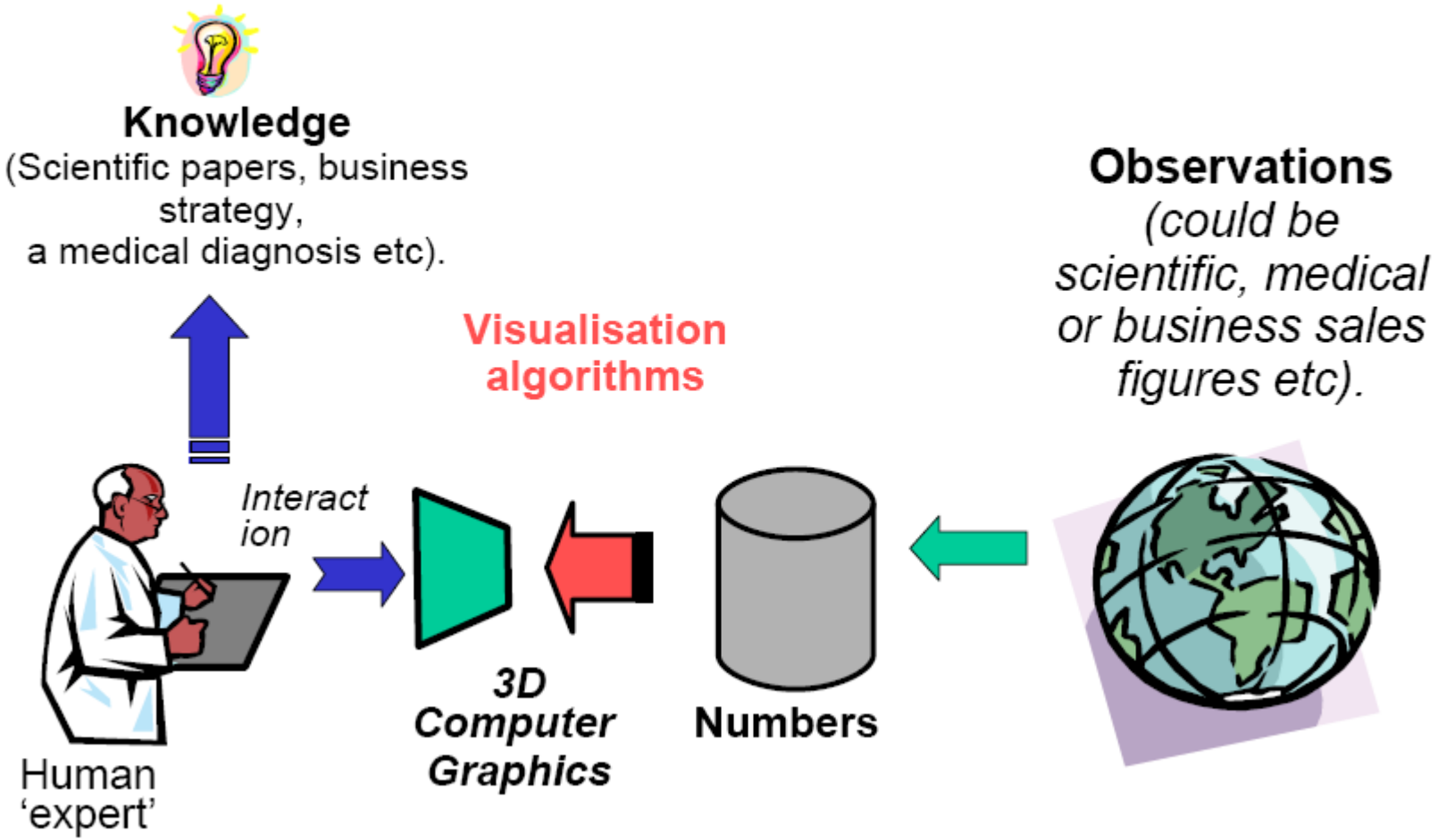




Numbers

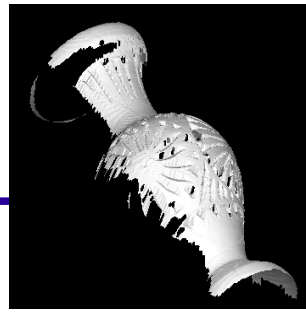
The visualisation process

- the effective presentation of knowledge



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**

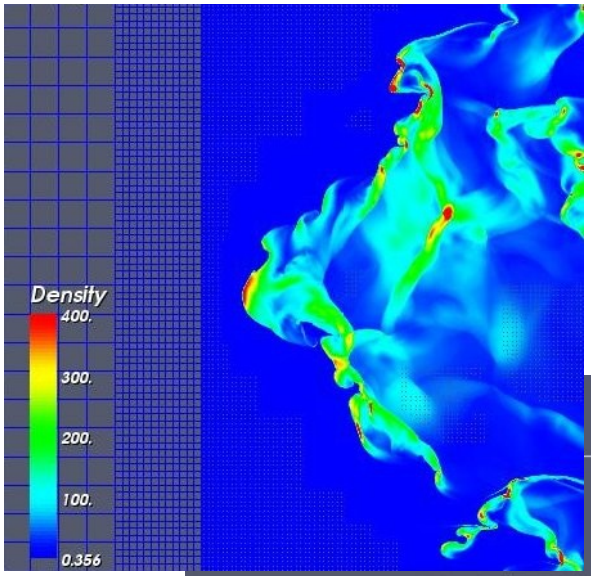


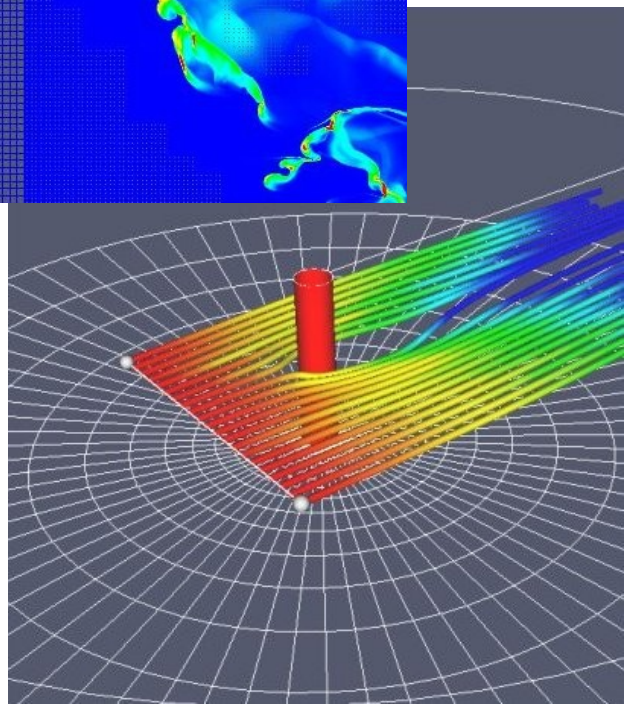
What's in this course?

- **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/

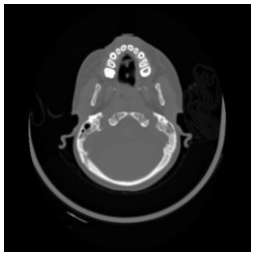
