Computer Animation and Visualisation

Lecture 1

Introduction

Taku Komura

The University of Edinburgh

Today's topics

Overview of the lecture

- Introduction to Computer Animation
- Introduction to Visualisation
- Motivation / Group Research

Introduction

Taku Komura

http://homepages.inf.ed.ac.uk/tkomura/
tkomura<at>ed.ac.uk *Informatics Forum 1.23*

Introduction video about my research topics

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

B.Sc. in Informatics, Univ. of Tokyo, 1995

M.Sc. in Informatics, Univ. of Tokyo, 1997

Ph.D. Student, Univ. of Tokyo, 2000

RIKEN, Japan Postdoc 2000-02

City University of Hong Kong 2002-06

University of Edinburgh 2006-now

Research focuses on character animation, computational geometry, robotics, 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** and/or **high-dimensional** data and visualize them for **analysis**

- *CRT, MRI, ultra-sound 3D volume data*
- *Flows simulated on the computer*
- *3D surface data captured by laser scanners, computed by stereo vision techniques*

Today's topics

Overview of the lecture

- **Introduction to Computer Animation**
- Introduction to Visualisation
- Motivation / Group Research

What is computer animation?

- Creating moving images via the use of computers.
- Subfield of computer graphics
- Applications :
  - Films & Special Effects
  - TV Programs
  - Computer Games
  - Web Contents
  - VR and AR

Demo Animation

https://www.youtube.com/watch?v=_MoIr7811Bs

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

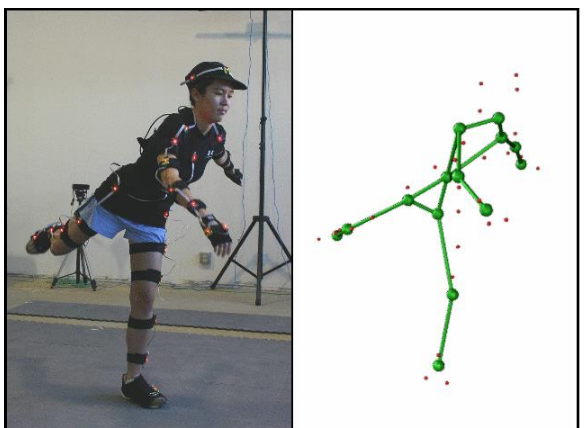
Character Animation

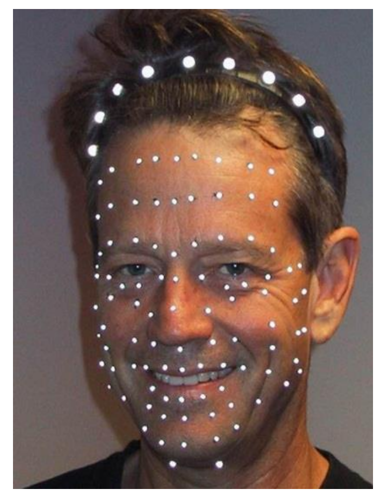
- Controlling characters
  - Different body structures (humans / cartoon characters / animals / ...)
  - using real human movements (MoCap)
  - manually creating the movements (KeyFrame)



Motion capture

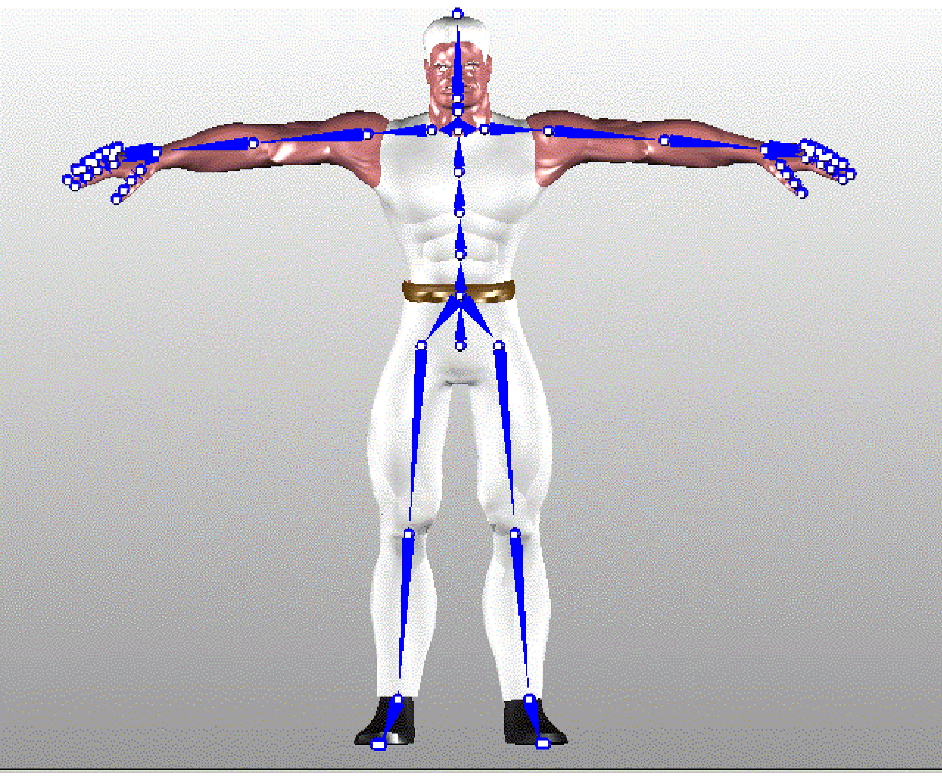
- Digitizing the human movements
- Tracking the movements of the markers
- Apply them to virtual characters





Skinning

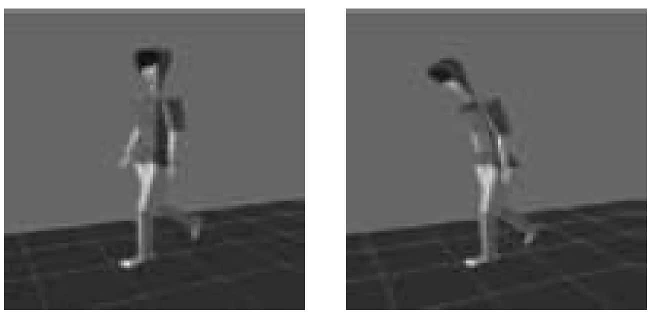
- Need to decide how the surface deforms according to the movements of the skeletal bones



