EBU5405
3D Graphics Programming Tools

Introduction

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Today's agenda

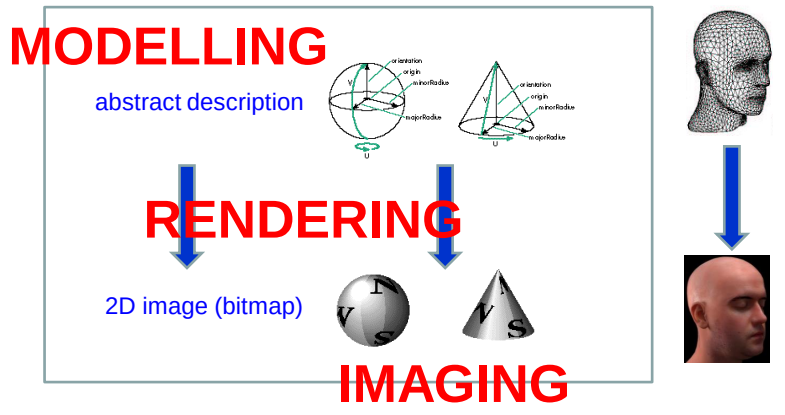
- 3D graphics:
  - 3D basics
  - 3D rendering pipeline
  - Application examples
- Introduction to EBU5405

3D Graphics

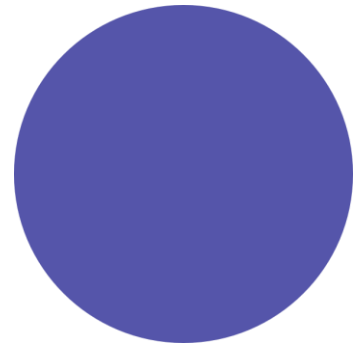
3D graphics programming is the subject concerned with how 2D images can be generated from abstract descriptions of 3D objects.

3D computer graphics are graphics that use a three-dimensional representation of geometric data that is stored in the computer for the purposes of performing calculations and rendering 2D images.

3D Graphics

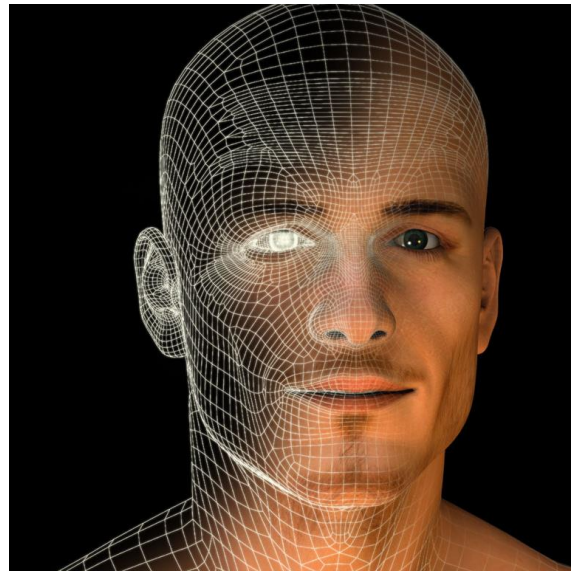


3D Graphics



3D Graphics

3D Graphics



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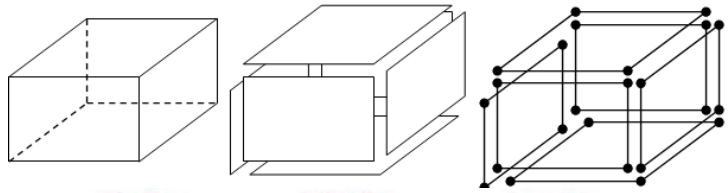
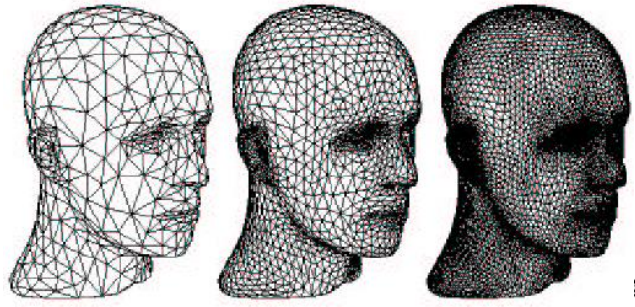
Modelling

The generation of abstract descriptions of 3D objects is called geometric modelling.





