Computer Graphics
3080, GV10

Lecturers

- Jan Kautz, j.kautz@cs.ucl.ac.uk
- David Swapp, d.swapp@cs.ucl.ac.uk

Course information

- http://www.cs.ucl.ac.uk/staff/j.kautz/teaching/3080
- Mailing lists
  - You need to register to one of the mailing lists:
    - 3080@cs.ucl.ac.uk
    - gv10@cs.ucl.ac.uk
  - Information on how to register
    http://www.cs.ucl.ac.uk/teaching/coursemail.htm

Assessment

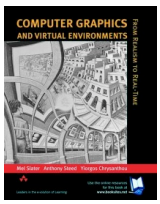
- Written Examination (2.5 hours, 75%)
- Coursework Section (2 pieces, 25%)

Timetable

- **Lecture Times**
  - Mondays, 10:00-11:00, Roberts 508
  - Thursdays, 11.00-13.00, Medawar Watson LT
- **Lab Times**
  - Friday 16:00-18:00, Malet Place Eng 1.21

Course Book

- The book supporting the lectures is
  - Computer Graphics And Virtual Environments - From Realism to Real-Time. Mel Slater, Yiorgos Chrysanthou, Anthony Steed, ISBN 0201-62420-6, Addison-Wesley, 2002.



Course content (1)

- *Introduction*
  - The painter's method
- *Creating an image using ray tracing*
  - Ray casting using a simple camera
  - Local illumination
  - Global illumination with recursive ray tracing
- *Specifying a general camera*
  - World / image coordinates
  - Creation of an arbitrary camera
  - Ray tracing with an arbitrary camera

Course content (2)

- *Constructing a scene*
  - Definition of polyhedra
  - Scene hierarchy
  - Transformations of objects / rays
  - Other modelling techniques
- *From ray tracing to projecting polygons*
  - Transforming the polygons to image space
  - Sutherland-Hodgman clipping
  - Weiler-Atherton clipping

Course content (3)

- *Polygon rasterization /Visible surface determination*
  - Scan conversion
  - Z-buffer
  - Interpolated shading
  - Texture mapping

Introduction to 3D Graphics

Lecture 1: Illusions and the Fine Art of Approximation

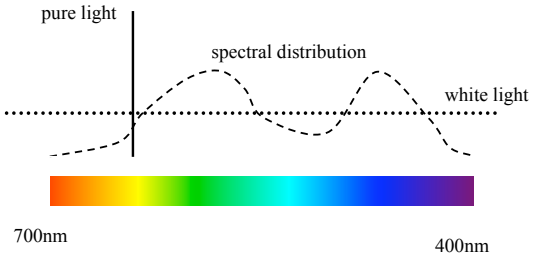
Outline

- Anatomy of an Illusion
  - Environment
  - Light transport and interaction
  - Reception at the eye
- The Painter's Method
  - Ray-casting
  - Approximations

Environment

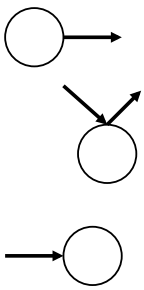
- A description of a space consisting of *objects*
- Objects have *description* and *state*
- Description consists of *behaviour*, *geometry* and *appearance*
- Geometry must be described relative to a *co-ordinate frame*
- State defines the object at a particular moment in time

Radiometry - How does light propagate in the real world?



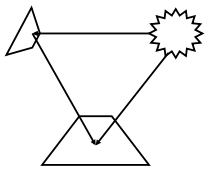
Life and Death of a Photon

- Emission
- Reflection
- Absorption



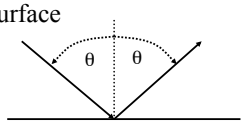
Lighting is a Global Problem

- That is, if you consider any point in the environment, it receives light from all around

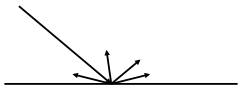


Surfaces are Rarely Mirrors

- Specular surface



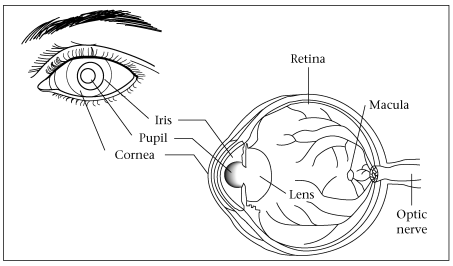
- Diffuse Surface



Some Simplifying Assumptions

- Wavelength independence
  - No fluorescence
- Time invariance
  - No phosphorescence
- Light transport in a vacuum
  - No participating media
- Objects are isotropic
  - Reflectance characteristics are constant over the surface

Photometry - How do we see light?



