CSCE565: Computer Graphics

Fall 2016

Prof. Yan Tong

Today's Agenda

Welcome.

Various administrative issues.

What is computer graphics?

What is this course about?

On This Course

Time and Place: MW 1:15PM-2:30PM, in SWGN 2A19

Instructor: *Yan Tong*,

SWGN 3A52,

777-0801 (Office),

tongy@cec.sc.edu

Office Hour: MW 10:00AM-11:00AM,

Course Webpage:
http://www.cse.sc.edu/~tongy/csce565/csce565.html

Class Communication

Class website

http://www.cse.sc.edu/~tongy/csce565/csce565.html

Department dropbox

dropbox.cse.sc.edu

Check them regularly for

- important announcements related to this course
- some useful links and additional readings

On the Tentative Syllabus

See the distributed sheet for details

Grading Policy:

- A (90-100%)
- B+ (86-89%)
- B (80-85%)
- C+ (76-79%)
- C (70-75%)
- D+ (66-69%)
- D (60-65%)
- F (0-59%)
- Your scores on homework, projects, exams, etc. will be available to you at Department Dropbox when graded.

Your Grade Consists of

One in-class midterm exams (15 %)

Final exam (25%)

3~4 homework assignments (15%)

4~5 programming projects (35%)

Attendance (5%)

Quiz (5%)

Additional requirements in the homework, projects and/or exams to get graduate credits.

Notes: Attendance Grade

The total attendance score is 5

Attendance grade based on

- written quizzes in class
- my records from other sources (questioning, collecting or giving back homework, quizzes, or exams, etc.)

Absenting more than two classes, whether excused or unexcused, may result in the deduction points from the attendance score*.*

Homework and Projects

- **must be completed independently by yourself while peer discussion is encouraged**
- **there may be some team projects**
- **homework assignments are due at the beginning of the class and will be submitted either in departmental dropbox dropbox.cse.sc.edu or in class depending on the nature of the assignments**
- **Projects should be submitted in the departmental dropbox dropbox.cse.sc.edu**
  - evaluated (compiled, linked, and run) at the department Linux workstations
  - A list of linux machines https://www.cse.sc.edu/resources/workstations
- **without the special permission from the instructor, no late homework or project will be accepted**

Code of Student Academic Responsibility

Please check this for detailed requirements on academic integrity

the departmental chair emphasized this issue and required all the violation behavior will be reported to the department chair

Questions

The Nature of This Course

This is a computer science course

- substantial programming projects (in C++)
- a fair amount of math (esp. linear algebra)
- make sure you're prepared for this

This is a computer graphics course

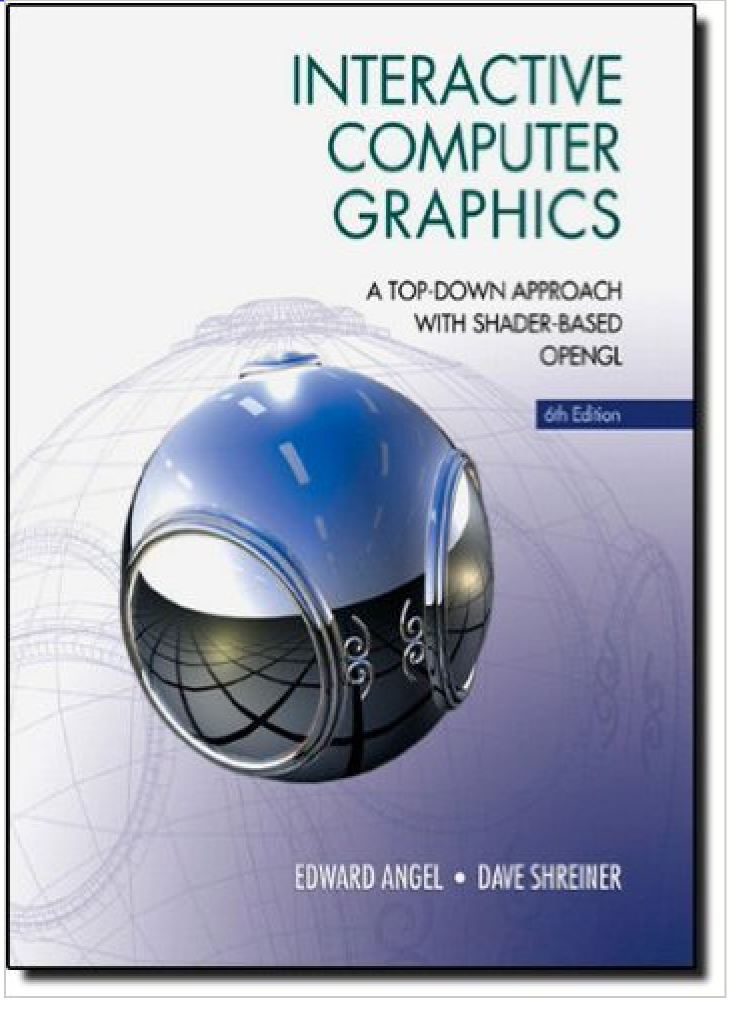
- projects are results-oriented — final images are key
- many projects are open problem – be imaginative
- and above all, it's cool and enjoy it