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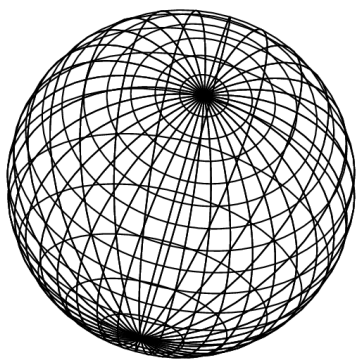
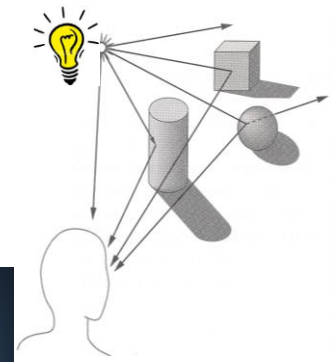
Rendering

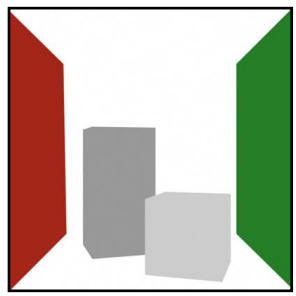
The generation of 2D images from 3D models is called rendering.



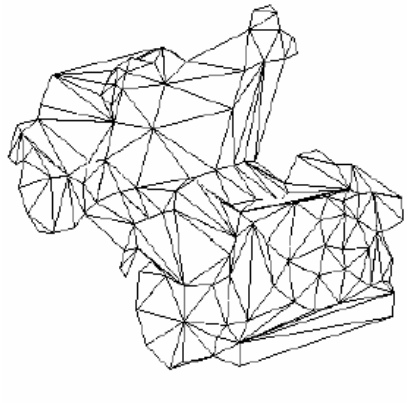
Rendering: Lighting

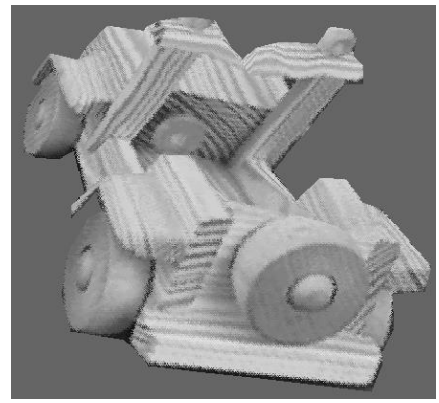
By simulating the interaction between light and matter (lighting) the object surfaces can be realistically coloured (shading).





