Computer Graphics

An Introduction

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Computer Graphics

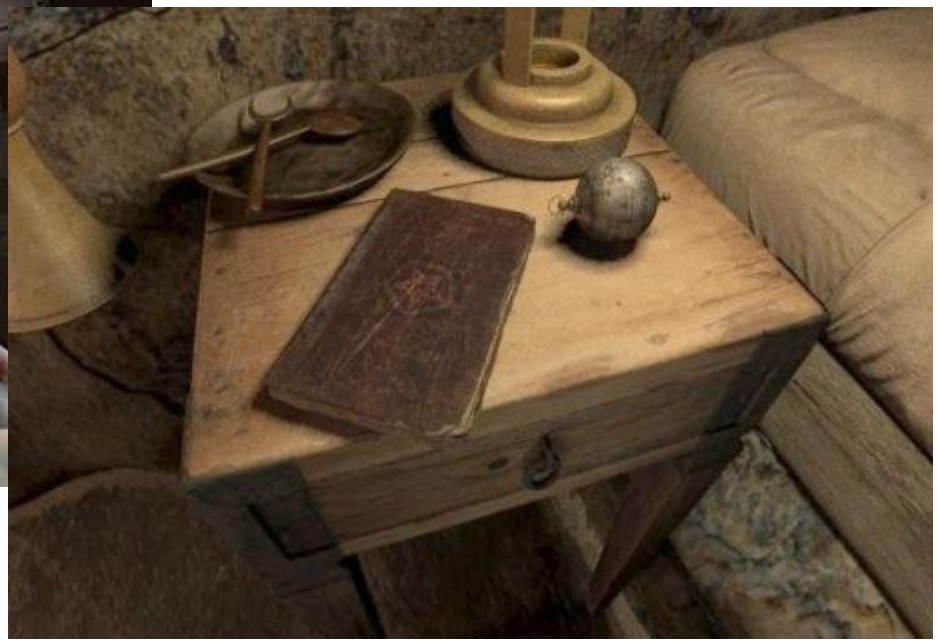
- Images and movies produced by computers
- Applied in many areas nowadays, becoming an important topic of our society.

Applications:

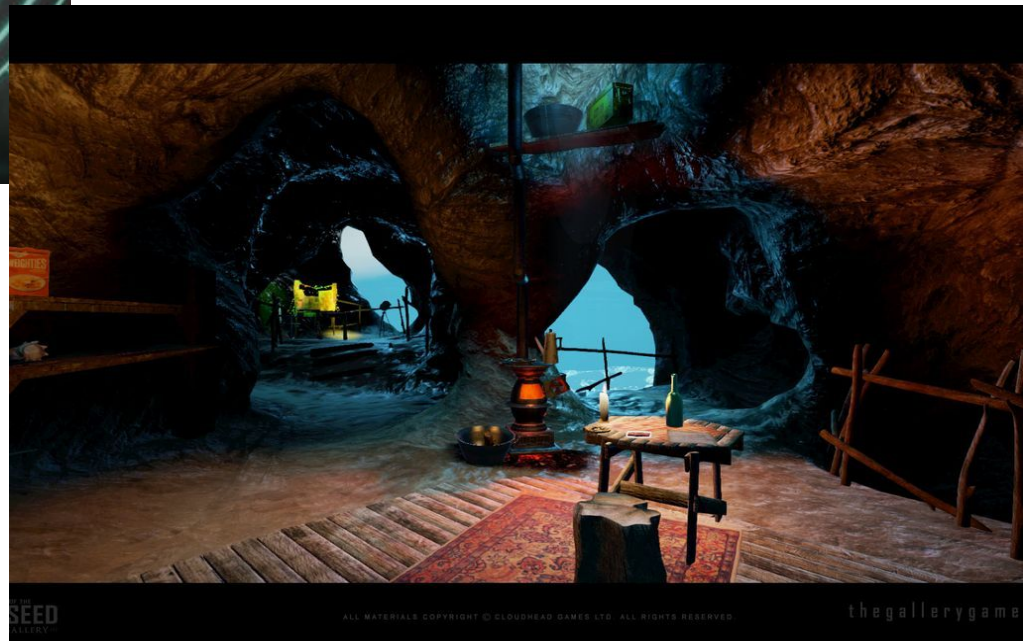
- Films
- Computer games
- Virtual reality, augmented reality
- Medicine
- 3D design
- Scientific visualization

Computer Graphics is about animation (films)

Games are very important in Computer Graphics



VR and AR



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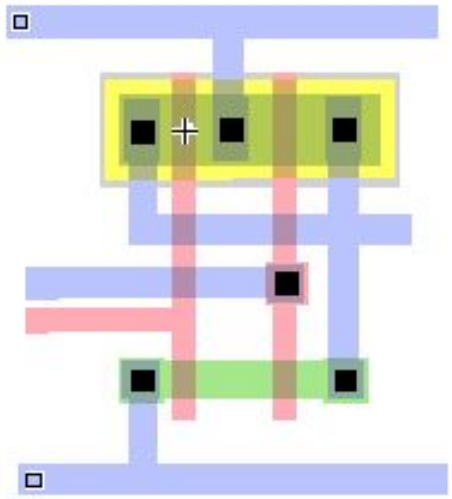
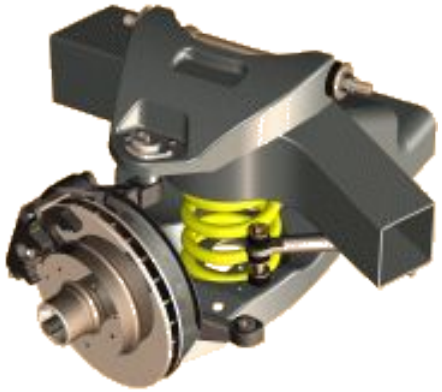
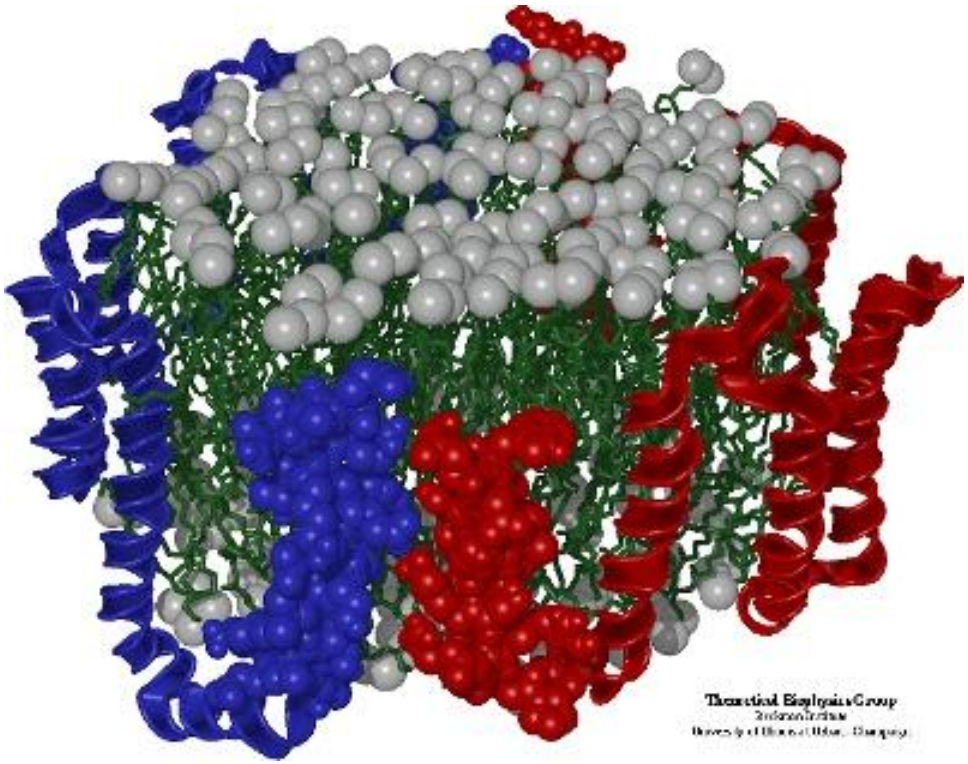
Medical Imaging is another driving force

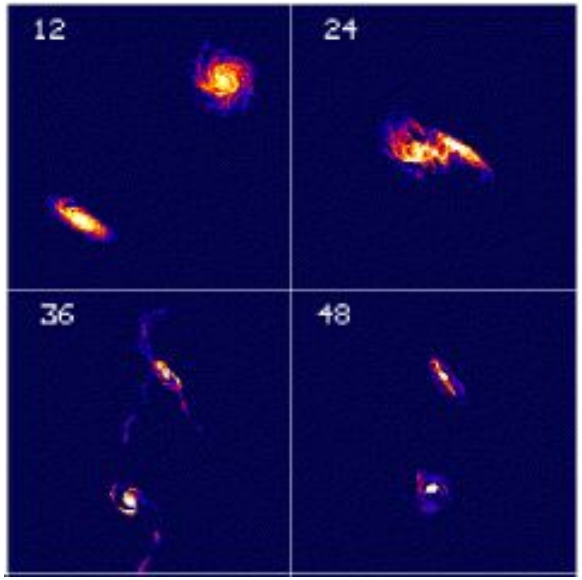
Computer Aided Design too





Scientific Visualisation





What's this course all about?