Required Textbook

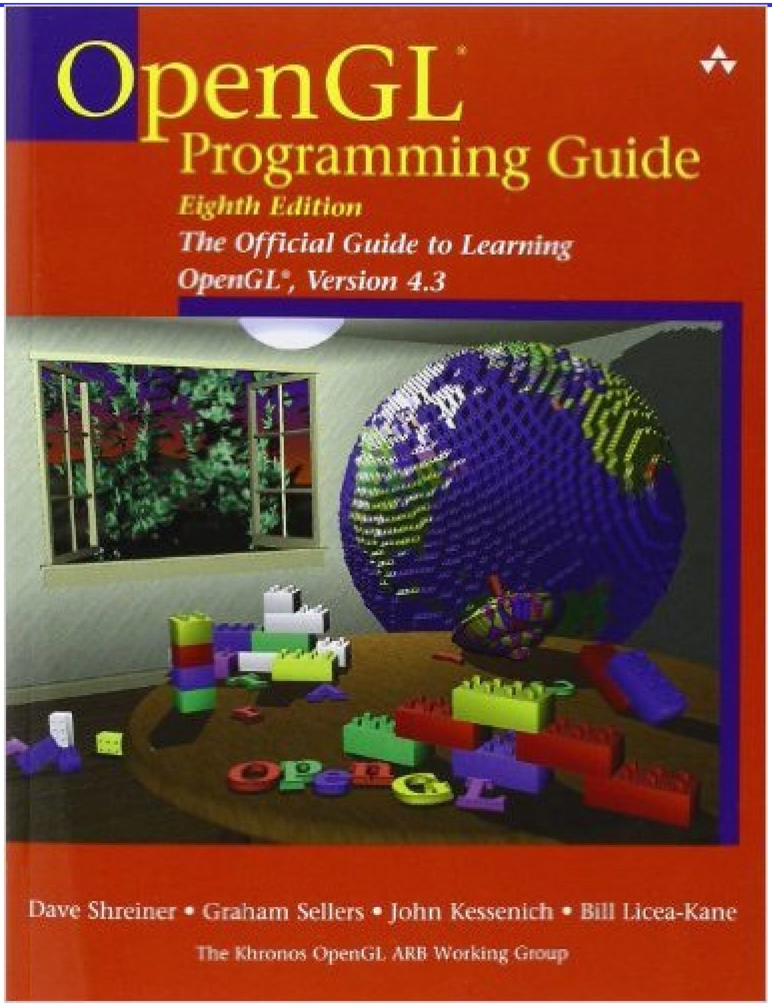
Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL (Sixth Edition)
Edward Angel and Dave Shreiner,
Pearson, 2011. **(required)**

Basic coverage of graphics

- try to cover most of materials
- may involve additional material not covered in this book
- some readings in this book