Rendering: Texture

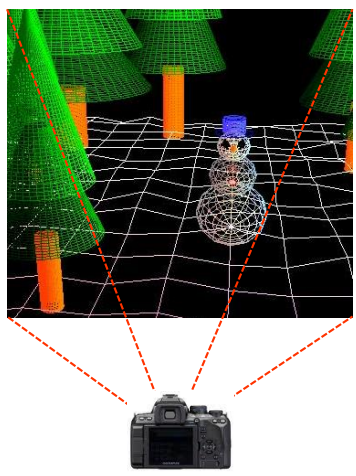




Rendering: Viewing

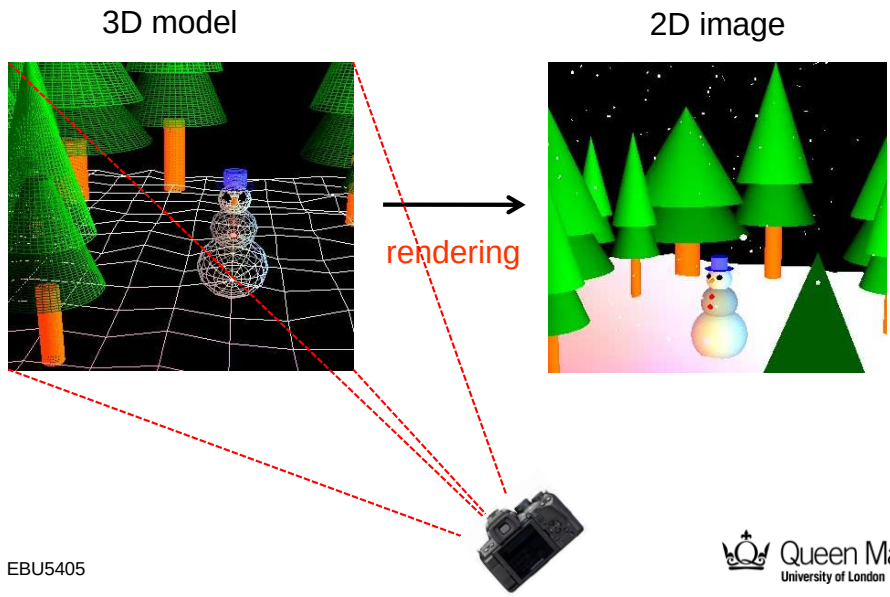
3D model

2D image

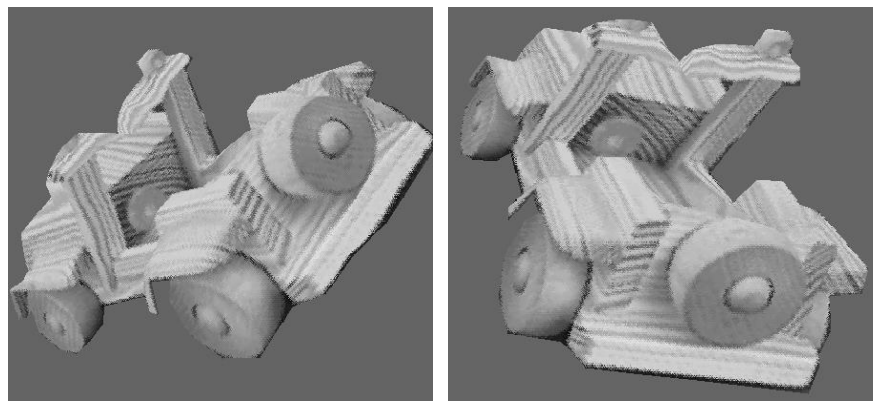


rendering

Rendering: Viewing



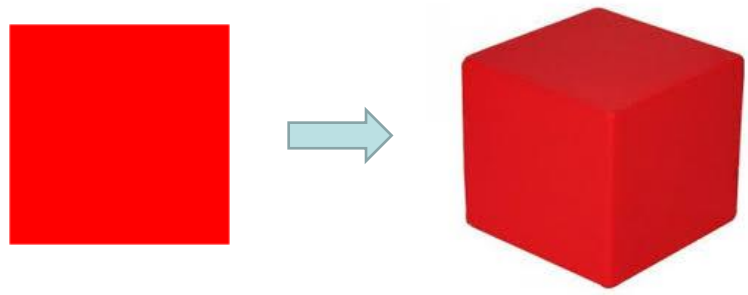
Rendering: Viewing



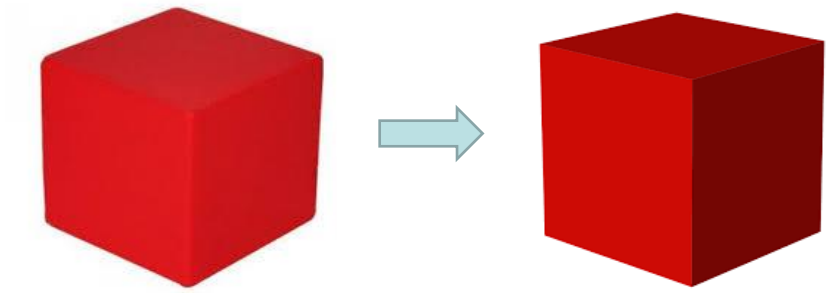
2D versus 3D : spot the differences!

This is a cube … really?