We will cover…

- Graphics programming and algorithms
- Graphics data structures
- Colour
- Applied geometry, modelling and rendering

First Lecture

Some definitions

Fundamental units we use in these processes

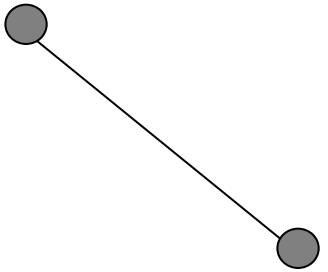
Summary of this course

describing through the graphics pipeline

Graphics Definitions

Point

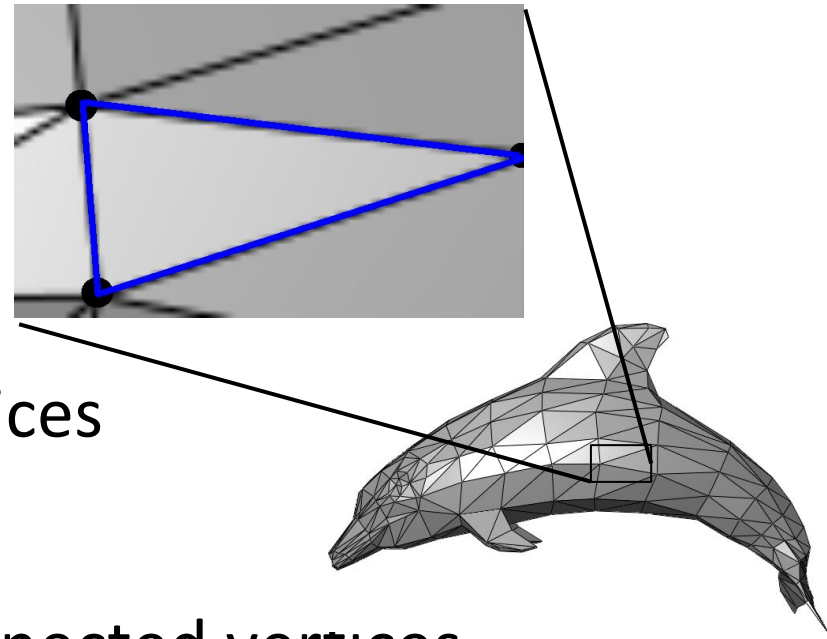
- a location in space, 2D or 3D
- sometimes denotes one pixel



Line

- straight path connecting two points
- infinitesimal width, consistent density
- beginning and end on points

Graphics Definitions

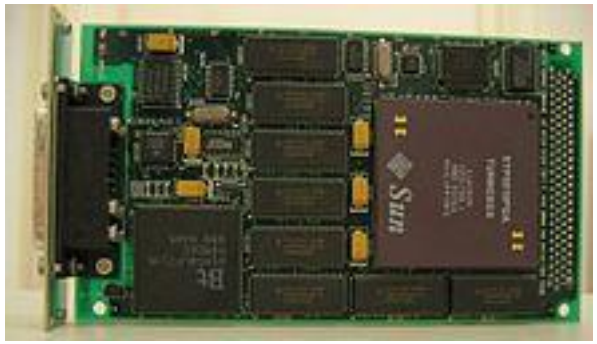


- Vertex
  - point in 3D
- Edge
  - line in 3D connecting two vertices
- Polygon/Face/Facet
  - arbitrary shape formed by connected vertices
  - fundamental unit of 3D computer graphics
- Mesh
  - set of connected polygons forming a surface (or object)
- :

Graphics Definitions

Rendering : process of generating an image from the model

Framebuffer : a video output device that drives a video display from a memory containing the color for every pixel



Overview of the Course

- Graphics Pipeline (Today)
  - (Local lighting effects) Illumination, lighting, shading, mirroring, shadowing
  - Rasterization (creating the image using the 3D scene)
- Ray tracing
- Global illumination
- Modelling
  - Curves and Surfaces

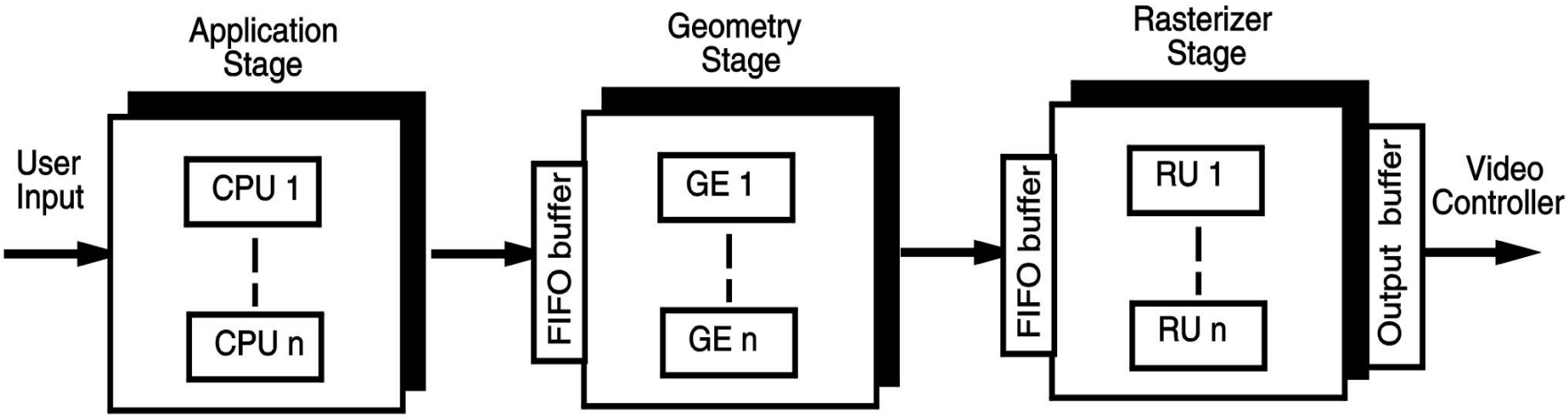
Graphics/Rendering Pipeline

- Graphics processes generally execute sequentially
- Pipelining the process means dividing it into stages
- Especially when rendering in **real-time**, different hardware resources are assigned for each stage

Graphics / Rendering Pipeline

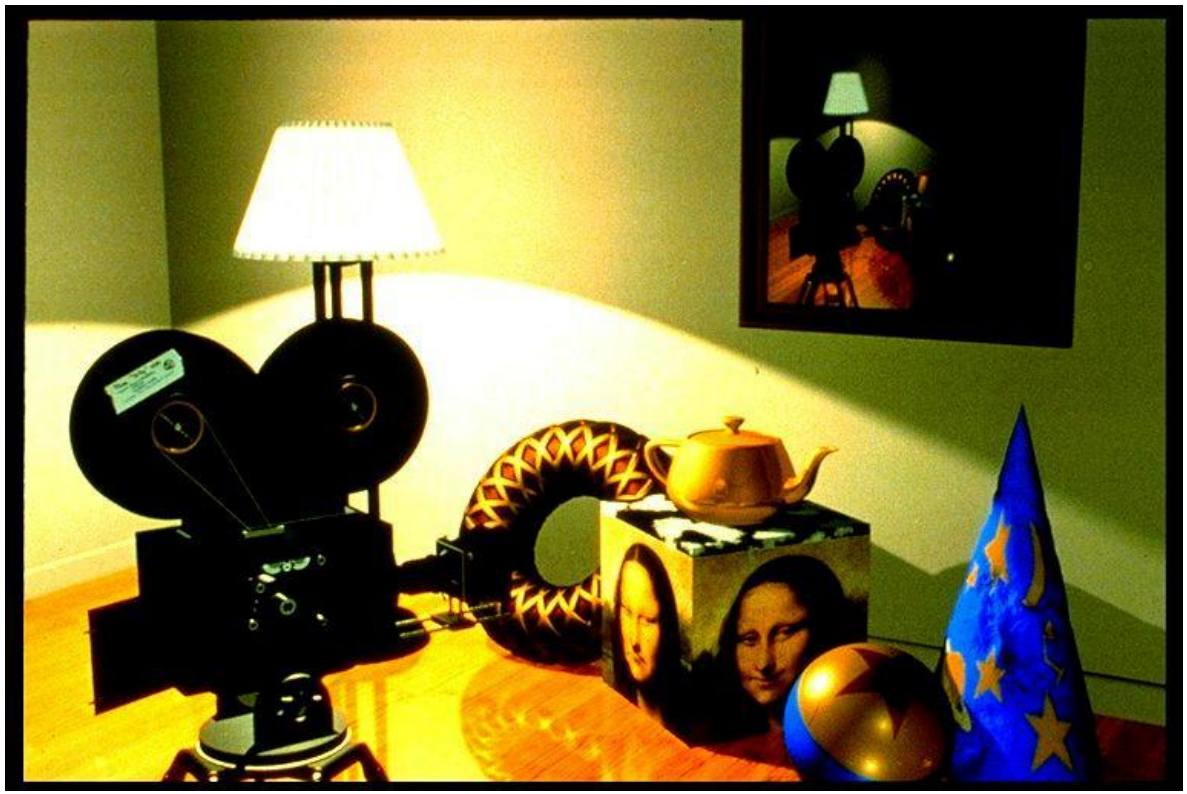
There are three stages

- Application Stage
- Geometry Stage
- Rasterization Stage



An example through the pipeline…

The scene we are trying to represent:



Application Stage

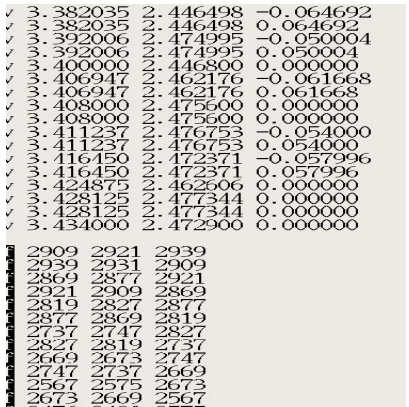
Entirely done in software by the CPU

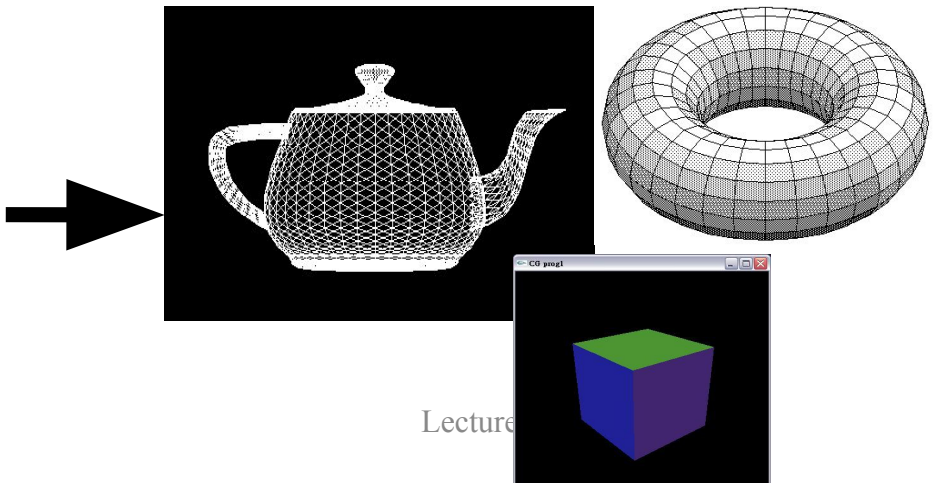
- Read Data

  Load the geometry of the scene,

  User's input by mice, trackballs, trackers, or sensing gloves

- In response to the user's input, the application stage change the view or scene