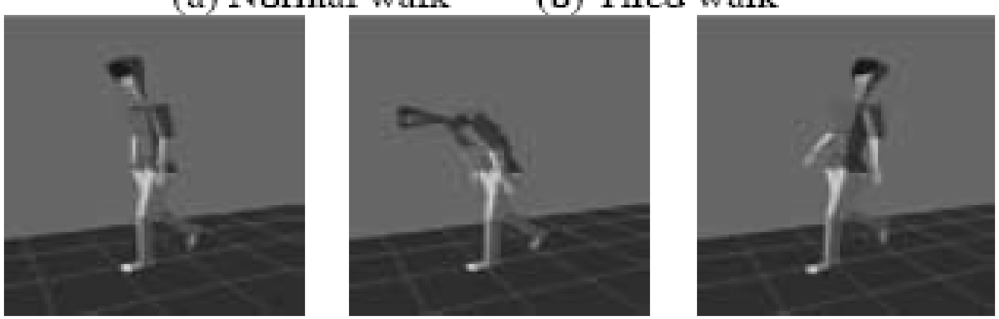
Motion Editing

- Making use of the captured motions for different scenes

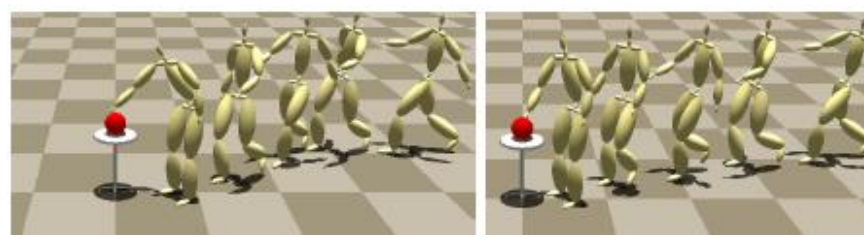
- Adjust the movements so that they satisfy constraints