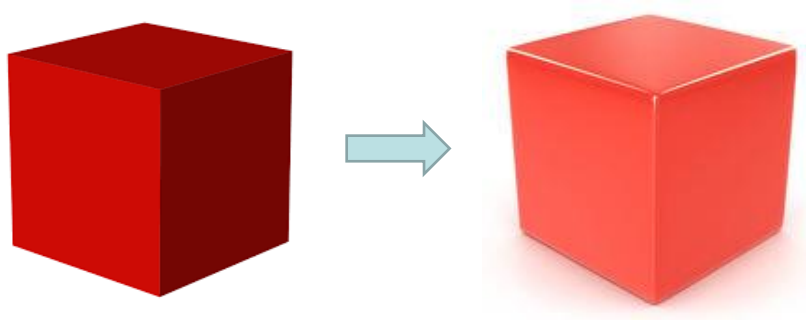
Modelling Transformation (rotation)



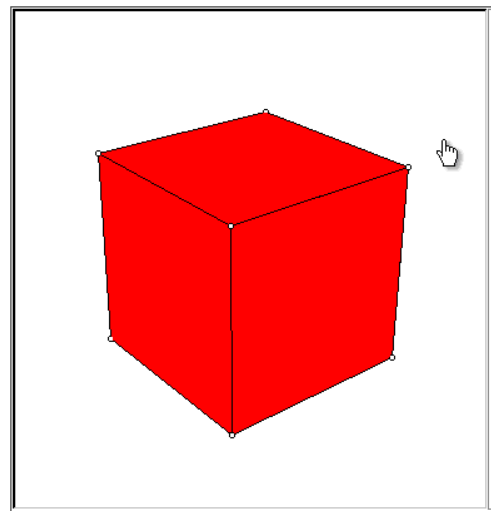
Lighting and Shading



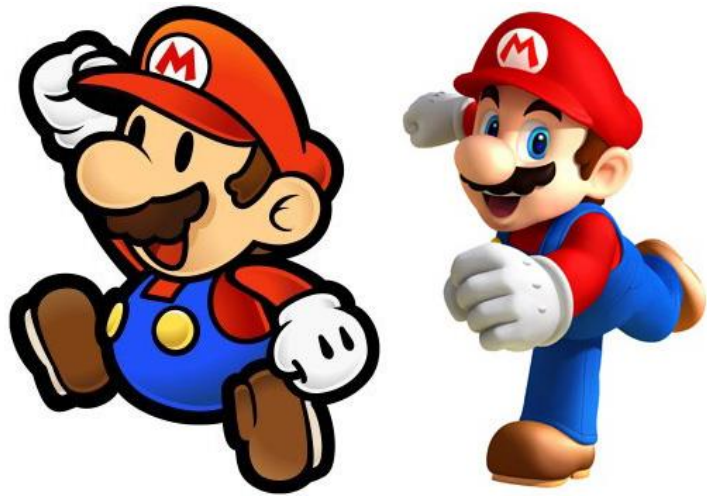
Perspective Projection



Perspective = Distortion



2D versus 3D : spot the differences!



Rendering

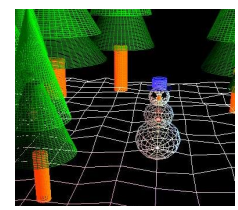
Rendering a 3D scene needs the representation of a number of objects:

- The 3D objects of the 3D scene, characterised by:
  - Their geometry
  - Their respective positions
  - Their material (used for shading calculations)
- A camera (a viewer), characterised by:
  - Its position
  - Its lens (used for projection calculations)
- A light source, characterised by:
  - Its position
  - Its geometry
  - Its colour

MODEL

VIEWER

LIGHT



The 3D basics

- 3D Computer graphics
  - generating 2D images of a 3D world represented in a computer
- Modelling
  - Representing 3D objects
    - (shape) creating & representing the geometry of objects in the 3D world
- Rendering
  - Constructing 2D images from 3D models
    - (light, perspective) generating 2D images of the objects
- Imaging
  - Representing 2D images
- Animation
  - Simulating changes over time
    - (movement) describing how objects change in time

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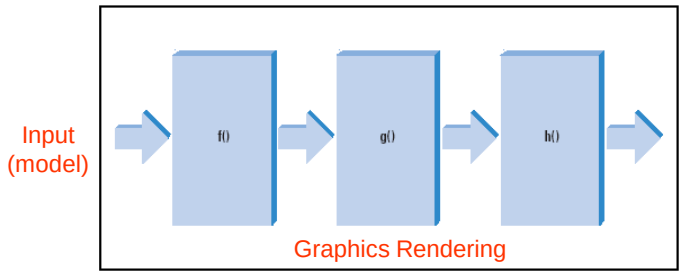
  - 3D rendering pipeline
  - Application examples
- Introduction to EBU5405