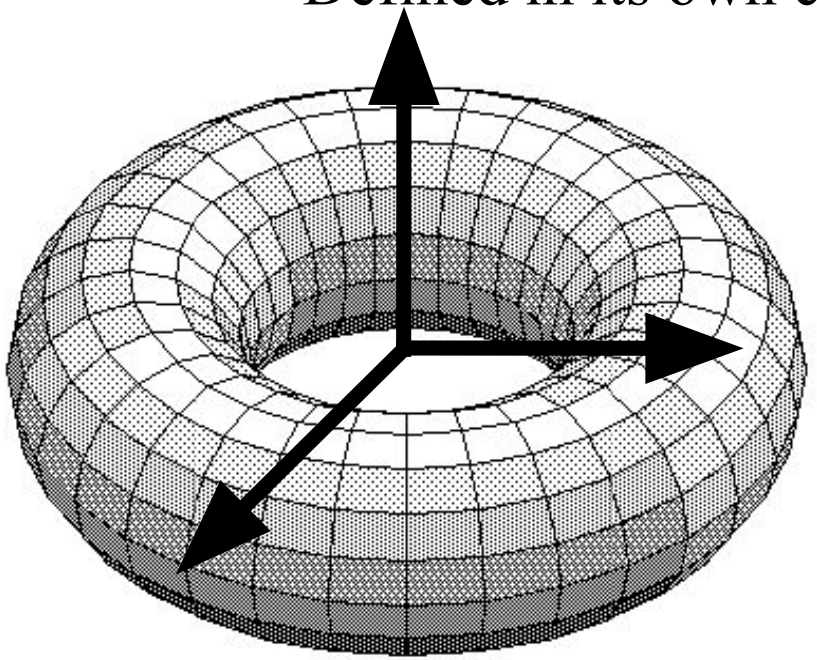


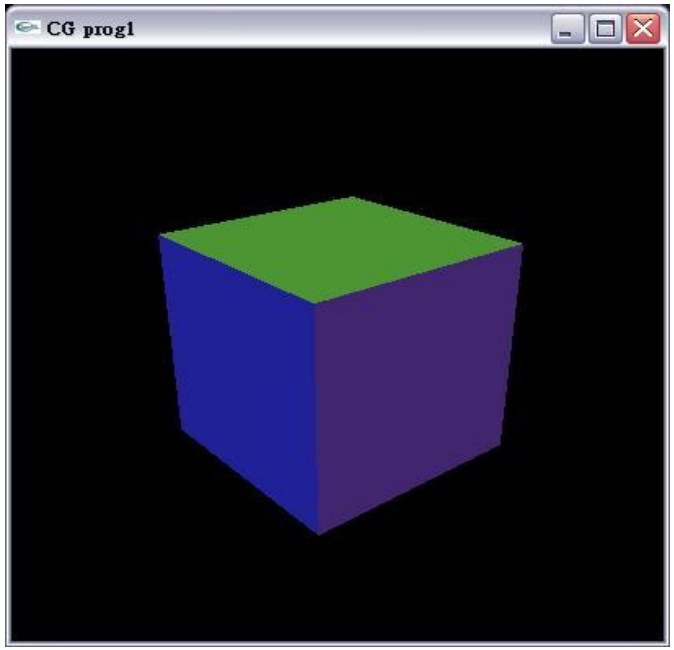


3D Shape Models

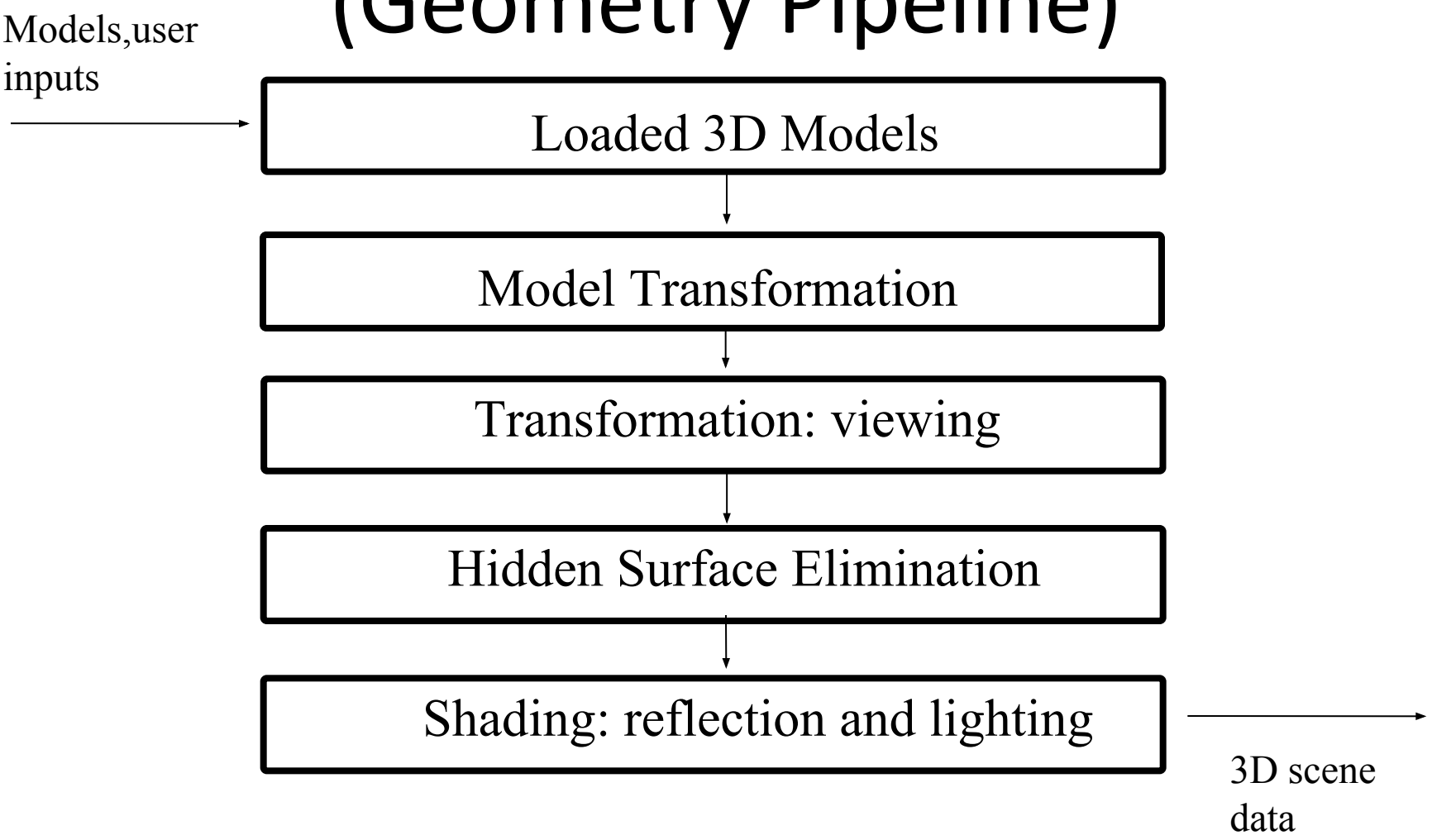
Designed by polygons, parametric curves/surfaces, implicit surfaces and etc.

Defined in its own coordinate system





Geometry Stage (Geometry Pipeline)