Example : Medical Imaging

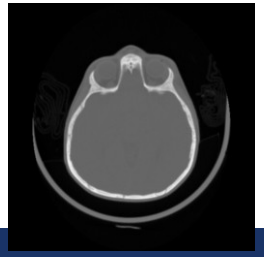
- Computer imaging in medicine:
  - *Computed Tomography* (CT) imaging uses pencil thin X-ray beams
    - *Computer Aided Tomography (CAT)*
  - *Magnetic Resonance Imaging* (MRI) uses large magnetic fields with pulsed radio waves

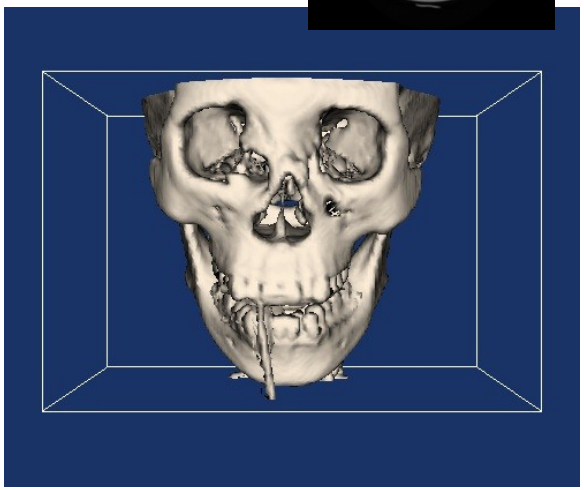
Chest CT section

Magnetic Resonance Image showing a vertical cross section through a human head.