Required Textbook



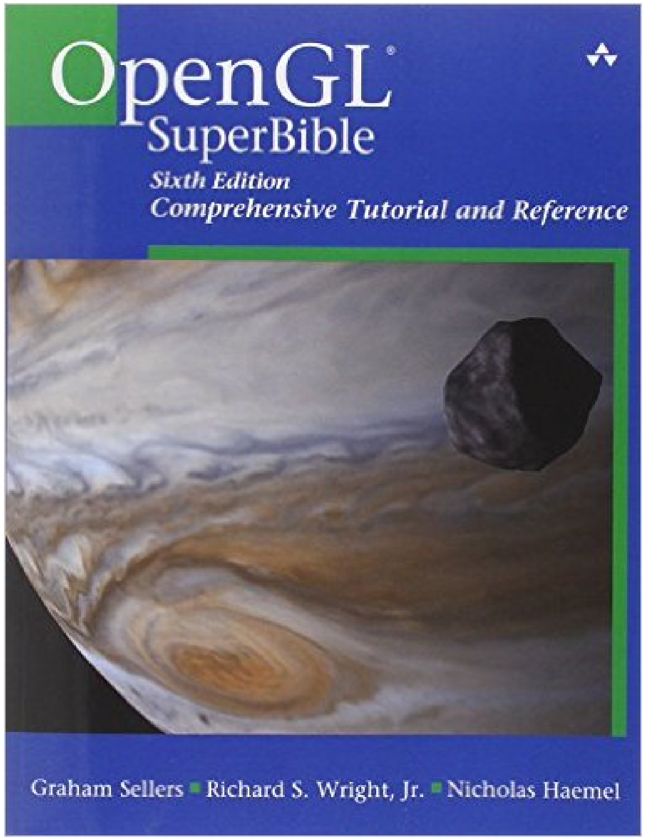
Will use OpenGL in all projects.

This has a wealth of OpenGL information.

You will find it very helpful.

Useful

OpenGL SuperBible: Comprehensive Tutorial and Reference (6th Edition)