Pipeline architecture

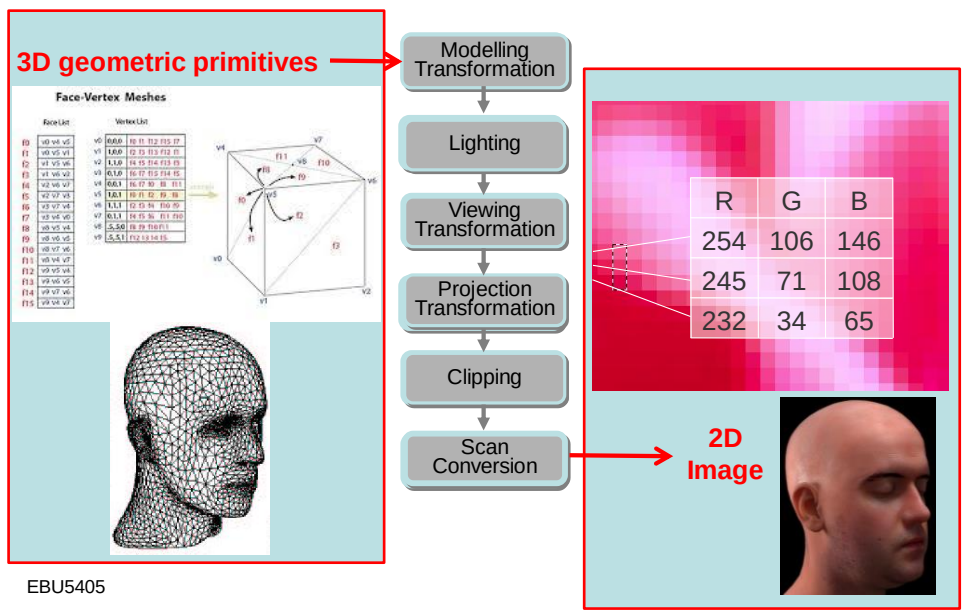


- Graphics rendering is like a manufacturing assembly line with each stage adding something to the previous one.
- Within a pipeline architecture, all stages are working in parallel.
- Because of this pipeline architecture, today's graphics processing units (GPUs) perform billions of calculations per second. They are increasingly designed with more memory and more stages, so that more data can be worked on at the same time.

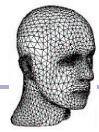
Pipeline architecture

Pipeline architecture

The 3D Rendering Pipeline



The 3D Rendering Pipeline



3D geometric primitives

Modelling Transformation

Lighting

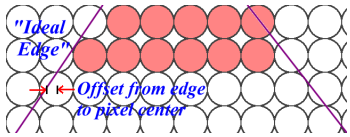
Viewing Transformation

Projection Transformation

Clipping

Scan Conversion

2D Image



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The 3D rendering pipeline

3D geometric primitives

Modelling Transformation — Transform individual object coordinates into 3D world coordinate system

Lighting — Illuminate according to lighting and reflectance

Viewing Transformation — Transform 3D scene into 3D camera coordinate system

Projection Transformation — Transform 3D coordinates into 2D screen coordinate system

Clipping — Clip primitives outside camera's view

Scan Conversion — Draw pixels (includes texturing, hidden surface, ...)