(a) Normal walk (b) Tired walk

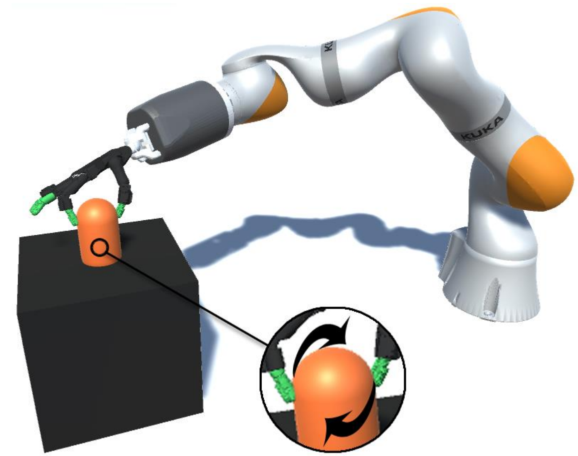


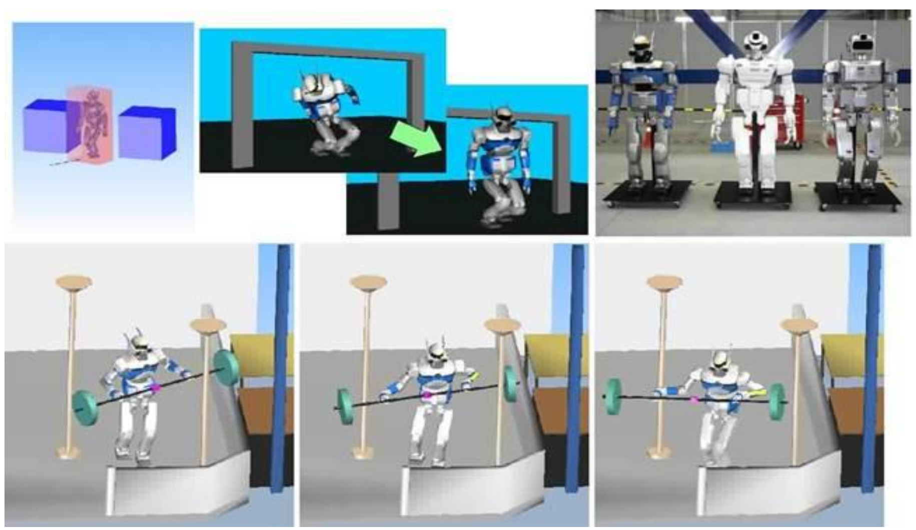
(c) s = 0.5 (d) s = 2.0 (e) s = -0.5

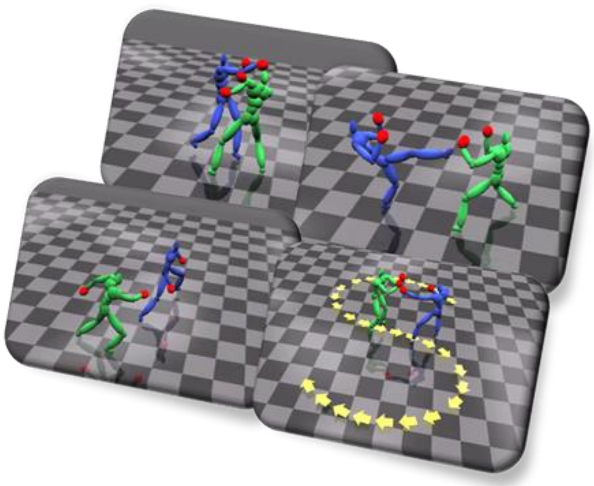


Motion Planning

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

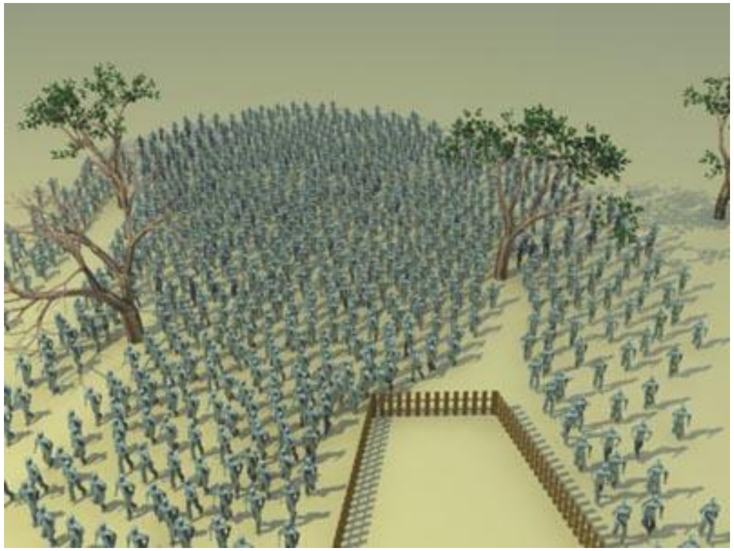






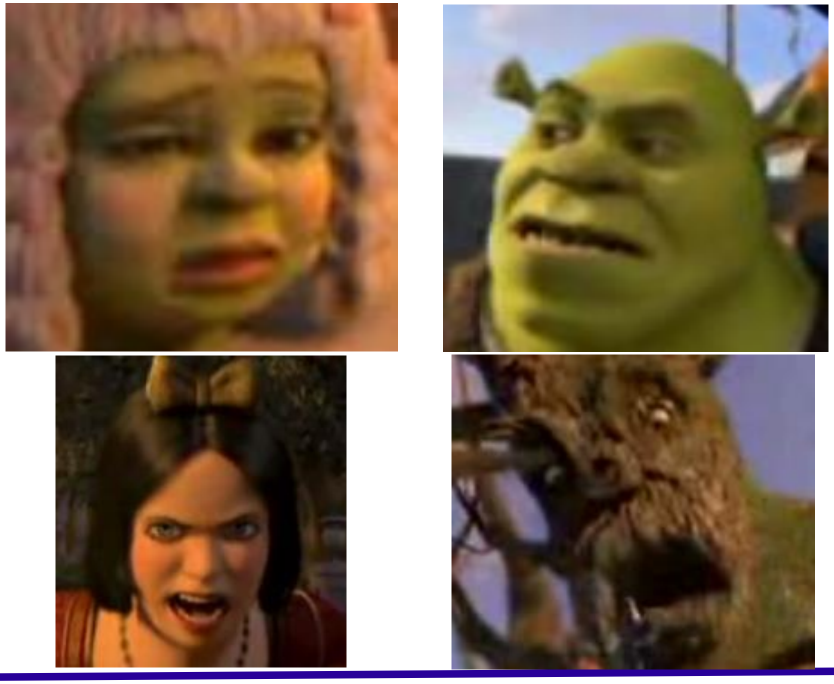
Crowd simulation

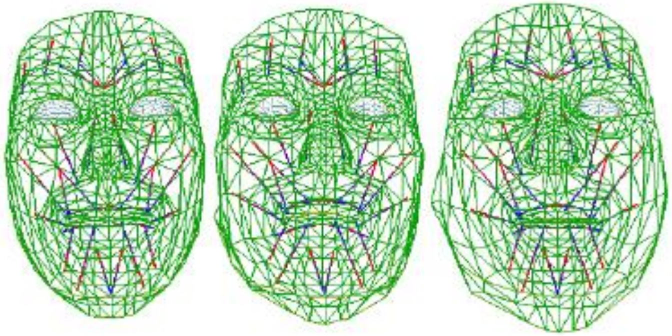
- Simulating the pedestrians in the streets
- How does one's movement affect those of the others



Facial animation

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

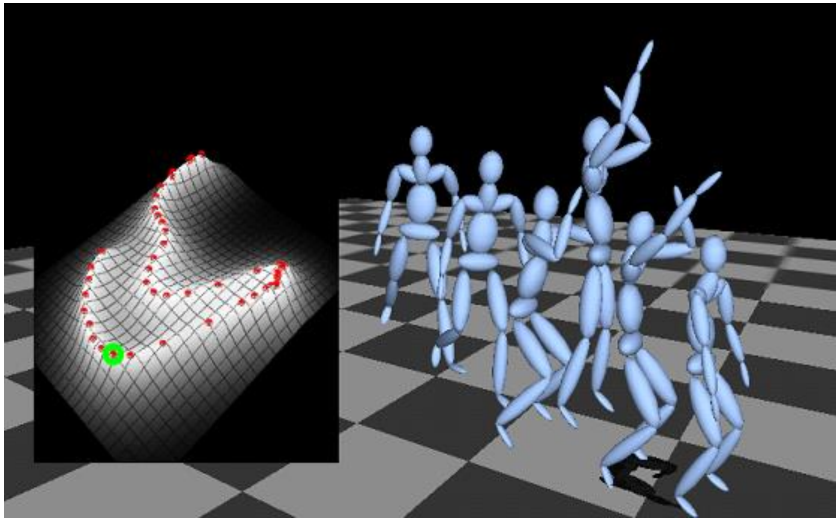




Machine Learning Techniques for Computer Graphics

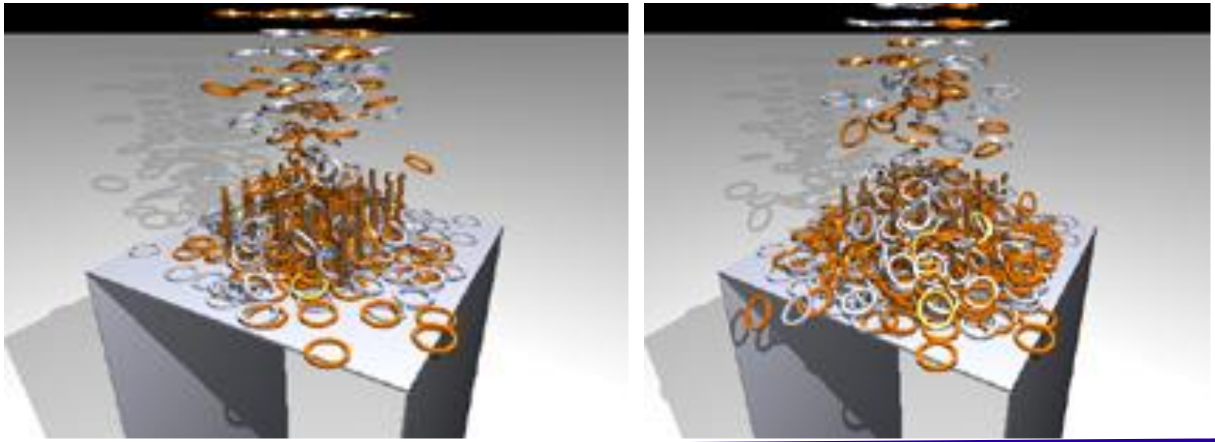
- In computer graphics, the user input should be in low dimension (runtime speed & computational requirements)
- But we expect high dimensional outputs (face models, 3D postures, scenes etc)
- Machine learning techniques such as
  - Dimensionality reduction
  - Nonlinear regression

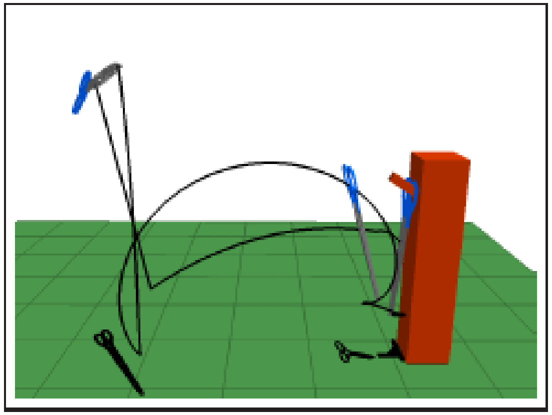
  can be helpful.