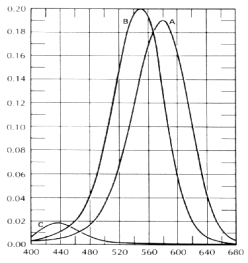
Physiology of Eye Response

- 6 million cones in the fovea
  - cones sense red green or blue light
  - colour perception region is very small
- 120 million rods over the whole eye
  - peripheral vision
  - motion sensitive

Colour Response

Cones

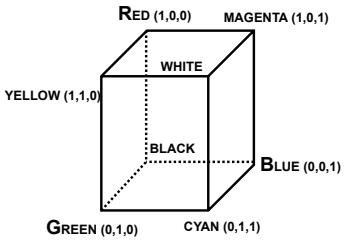
- A = “Red”
- B = “Green”
- C = “Blue”



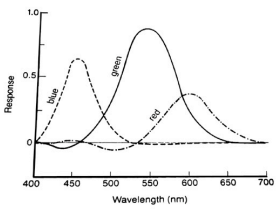
Assumption for Real-Time Graphics

- Ignore "real" spectral distributions
- Instead calculate at three wavelengths, Red, Green and Blue that monitors provide
- Obviously this is a gross approximation
  - Really should find the spectrum for each point calculate the closest RGB value

RGB Colour Model



Colour Matching

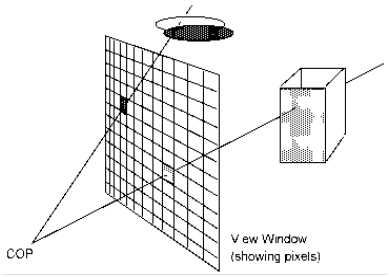


How much R,G,B do you need to make a particular "pure" colour?

Outline

- About the Course
- Anatomy of an Illusion
  - Environment
  - Light transport and interaction
  - Reception at the eye
- The Painter's Method
  - Ray-casting
  - Approximations

Painting Through a Window



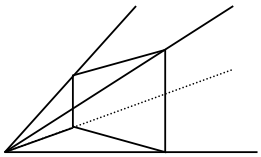
COP = Centre of Projection

Major Concepts of Graphics

- Separation of Scene Specification, Viewing and Rendering
  - Scene is modelled independent of any view
  - Views are unconstrained
  - There are many possible rendering methods given a scene and a view

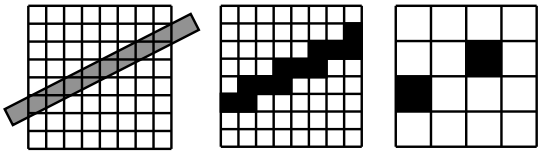
Major Concepts of Graphics

- View volume
  - The extent of the pixels on the screen and the COP define a pyramid
  - *Clipping* is the process of removing anything from the scene that is not in the view volume



Major Concepts of Graphics

- Aliasing
  - Pixels are square and only *sample* the actual light

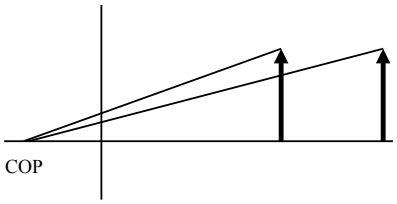


Combating Aliasing

- Send several rays through each pixel
  - Stochastic sample
  - Regular sample (full-screen anti-aliasing)
- Stochastic sample is “correct” since it removes regularity
- But only regular sample is easy with the rendering pipeline

Major Concepts of Graphics

- Perspective Projection
  - Image size depends on distance



Major Concepts of Graphics

- Lighting
  - Ray-casting is the simple part
  - Determining the colour of the pixel is hard for all the reasons described earlier
  - Theoretically we have to calculate all incoming light
  - In practice we will consider only *local illumination* - light received directly from light sources

Summary

- Taken a brief look at the general problem of doing visual simulation
- Reviewed the limits of human response
- Given an over-view of the simulation process and the concepts of
  - Scene, view, rendering
  - Aliasing
  - Projection
  - Lighting

Future Work

- To Develop
  - Mathematics of scene description
  - Geometric descriptions
  - Lighting models
  - Move from ray-cast to forward projection
    - Stages in the graphics pipeline