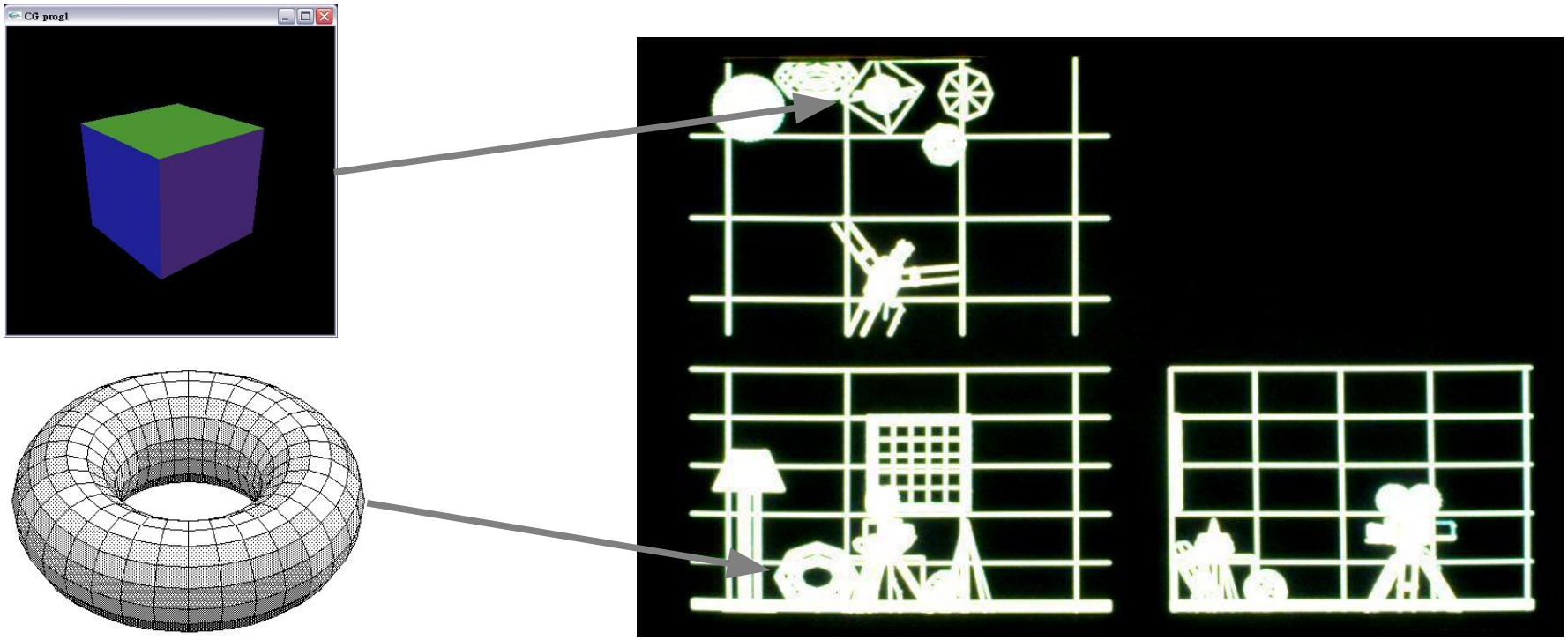


Model Transformation

Objects put into the scene by applying translation, scaling and rotation

Linear transformation called homogeneous transformation is used

The location of all the vertices are updated by this transformation

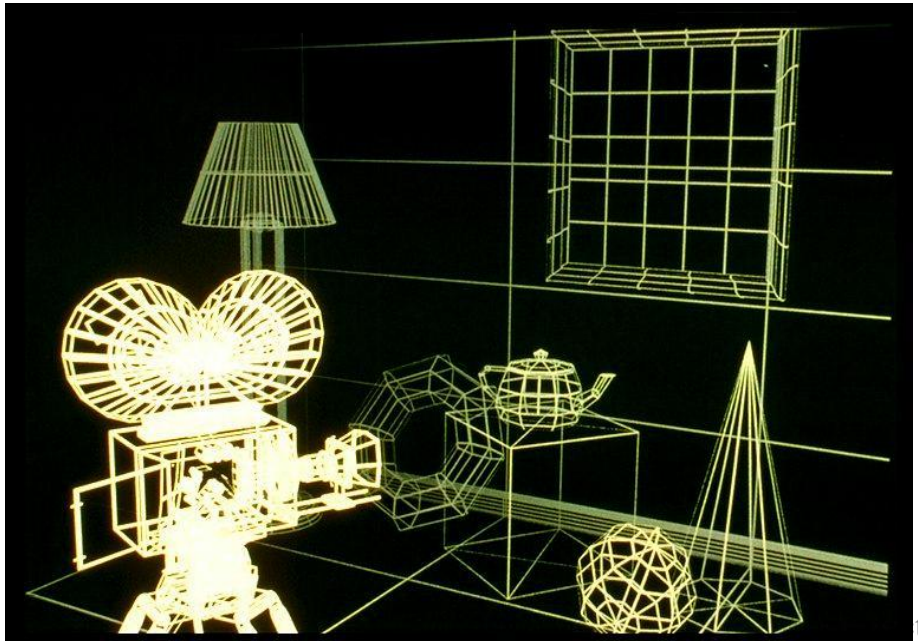


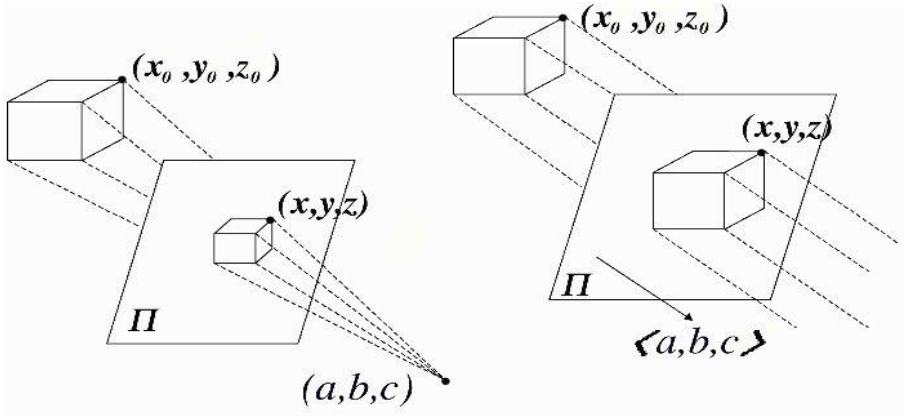
Perspective Projection

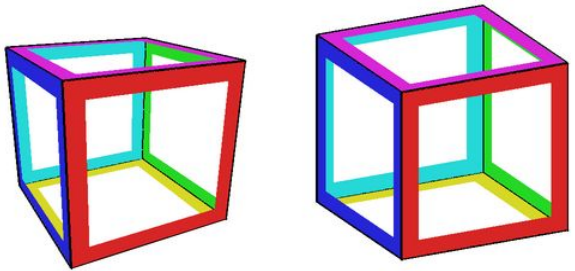
We want to create a picture of the scene viewed from the camera

We apply a perspective transformation to convert the 3D coordinates to 2D coordinates of the screen