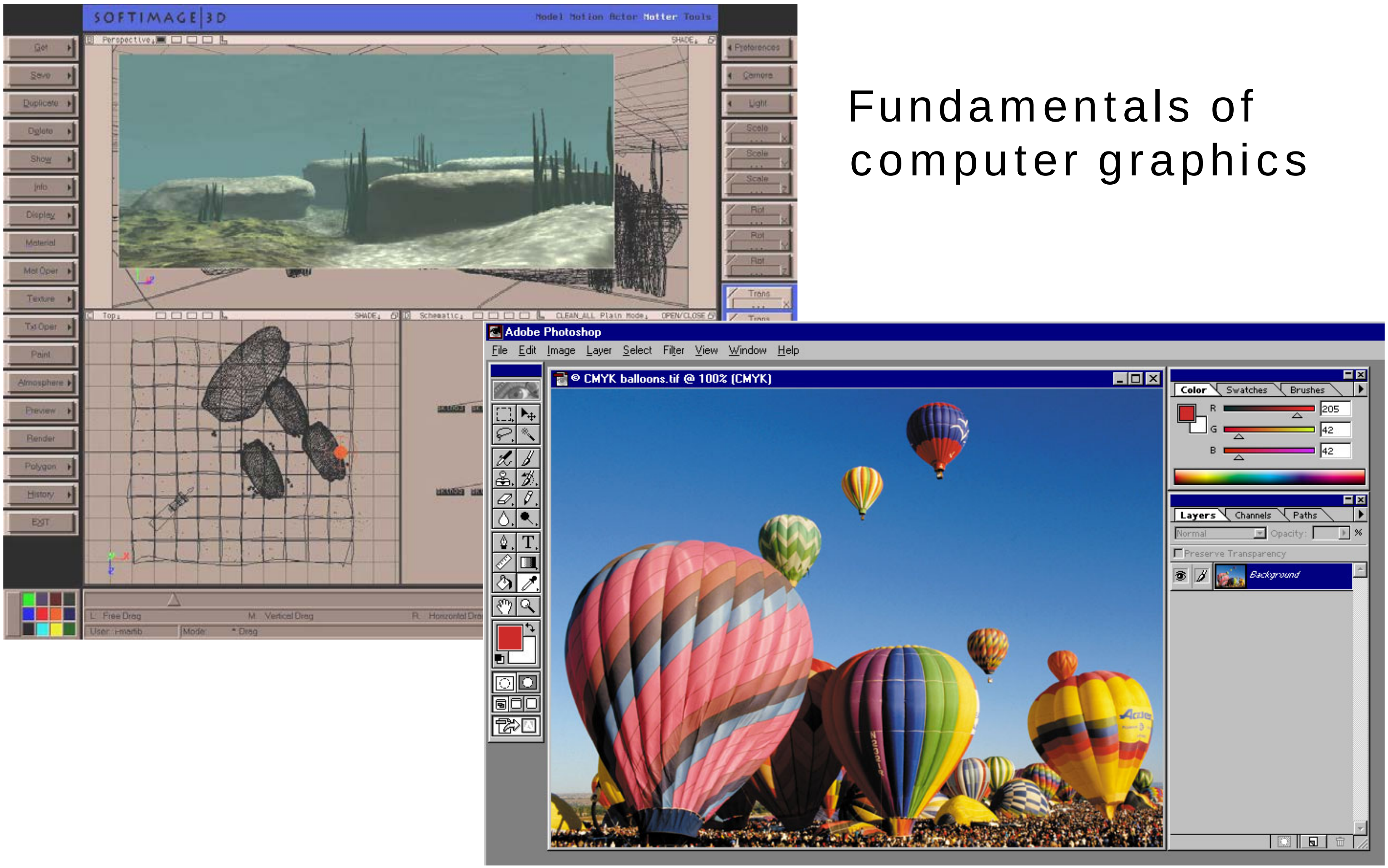


Online OpenGL API Documentation

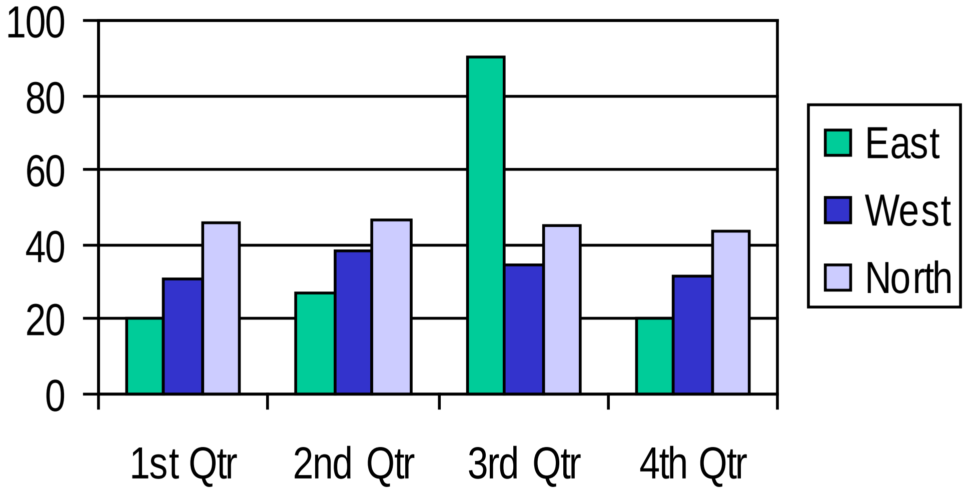
https://www.opengl.org/documentation/

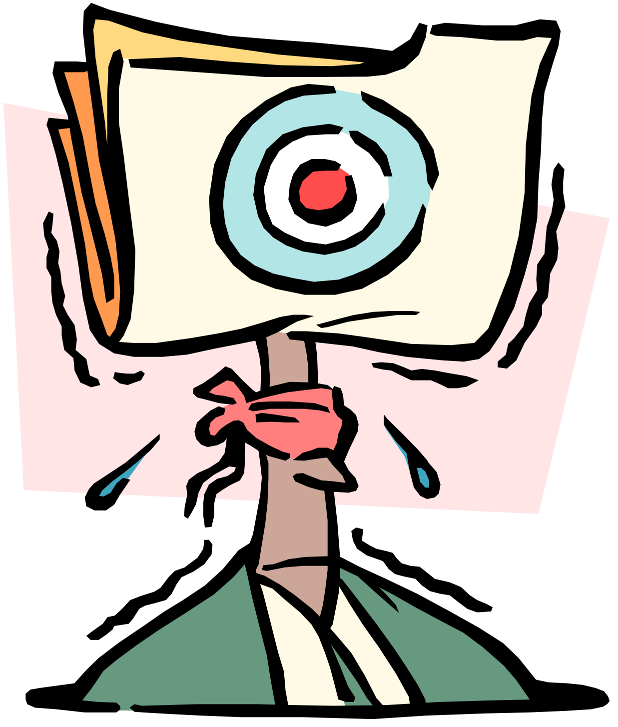
This is not a tutorial on commercial software