Physically-based Animation: Rigid Objects

- Simulating rigid objects flying, colliding, and bouncing
- Technical issues
  - Collision detection
  - Deciding the initial conditions and adding virtual forces so that the scene appears in the way you like





Physically-based Animation: Cloth simulation

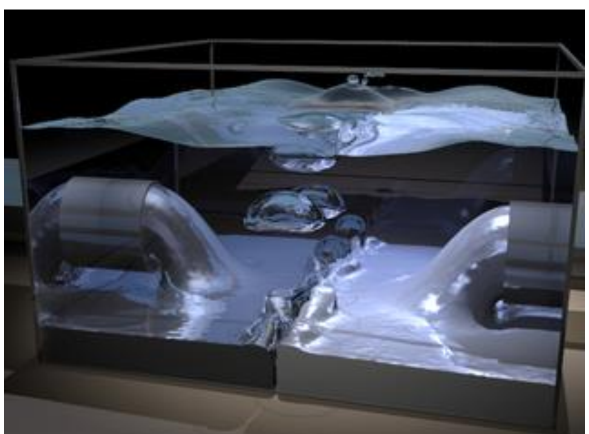
- Simulating the movements of clothes when the body moves
- How the wind affects the shape

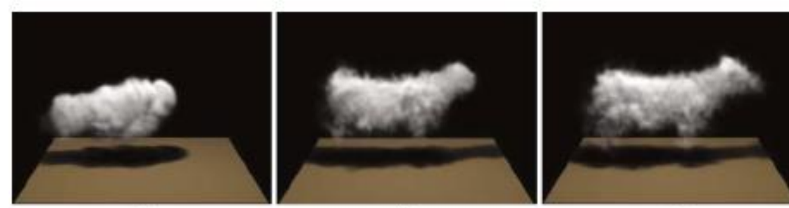
Physically-based animation: Hair

- 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

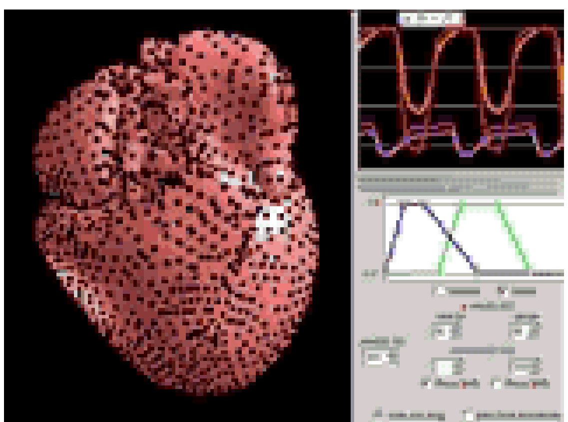
- Simulating liquid, mud, fire, bubbles
- How to efficiently simulate the motion of the fluids
- How to control the fluids so that the animator can get what s/he wants



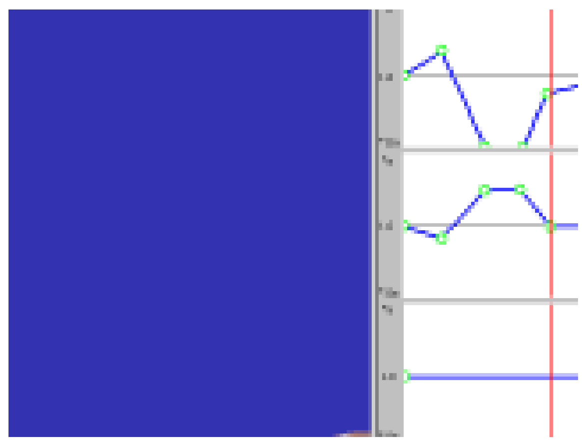



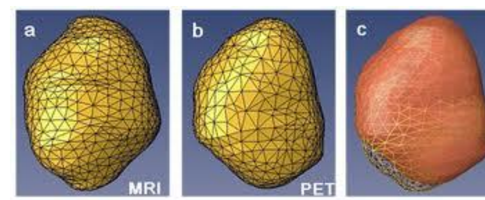
Finite Element Method

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



On courtesy of Dr. Takashi Ijiri



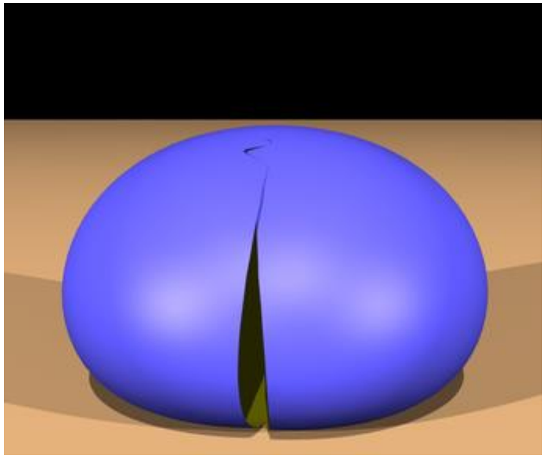


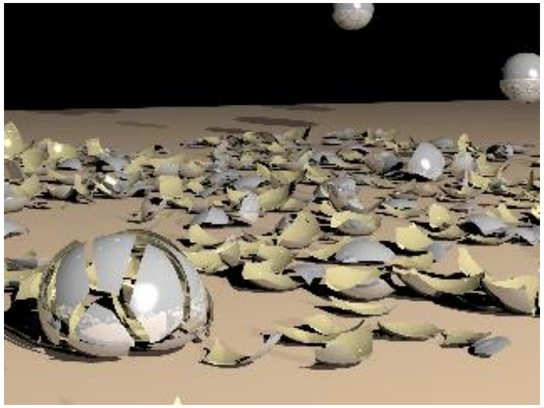
Wrecks/Crashes/Destruction

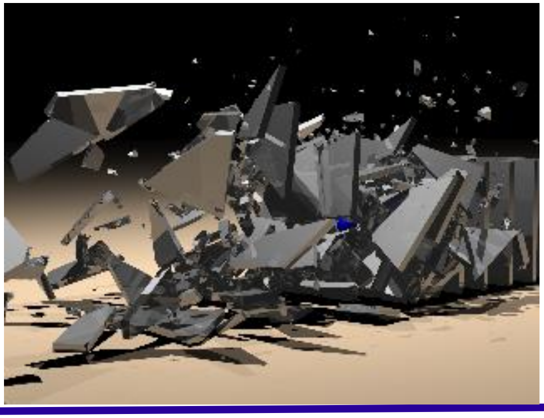
- Simulate how / where the destruction starts and expands