Objects far away appear smaller, closer objects appear bigger

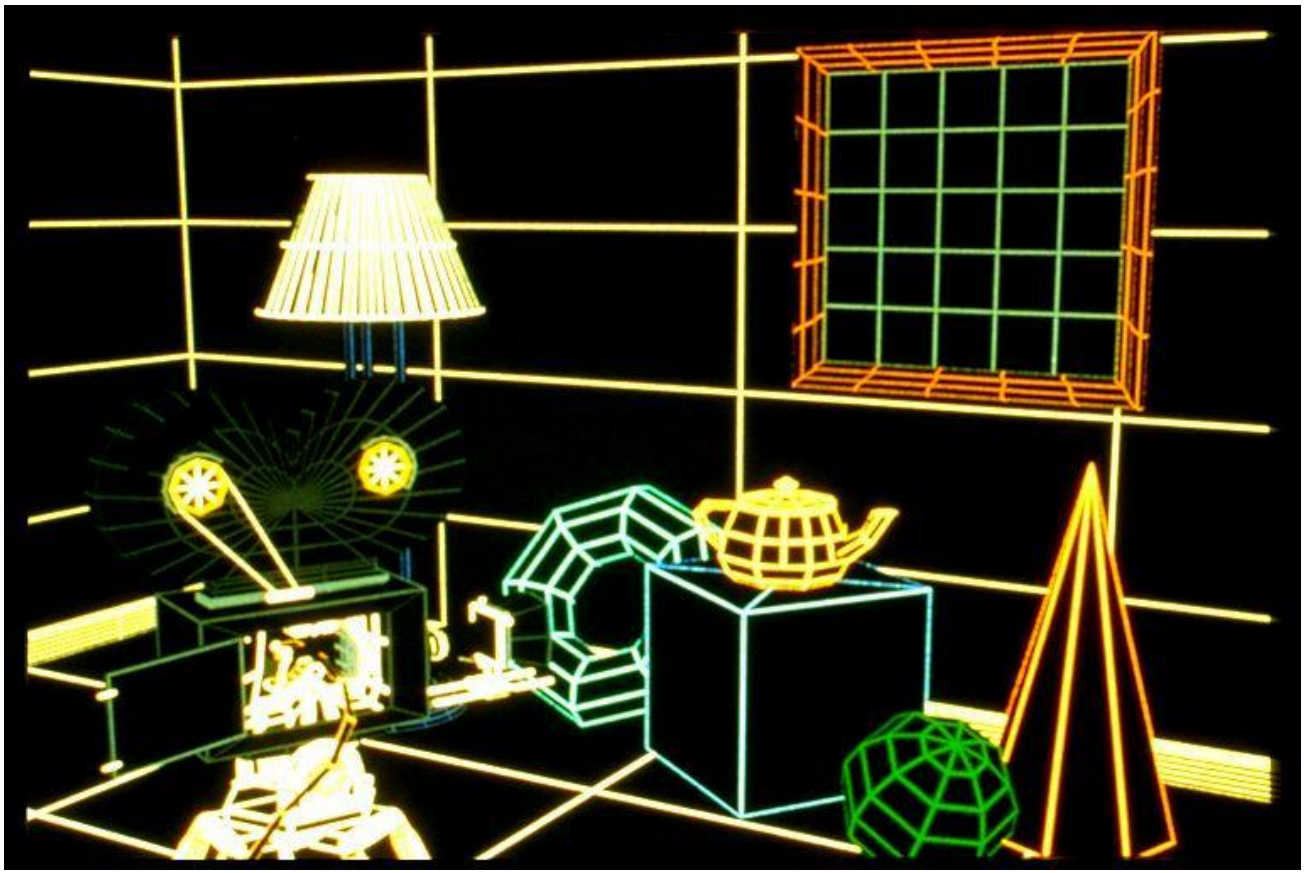






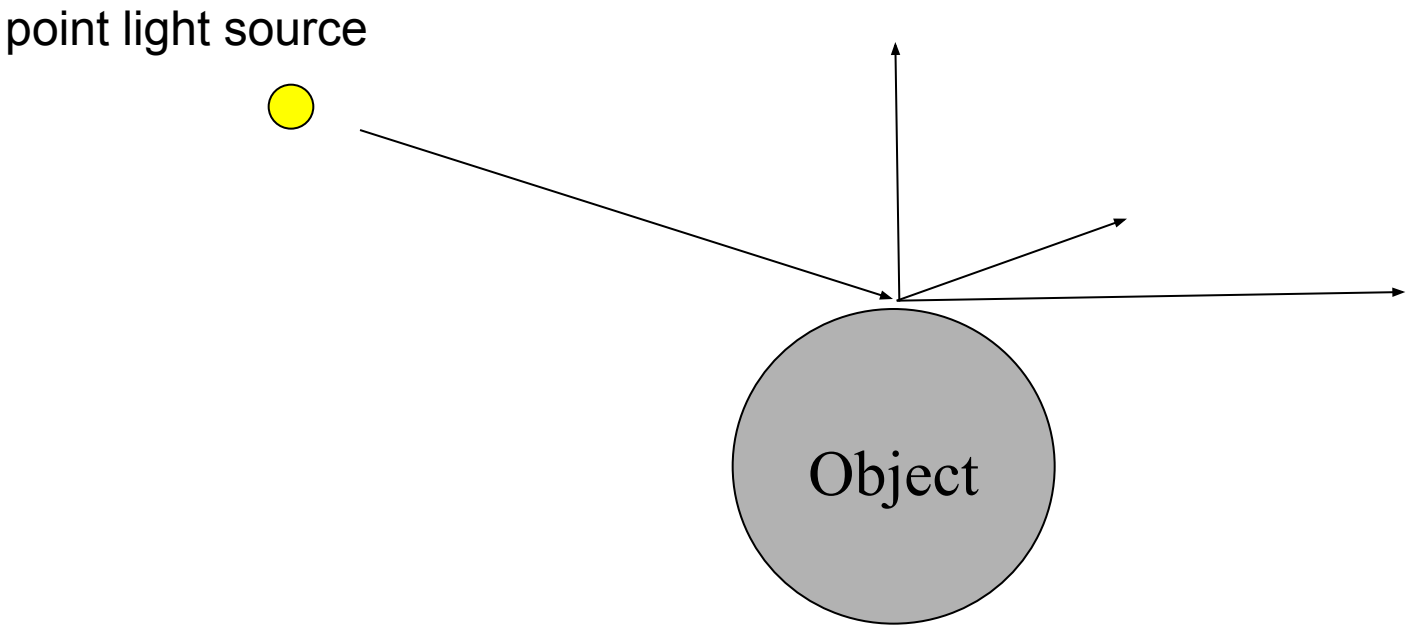
Hidden Surface Removal

Objects occluded by other objects must not be drawn



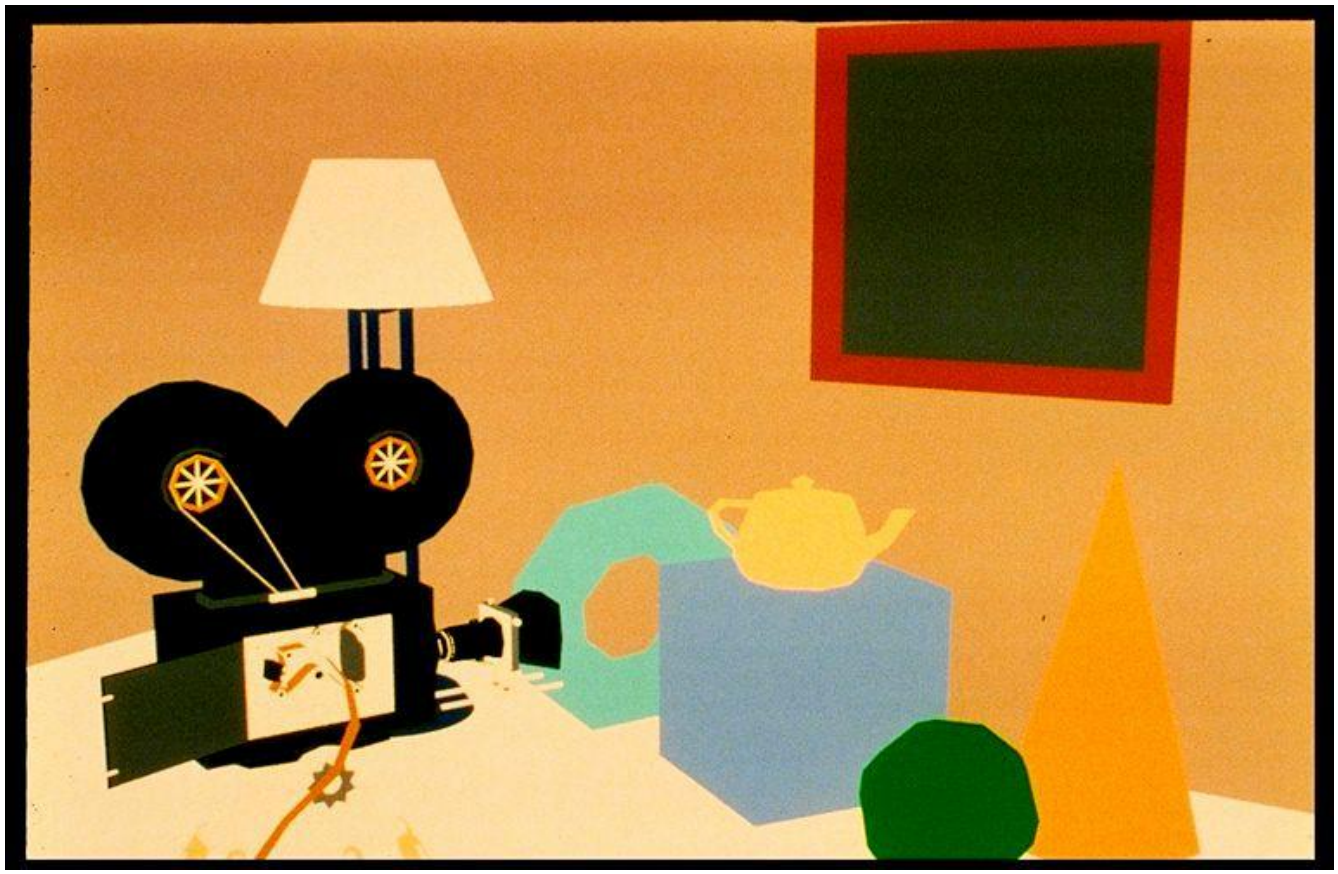
Shading

Now we need to decide the colour of each pixels taking into account the object's colour, lighting condition and the camera position