Fundamentals of computer graphics

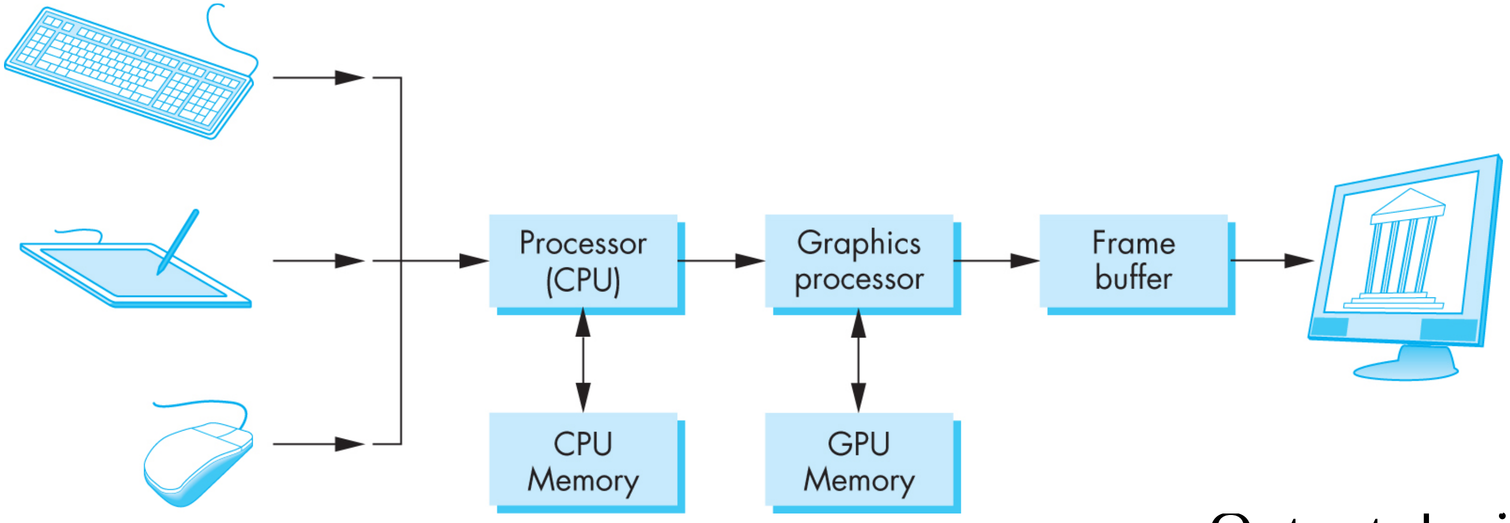


And it's not about "Business Graphics"





Basic Graphics System



Output device

Input devices

Image formed in frame buffer

Graphics = Algorithms for Visual Simulation

Creating images with a computer

- Hardware
- Software
- applications

Important Application Areas

Human-computer Interaction (HCI)

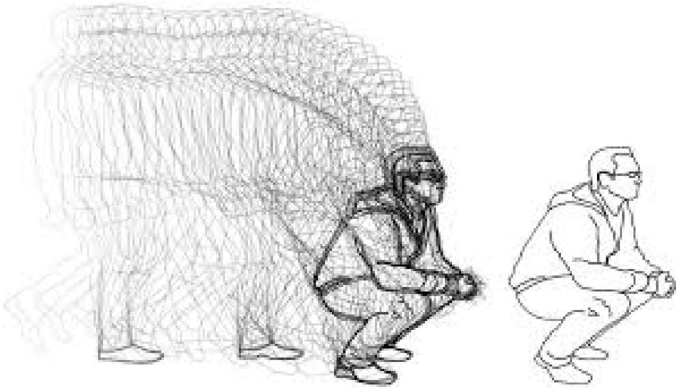
- Augmented Reality

http://augmentedrealityoverview.blogspot.com/2011/11/edibear.html

Important Application Areas

Movie production (special effects & full-length feature films)