https://www.youtube.com/watch?v=eDKp436YAxA

https://www.youtube.com/watch?v=NGpJBKhK7Zk

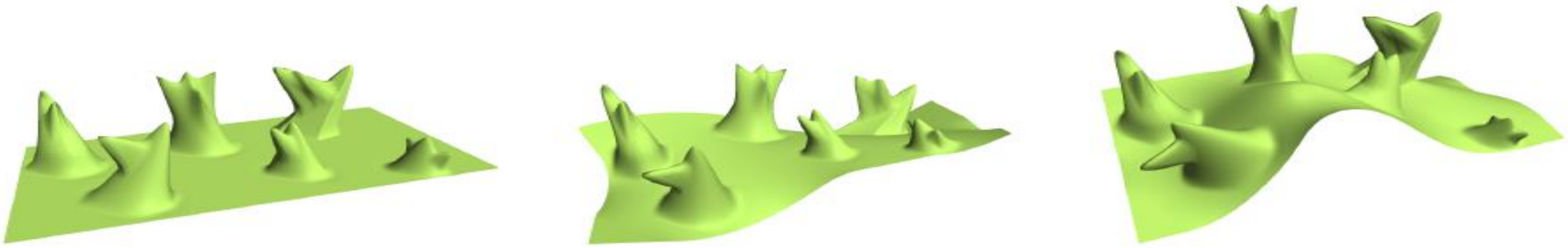






Shape Modelling and Editing

Designing shapes, editing shapes

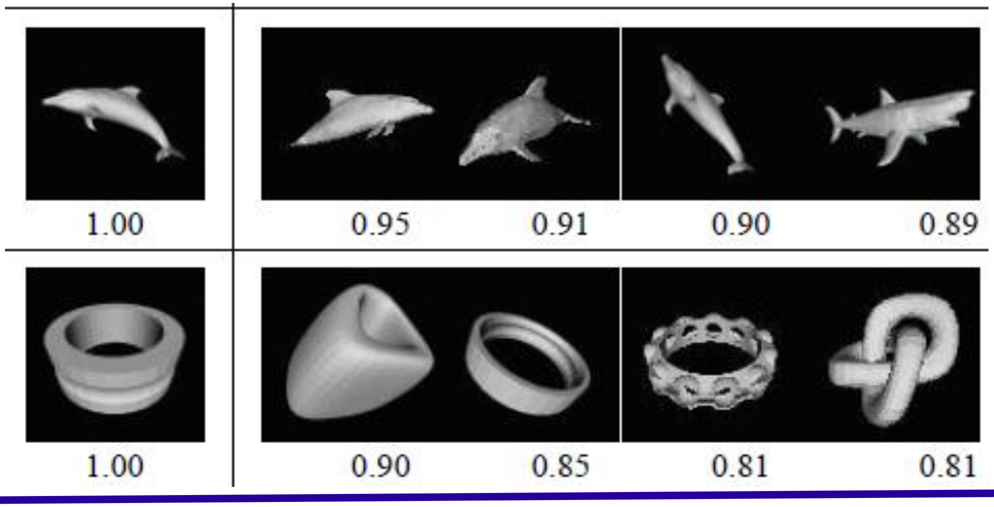


2D Cell animation

- For a 30 minute cartoon, 3000 cell pictures are needed
- This requires a month labour of 50 professional drawers
- How to create 2D Cell animation efficiently
  - Using 3D graphics and render in a 2D cell animation fashion
  - lighting, shadows, deformation

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.



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- Introduction to Computer Animation
- **Introduction to Visualisation**
- Motivation / Group Research

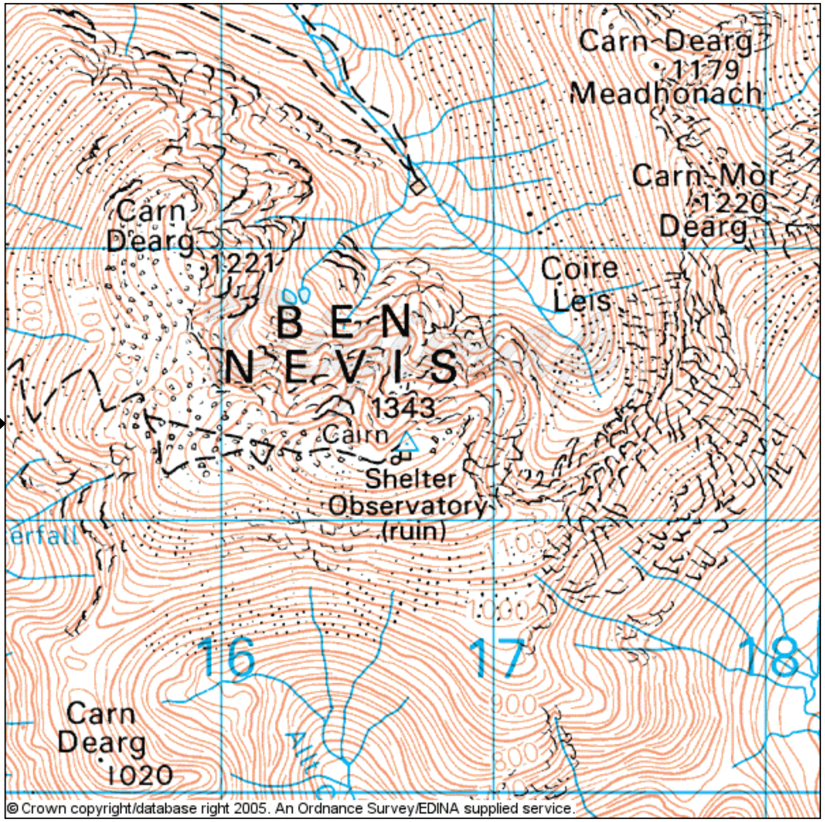
What is visualisation?