Shading : Constant Shading - Ambient

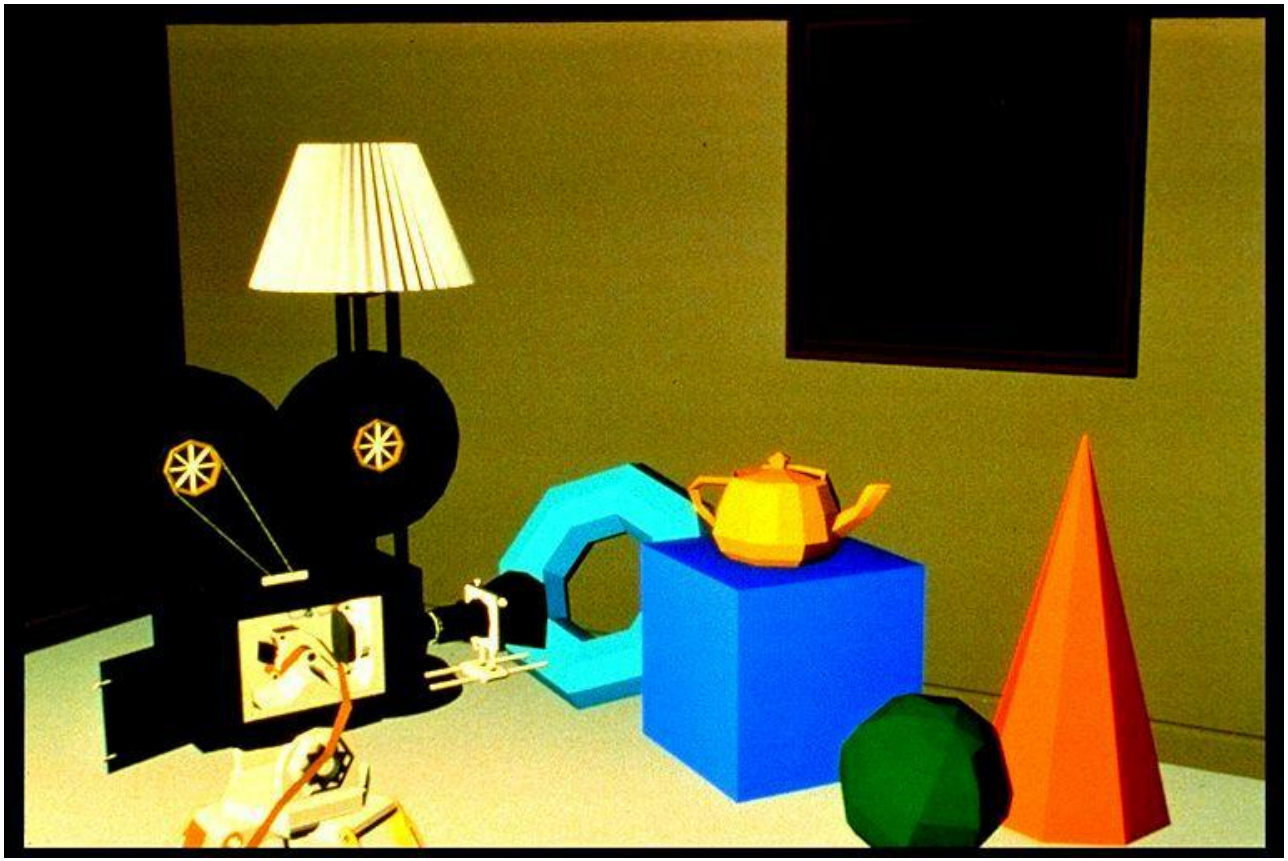
Objects colours by its own colour



Shading – Flat Shading

Objects coloured based on its own colour and the lighting condition

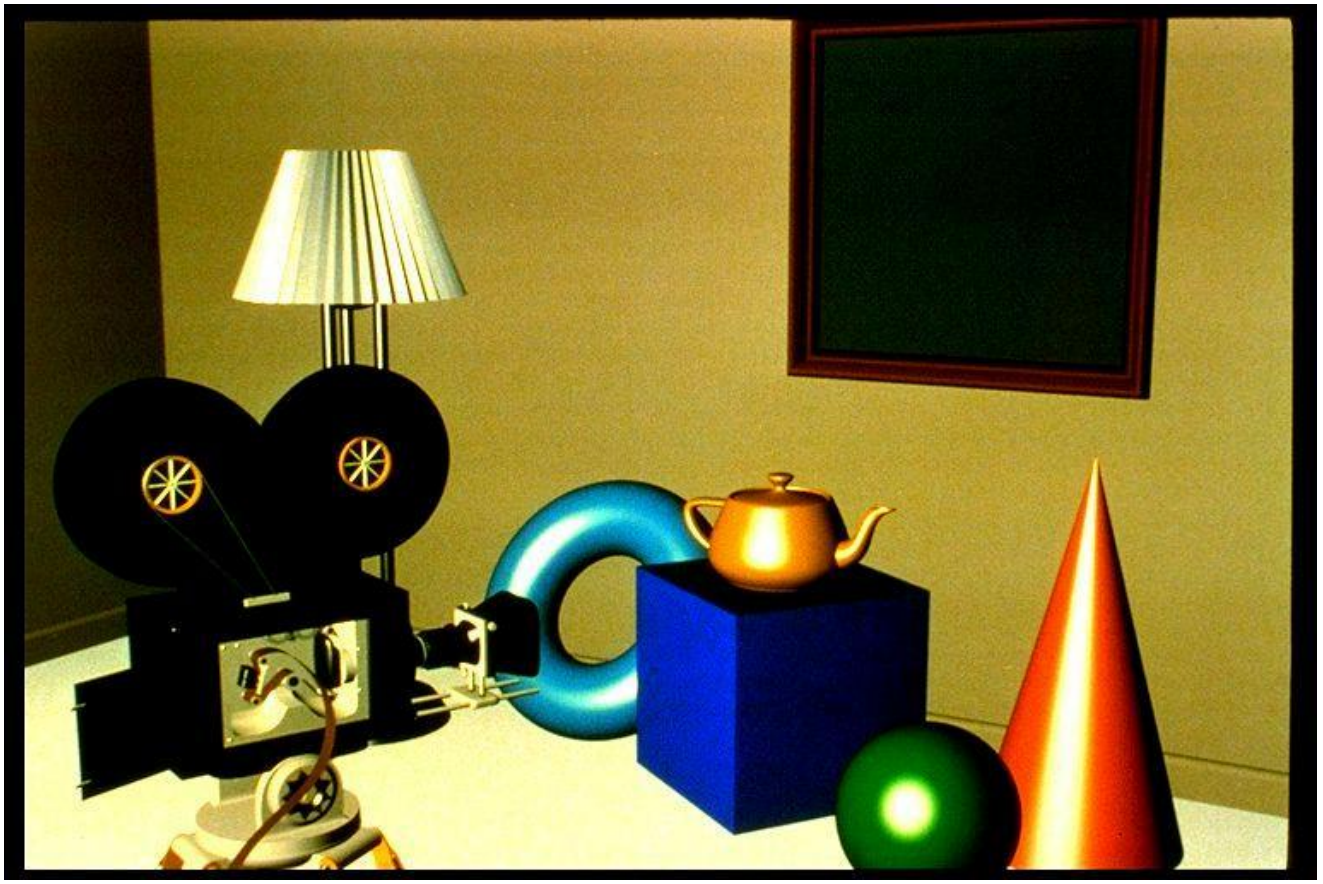
One colour for one face



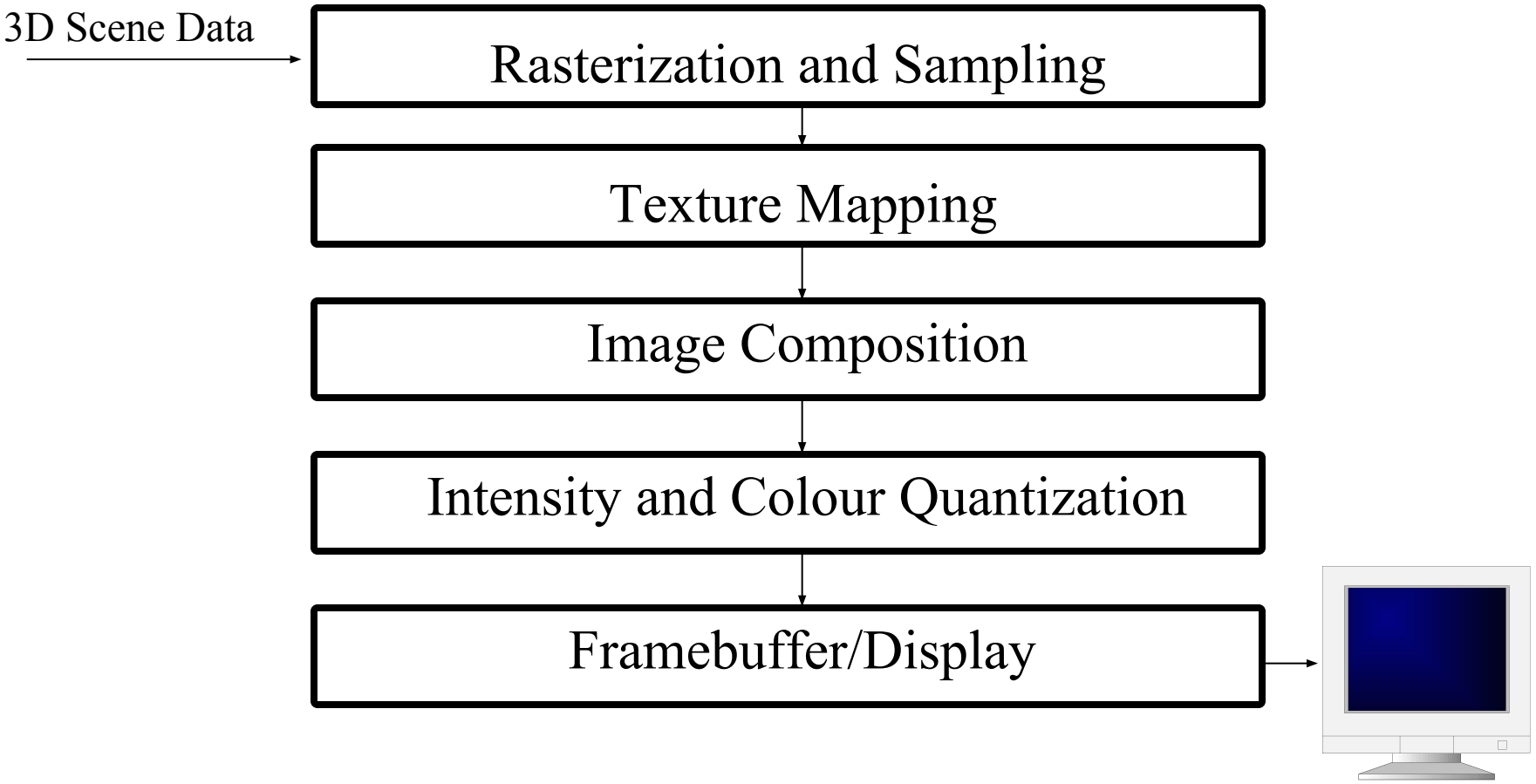
Gouraud shading, no specular highlights

Lighting calculation per vertex

Specular highlights added

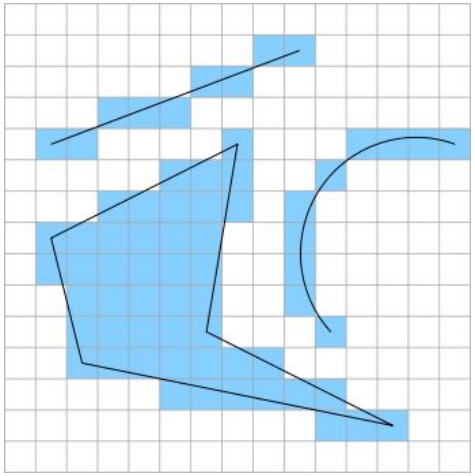


Rasterization Stage (imaging pipeline)



Rasterization

- Converts the vertex information output by the geometry pipeline into pixel information needed by the video display
- Aliasing: distortion artifacts produced when representing a high-resolution signal at a lower resolution.
- Anti-aliasing : technique to remove aliasing



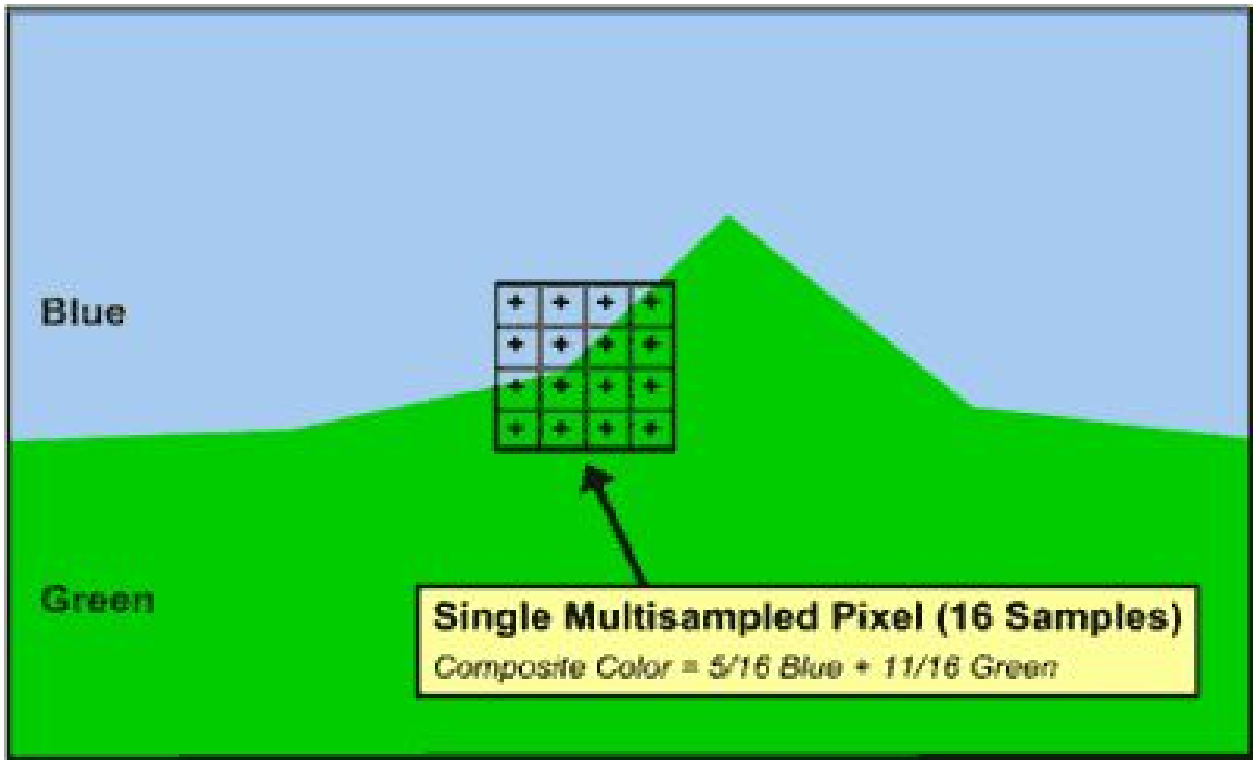
Anti-aliasing

Aliased polygons (jagged edges)

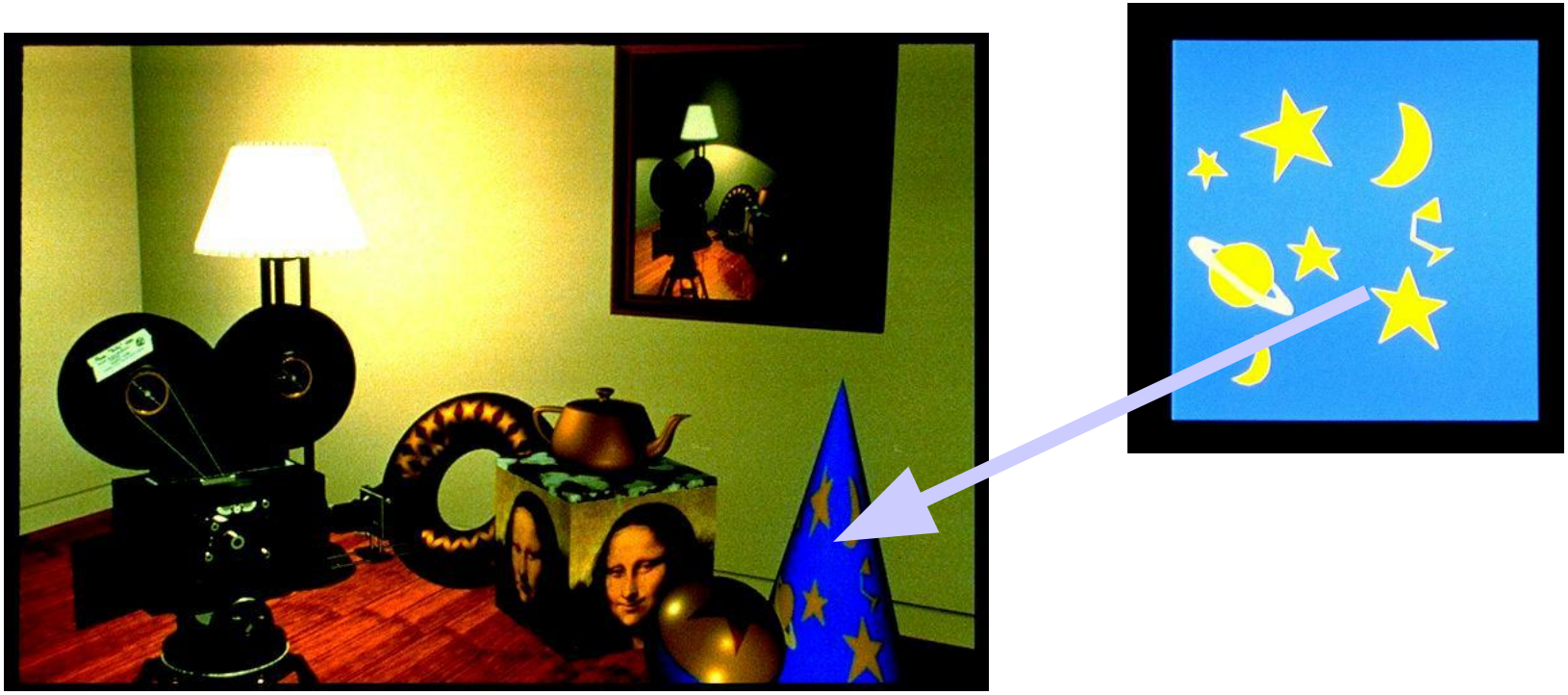
Anti-aliased polygons

✓**How is *anti-aliasing* done? Each pixel is subdivided (sub-sampled) in n regions, and each sub-pixel has a color;**