- Matte (traveling Matte – blue/green screen)
- Rotoscoping to computer animation



https://en.wikipedia.org/wiki/Chroma_key

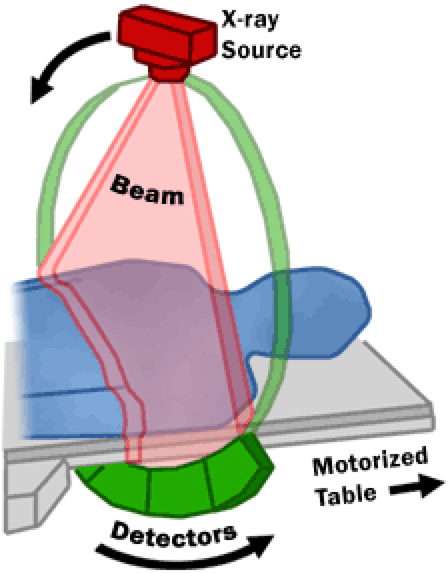
Important Application Areas

Industrial design

- CAD (Computer-aided Design)
- automated machining

Visualization

- scientific datasets
- medical scans (e.g., X-ray computed tomography (CT) scan and MRI)
- architectural prototyping

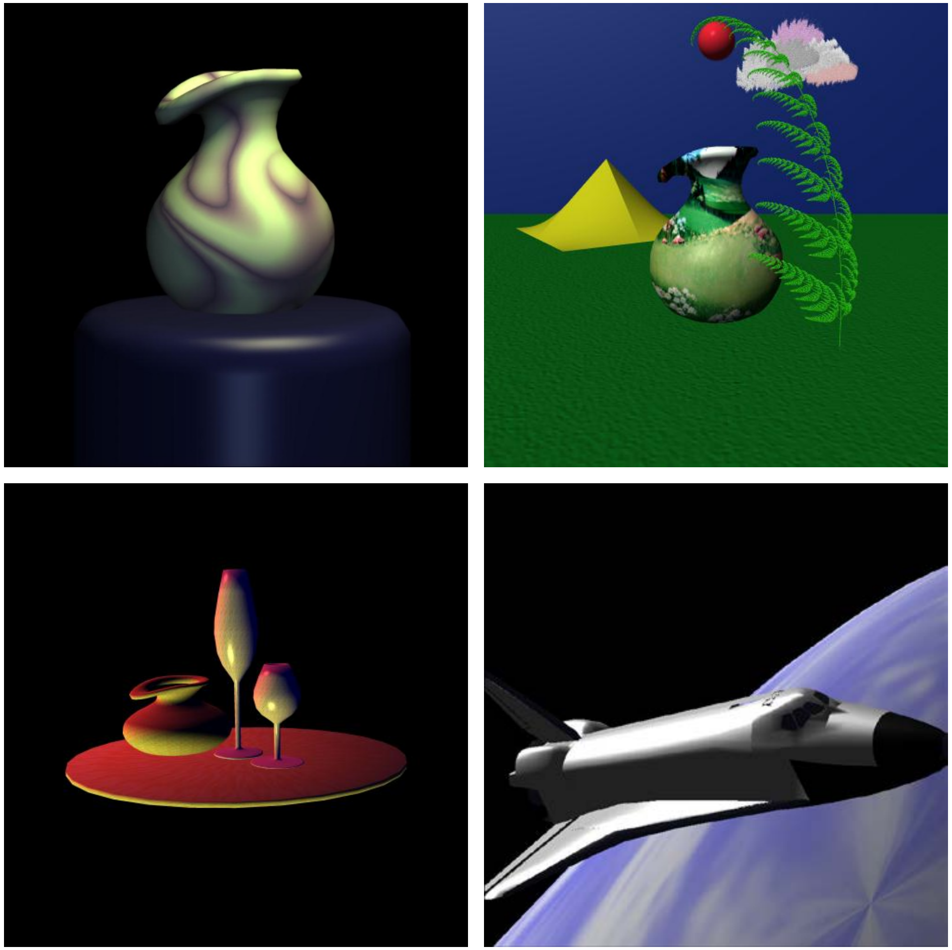


www.fda.gov

Important Application Areas

Computer games

Some Actual Class Projects



http://graphics.stanford.edu/courses/cs248-competition/spr94/

Input:

Data, model, algorithm

Output:

Image/video in the screen

Three Main Themes of Computer Graphics

Modeling

- How do we represent (or model) 3-D objects?
- How do we construct models for specific objects?

Animation

- How do we represent the motion of objects?
- How do we give animators control of this motion?

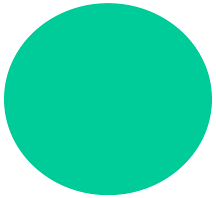
Rendering

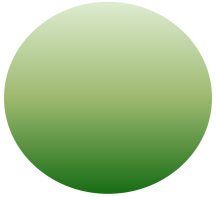
- How do we simulate the formation of images?
- How do we simulate the real-world behavior of light?