- **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”*

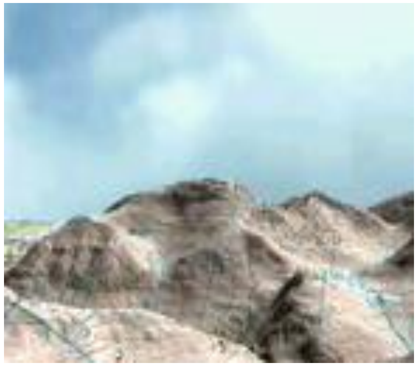
Simple Example : Maps

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	:

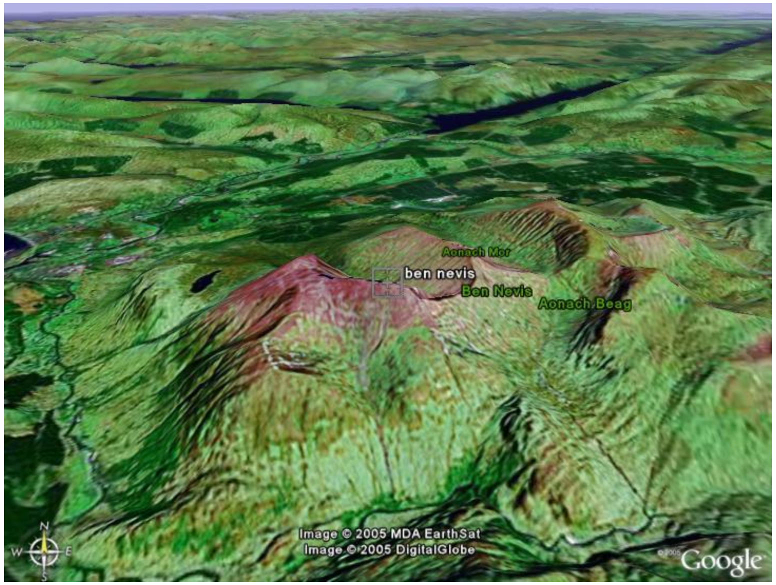


- Numbers represent height on a 2D map
- So what is the shape of this famous mountain?

Simple Example : Maps



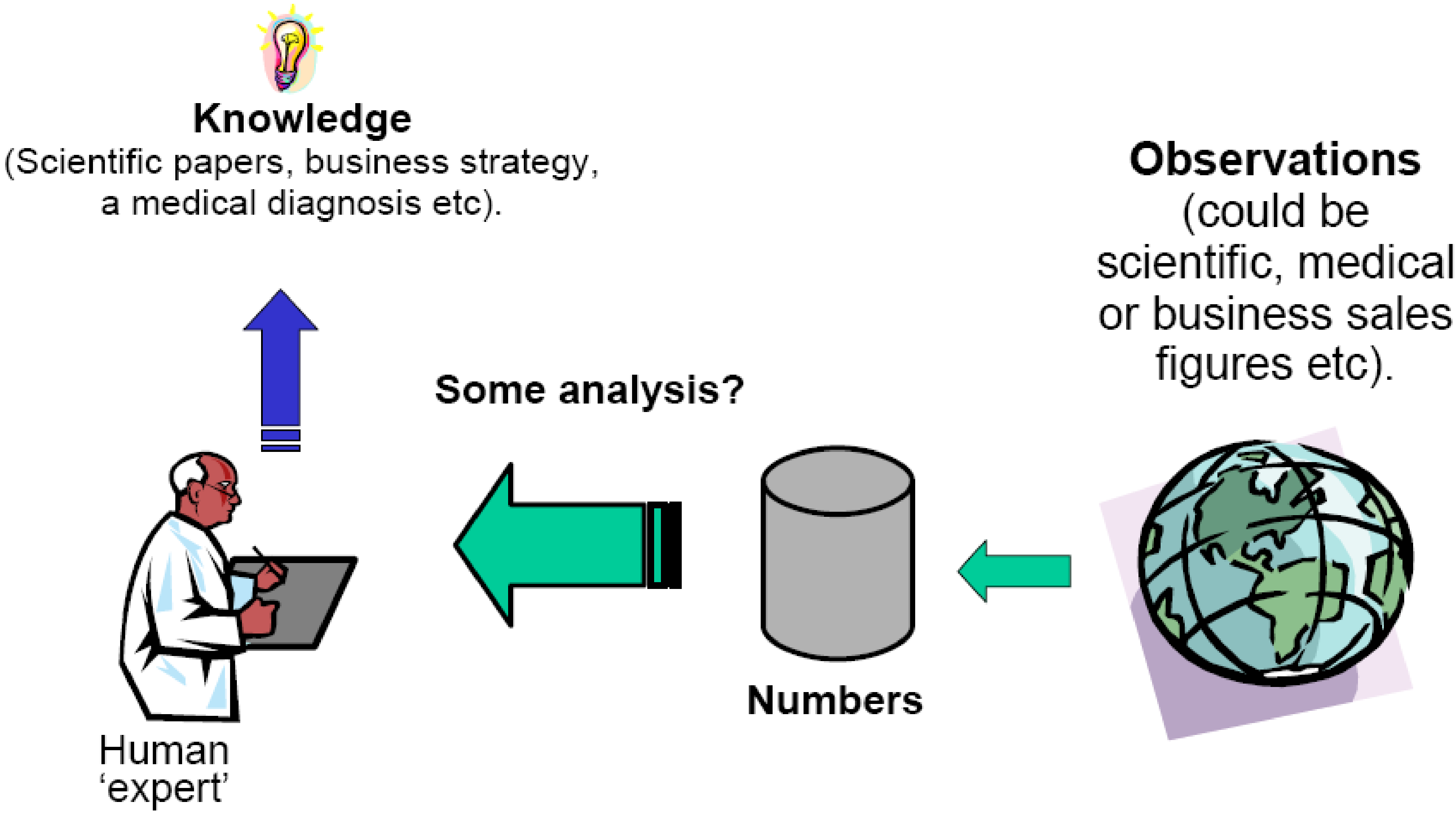
Ben Nevis Fly Through:
http://www.ordnancesurvey
.co.uk