✓**Compute the average color value**



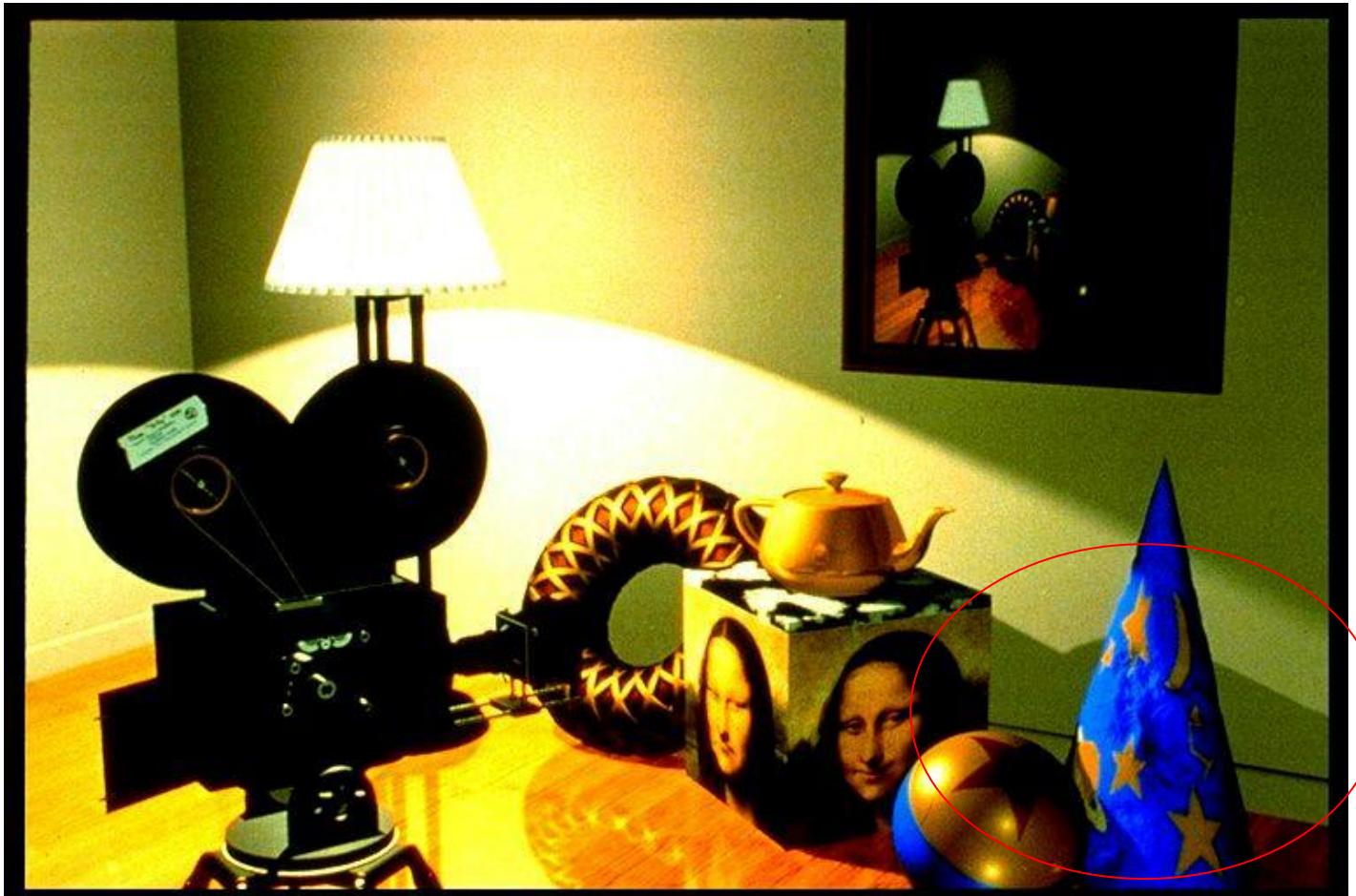
Texture mapping



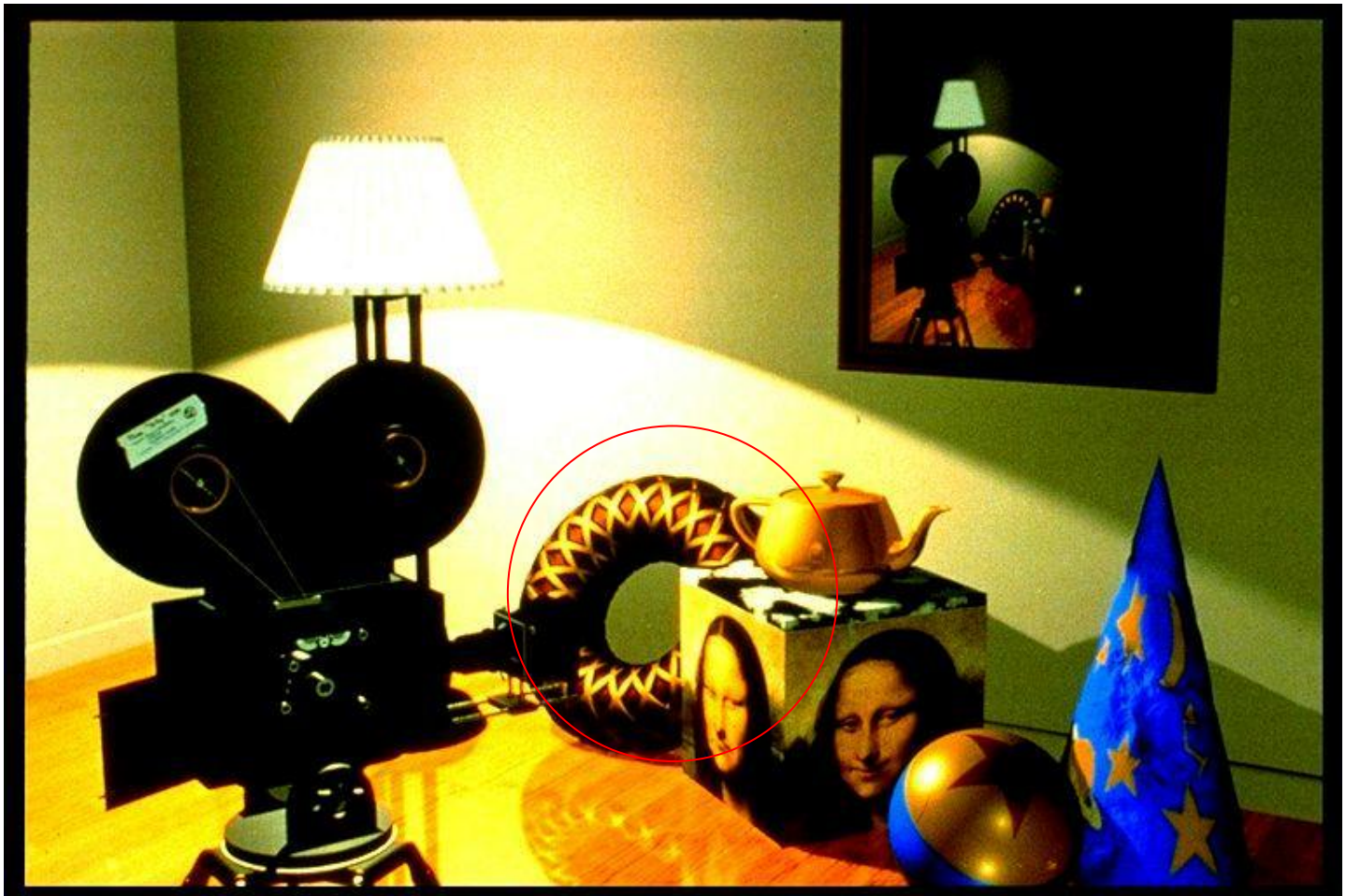
Other covered topics:
Reflections, shadows, bump mapping