Image

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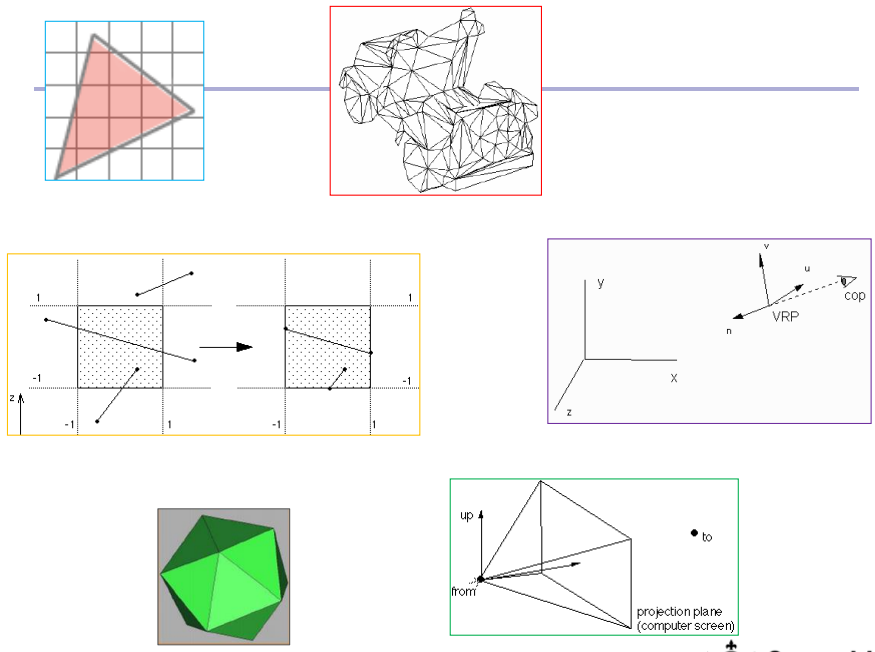

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Entertainment

Final Fantasy (Square, USA)

Entertainment

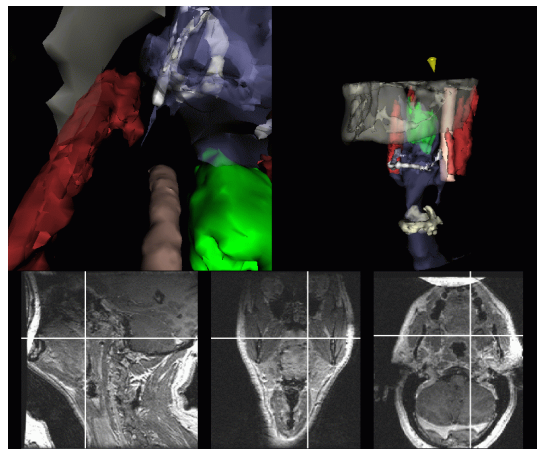
Minions (Universal Pictures)

Entertainment

Pixar: Monster's Inc.