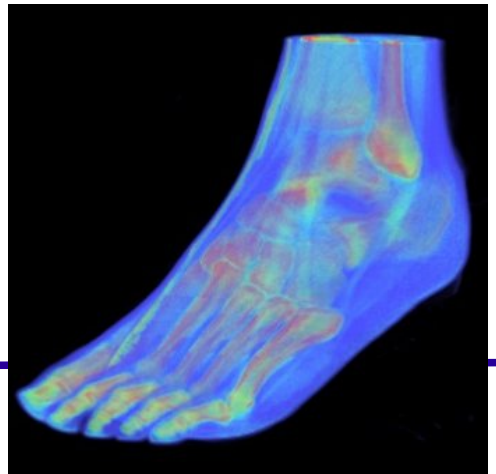
Example : 3D surfaces from CT slices





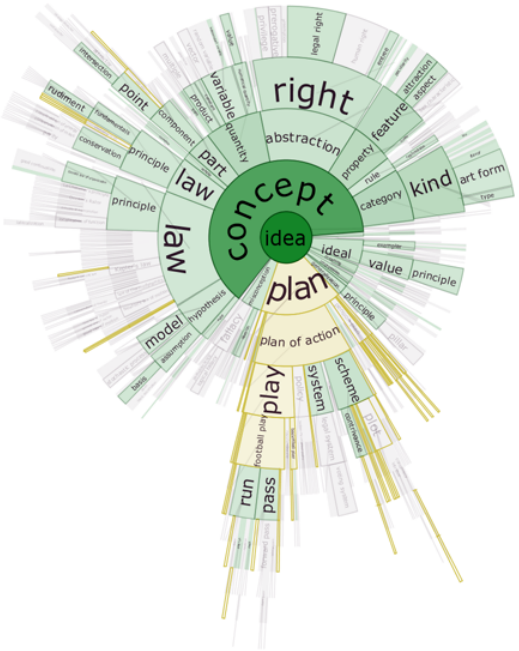


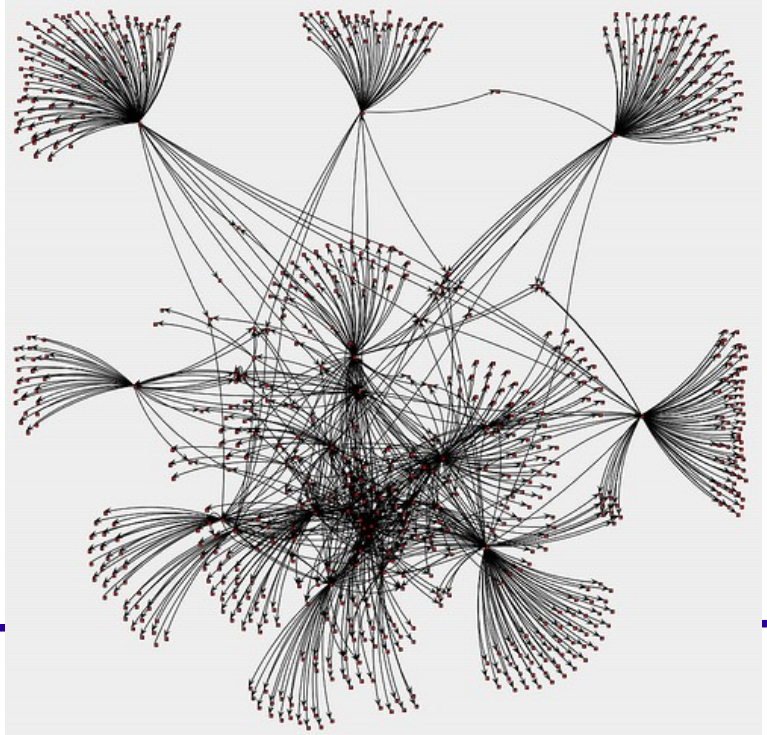
- Many planar slices (2D) can be combined (in topological order) to form a 3D volume of data
  - i.e. stack of 2D images
- Volume can be processed and rendered to reveal complete anatomical structures



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 2018, 22nd March 2018
  - **Assessment**
  - 1.75 hour examination (70%)
  - Practical assignments (15% each)
    - (variation between UG4 and M.Sc. requirements)

lfcs | Laboratory for Foundations of Computer Science

cisa | Centre for Intelligent Systems and their Applications

icsa | Institute for Computing Systems Architecture

epcc

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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**