Modeling

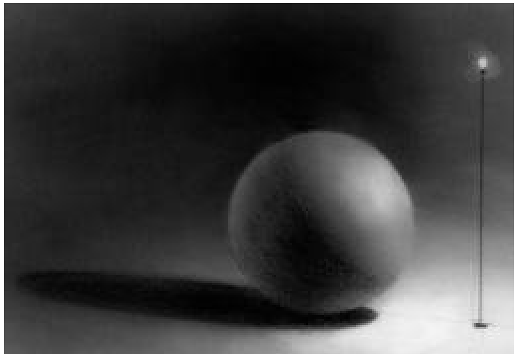
How do we represent objects/environments?

- shape — the geometry of the object
- appearance — emission, reflection, and transmission of light





Is it a ball or a circle?



http://www.sketchwiki.com/shading/shading-sphere.php

Modeling

How do we construct these models?

- manual description (e.g., write down a formula)
- interactive manipulation
- procedurally — write a generating program (e.g., fractals)
- scan a real object
  - laser scanners,
  - computer vision, …

Animation

How do we represent the motion of objects?

- positions, view angles, etc. as functions of time

How do we control/specify this motion?

- generate poses by hand, e.g., rotoscoping in traditional animation
- behavioral simulation (program little “brains” for objects, e.g., flock motion and artificial fishes)
- physical simulation
- motion capture

Tu & Terzopoulos SIGGRAPH’94

kinectic.net

Rendering

How do we simulate the formation of images?

- incoming light is focused by a lens
- light energy “exposes” a light-sensitive “film”
- represent images as discrete 2-D arrays of pixels $I(x,y)$
- need suitable representation of a camera

How do we simulate the behavior of light?

- consider light as photons (light particles)
- trace straight-line motion of photons
- must model interactions when light hits surfaces
  - refraction, reflection, etc.

Computer Graphics vs. Computer Vision (Image Processing)

Different areas

- model to image vs. image to model
- inverse processes
- Image synthesis vs. image analysis

Closely-related areas

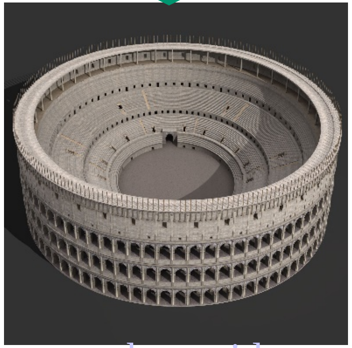
- model-based image analysis
- image analysis → models → visualization
- combining these two fields:
  recent trend