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

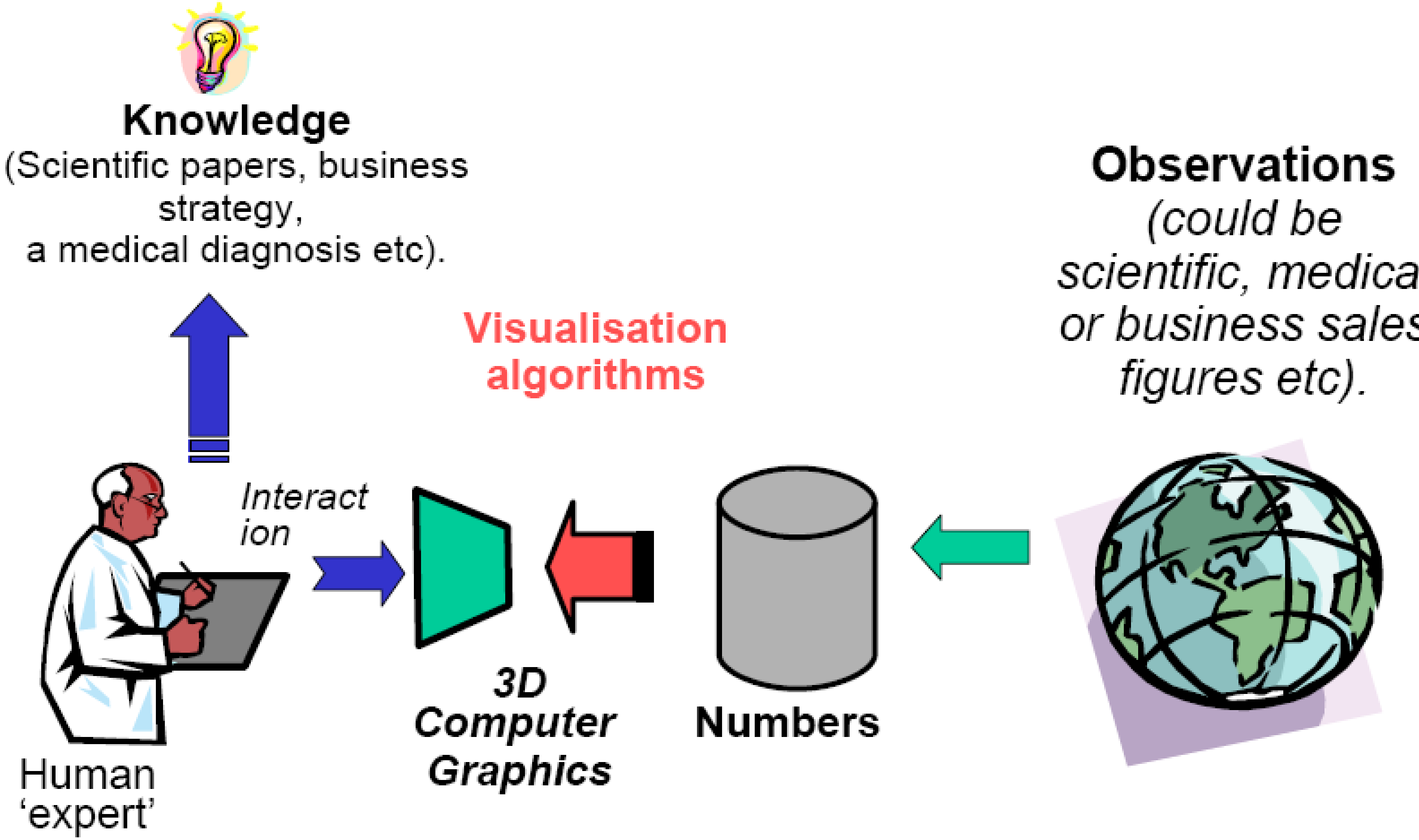
With 3D graphics, we can represent the shape of the mountain directly.
We can improve the visualisation of this height data by viewing it in 3D.

The ‘scientific’ process
- the *creation* of knowledge



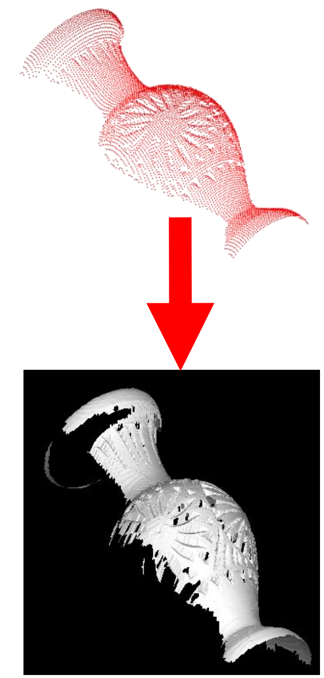
The visualisation process

- 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)



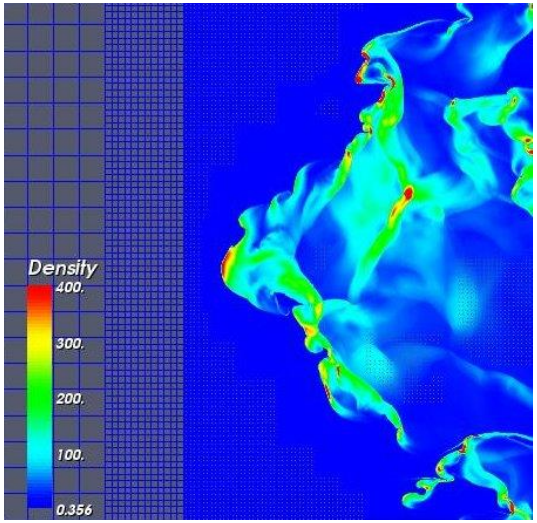
- This course:
  - **data representation & transformation for visualisation**

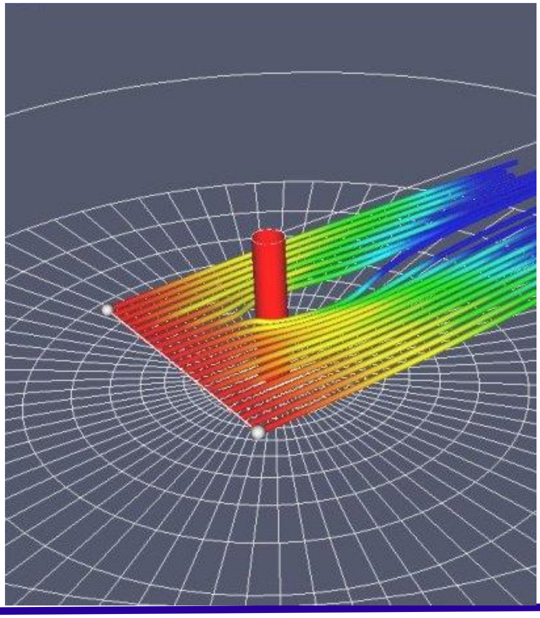
What's in this course?