Other covered topics: Reflections

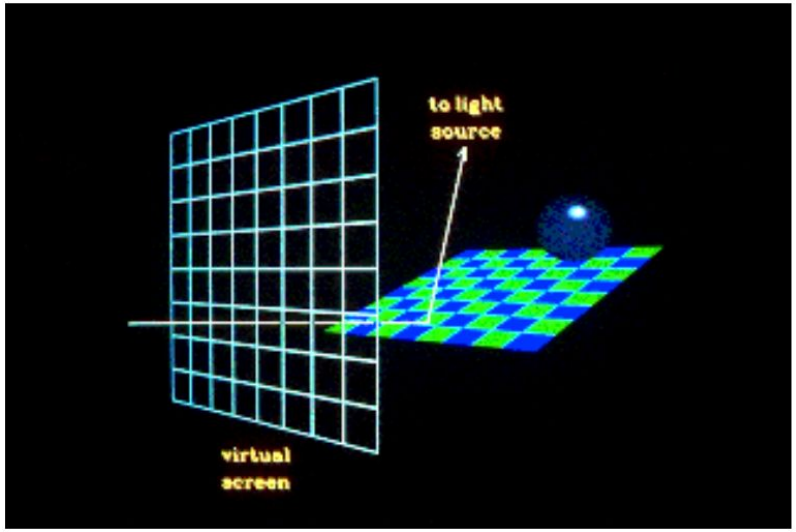
Other covered topics:
Shadows

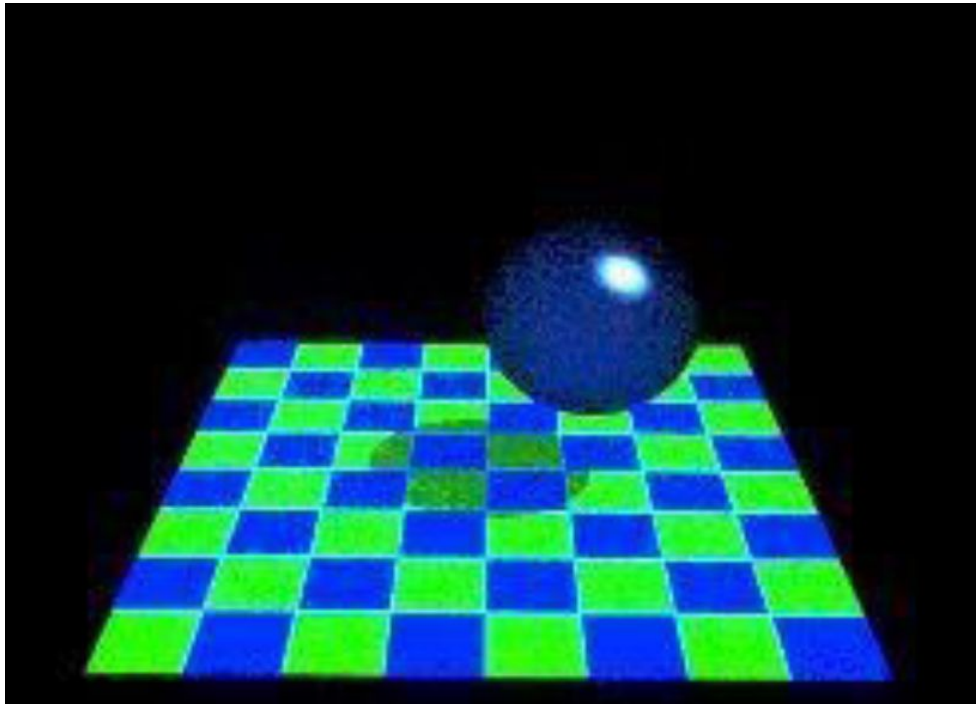


Other covered topics:
Bump mapping



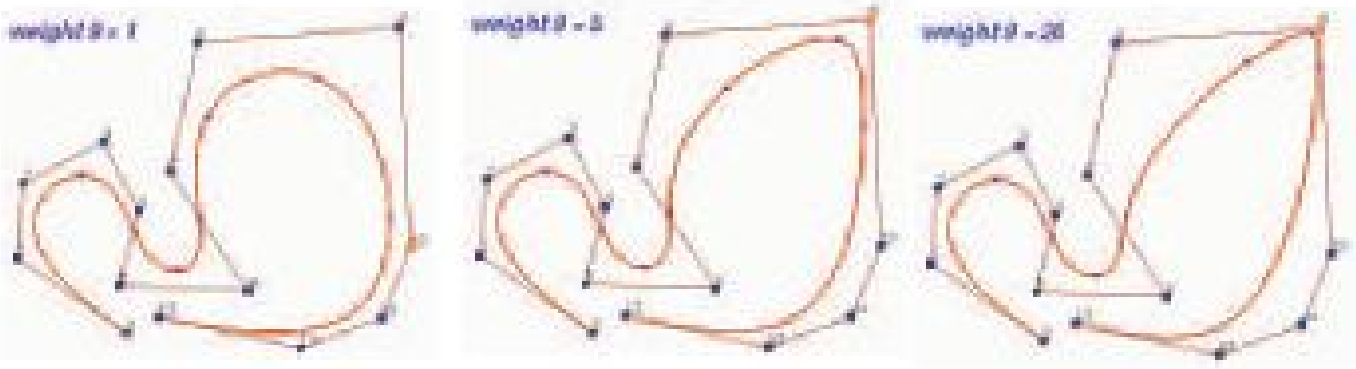
Other covered topics:
Ray Tracing

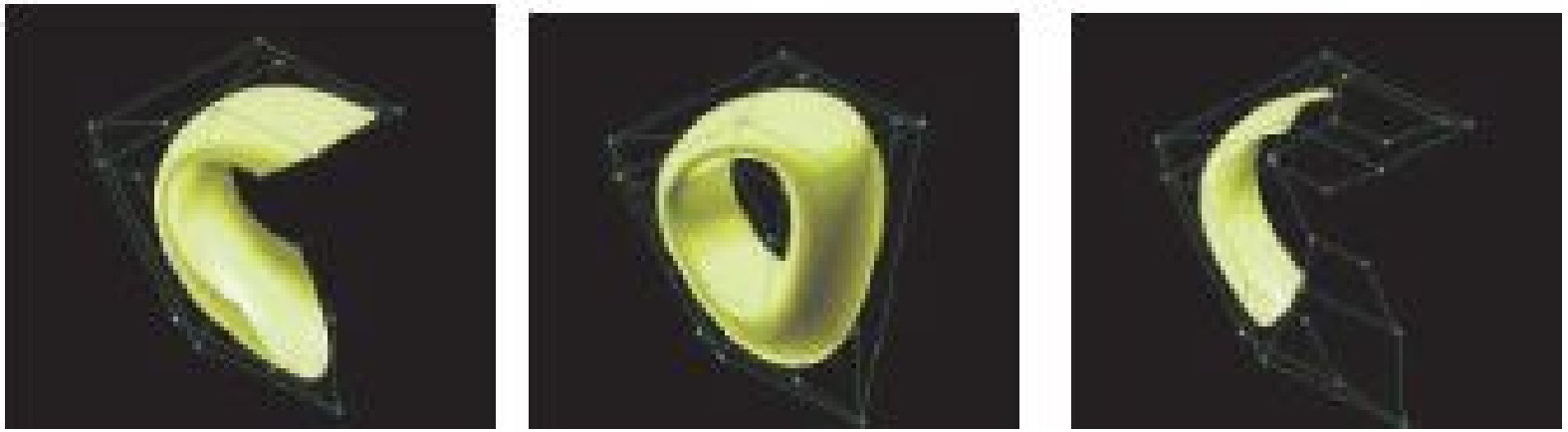




Other covered topics: Global Illumination

Polynomial Curves, Surfaces





Course support resources

Graphics course website

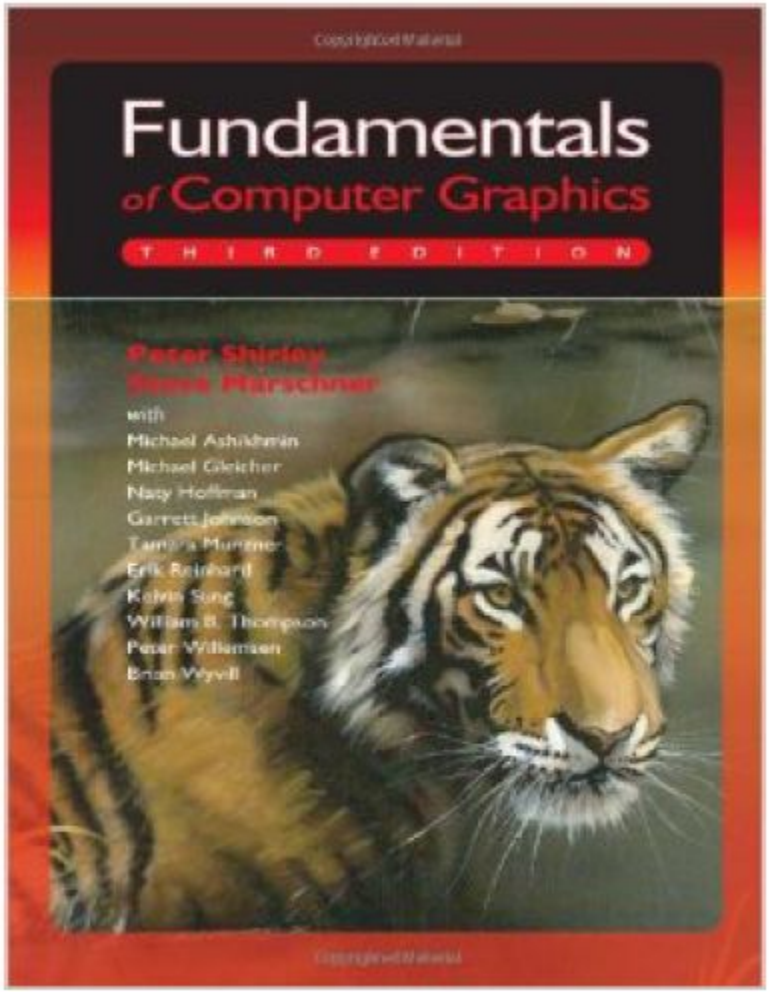
http://www.inf.ed.ac.uk/teaching/courses/cg

- lecture material,
- recommended reading,
- Links to support material for lectures and projects,
- Practical description and resources

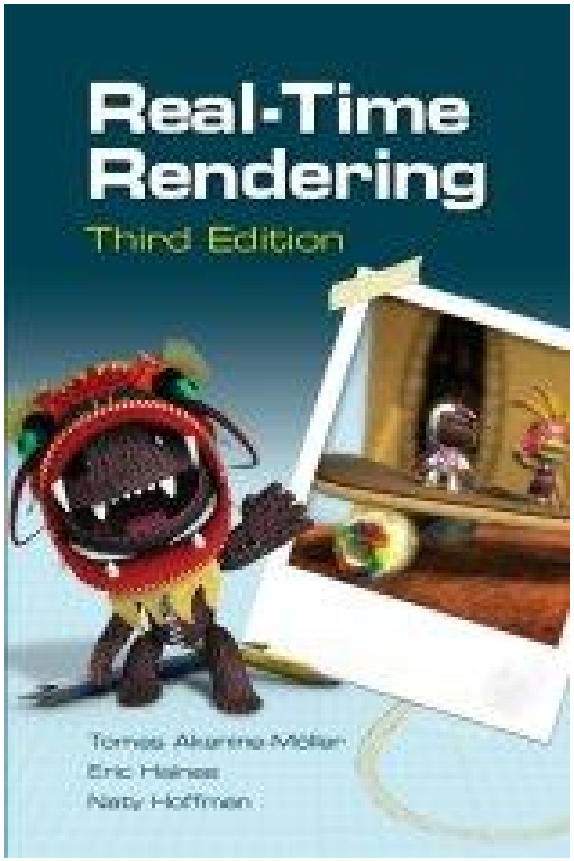
Some notifications

- 16 lectures in total
- 2 practicals
- Some tutorials (probably two) about the practicals

Books



Fundamentals of Computer Graphics
Shirley and Marschner, CRC Press, 2010.
Available online via the library



Tomas Akenine-Möller, Eric Haines, and Naty Hoffman, 1045 pages, from A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7, 2008,

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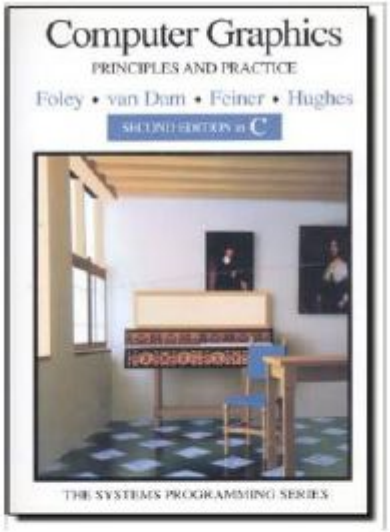
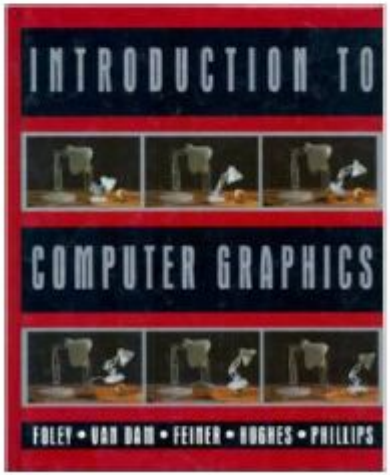


Computer Graphics Principles and Practice
Foley, van Dam, Feiner and Hughes, Addison Wesley, 1997.



Introduction to Computer Graphics
Foley, van Dam, Feiner, Hughes and Phillips, Addison Wesley, 1995.

Summary

The course is about algorithms, **NOT** applications

- Lots of mathematics

Graphics execution is a pipelined approach

Basic definitions presented

Some support resources indicated