Square: Final Fantasy

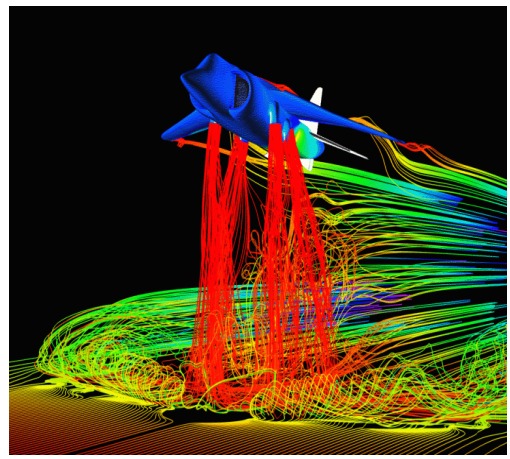
Medical Visualisation



MIT: Image-Guided Surgery Project

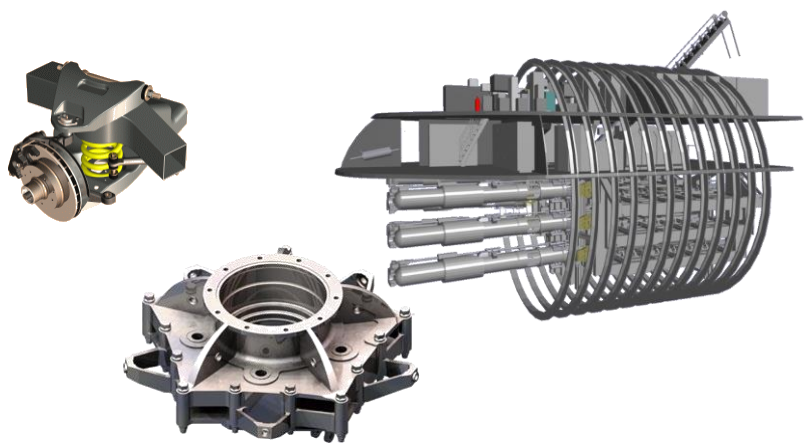
The Visible Human Project

Scientific visualization

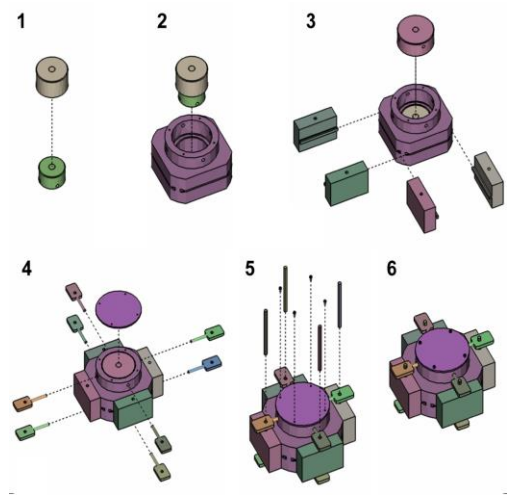


Airflow around a Harrier Jet (NASA Ames)

Computer Aided Design (CAD)

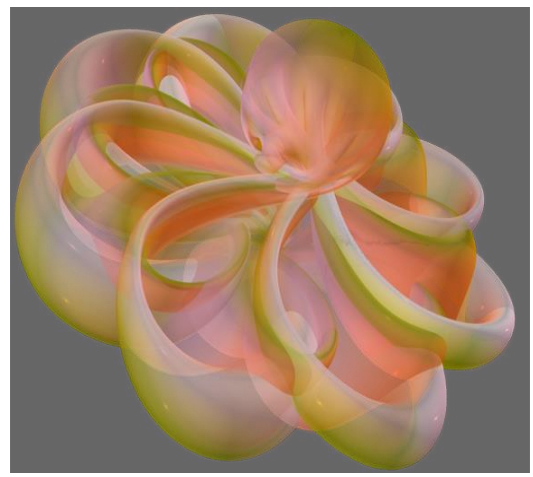


Training



Designing Effective Step-By-Step Assembly Instructions (Maneesh Agrawala et. al)

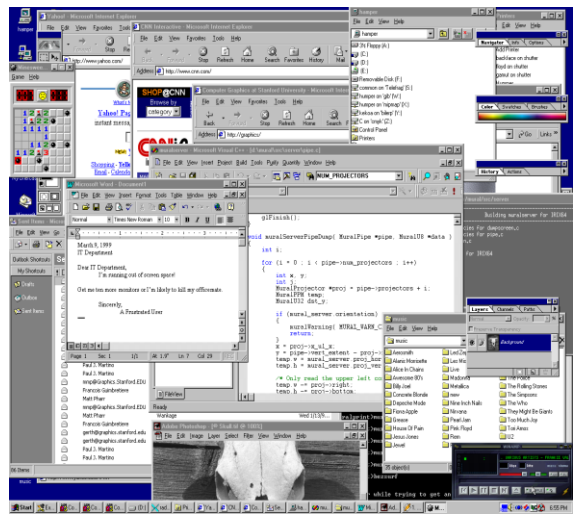
Education



Outside In (Geometry Center, University of Minnesota)

Flight Simulator

Everyday use



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Course Aims and objectives

- To understand the basic transformations and rendering techniques for the creation of 3D graphics
- Ability to implement computer generated animations
- Ability to implement 3D virtual environments using OpenGL

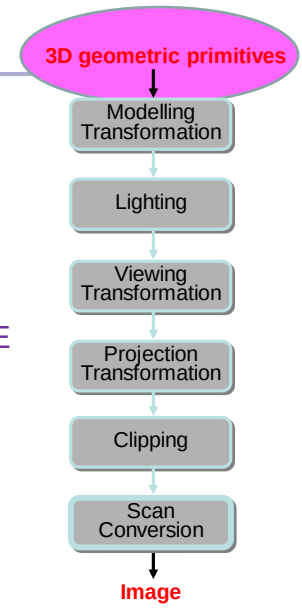
Content Overview : week 1

INTRODUCTION

- 3D basics
- 3D rendering pipeline
- Application examples

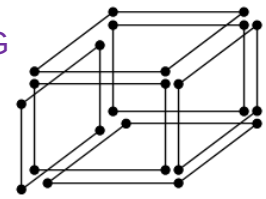
3D COMPUTER GRAPHICS SOFTWARE

INTRODUCTION TO OPENGL (2D)