- **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)*

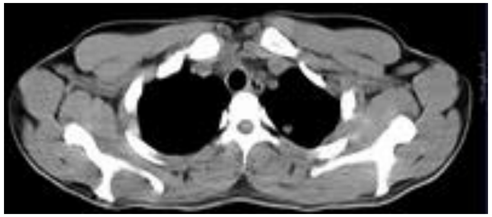




http://www.paraview.org/

Example : Medical Imaging

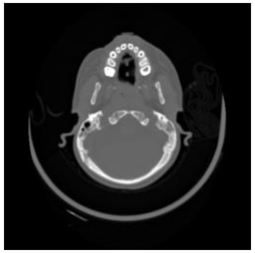
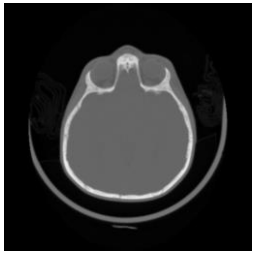
- Computer imaging in medicine:
  - *Computed Tomography* (CT) imaging uses pencil thin X-ray beams
  - Computer Aided Tomography (CAT)
  - Magnetic Resonance Imaging (MRI) uses large magnetic fields with pulsed radio waves



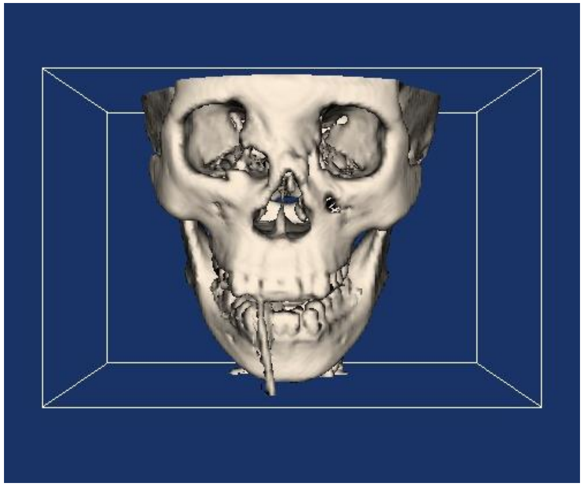
Chest CT section

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

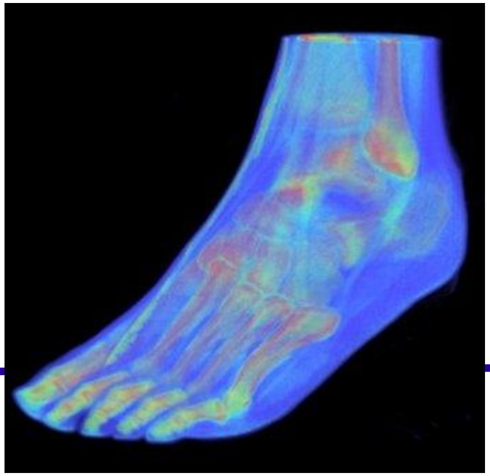
Example : 3D surfaces from CT slices

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

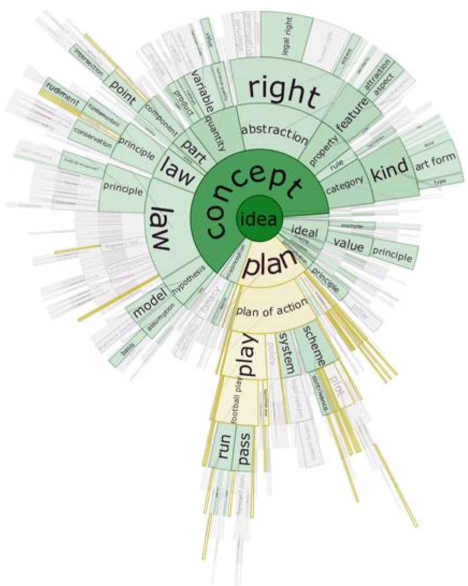


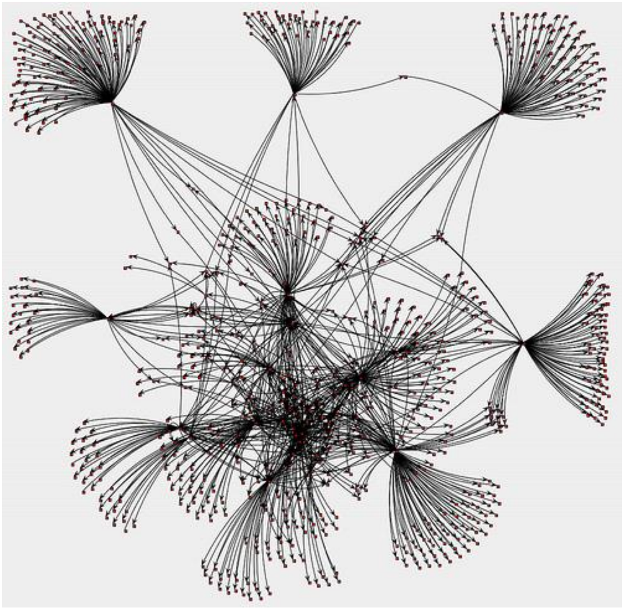
- Volume can be processed and rendered to reveal complete anatomical structures



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**
  - 2D & 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/)
  - will be updated over the year
  - background reading (mainly on-line)
- **2 Assessed Practicals**
  - 2 programming tasks
  - One for character animation (Unity), another for physical simulation and visualisation (OpenGL, C++)
  - Deadlines: 26th Feb 2020, 27th March 2020
  - **Assessment**
  - 1.75 hour examination (70%)
  - Practical assignments (15% each)

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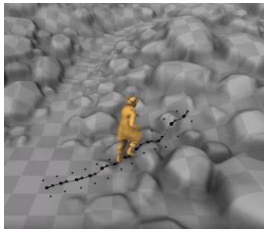
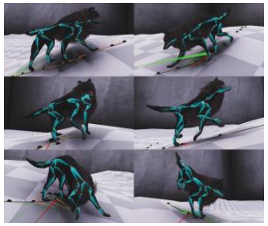
- **Motivation / Group Research**

Motivation / Research

Evolutionary IK https://www.youtube.com/watch?v=ik45v4WRZKI



Phase-Functioned Neural Networks https://www.youtube.com/watch?v=Ul0Gilv5wvY



Mode-Adaptive Neural Networks https://www.youtube.com/watch?v=uFJvRYtjQ4c

Neural State Machine https://www.youtube.com/watch?v=7c6oQP1u2eQ