Content Overview : week 2

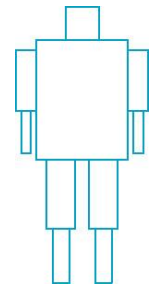
OBJECT MODELLING

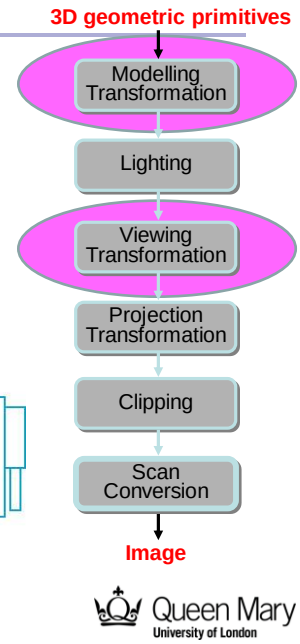


OPENGL (3D)

GEOMETRIC TRANSFORMS (modelling and viewing)

HIERARCHICAL MODELLING



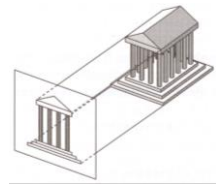


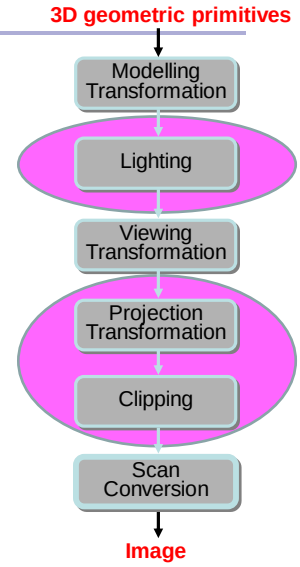
Content Overview : week 3

COLOUR

LIGHTING

PROJECTION

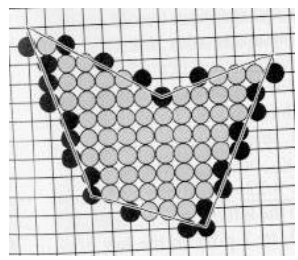


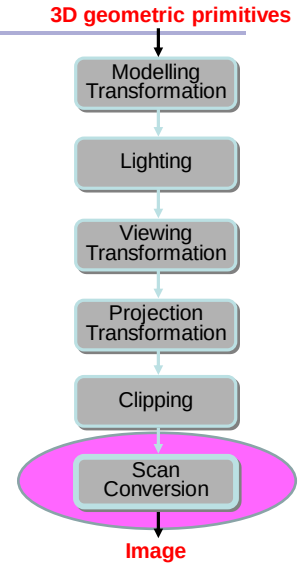


Content Overview : week 4

RASTERISATION

Revisions ..





Assessment

- Final exam: 75% of the final mark
- Coursework: 25% of the final mark
  - Individual coursework
  - Labs support the coursework (8 sessions)
  - Programming in C and OpenGL

Labs

- Two-hour sessions with Teaching Assistants
- 8 labs in total
  - **lab1 (OpenGL practice)**
  - **lab2 (OpenGL practice)**
  - **lab3 (OpenGL practice)**
  - **lab4 (modelling)**
  - **lab5 (transformations and animation)**
  - **lab6 (lighting)**
  - **lab7 (materials)**
  - **lab8 (end of coursework …)** → **submission due**

NOTE: Lab exercises and Coursework are linked

Resources

- Recommended book :

  Interactive Computer Graphics - A Top-Down Approach with OpenGL, by Edward Angel (Fifth Edition) Addison-Wesley 2009 - ISBN 0-321-54943-0

- Web
  - http://www.opengl.org/ Documentation, tutorials, source code
  - http://www.cs.uccs.edu/~semwal/indexGLTutorial.html OpenGL tutorial