news.nationalgeographic.com

images

www.cgtrader.com

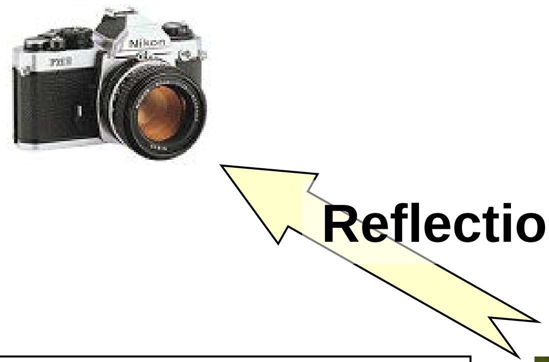
3D model

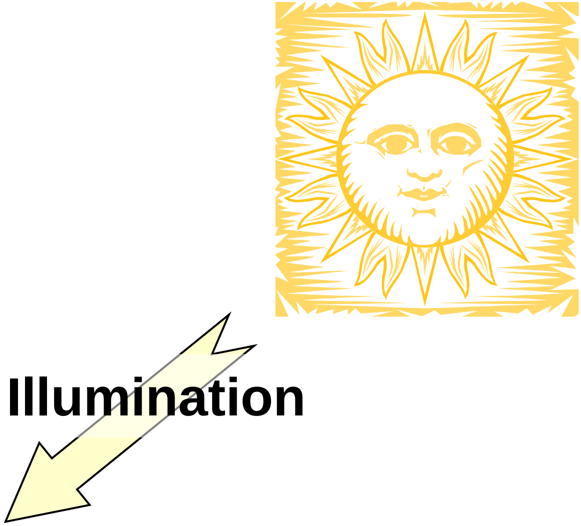


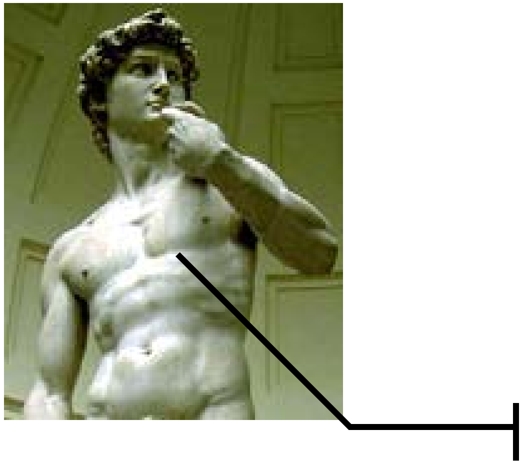
www.turbosquid.com

Synthesized 3D object

Image Formation at a Glance







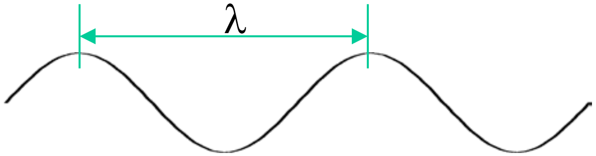
This is light transport.

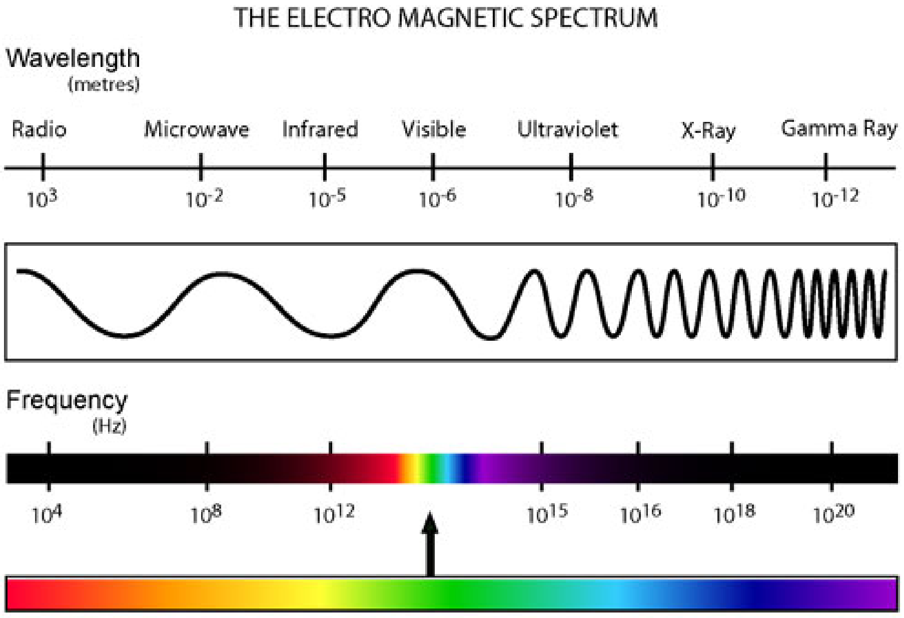
Illumination is generated at light sources, propagates thru world.

Interacts with objects in scene.

Light has a dual nature

- **a form of EM radiation** — waves propagate from light source
  - characterized by wavelength λ and frequency $f = 2\pi / \lambda$
  - amplitude of wave determines intensity
  - We perceive limited section of the spectrum
    - each wavelength is a specific color





http://www.kollewin.com/blog/electromagnetic-spectrum/

Modeling the Flow of Light in the World

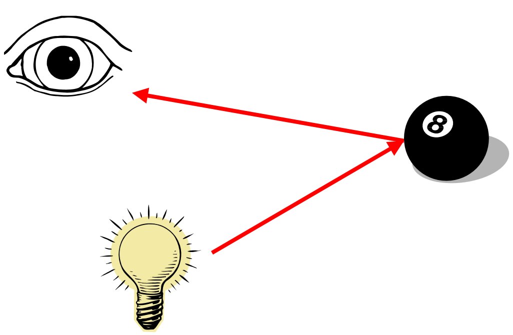
Light has a dual nature

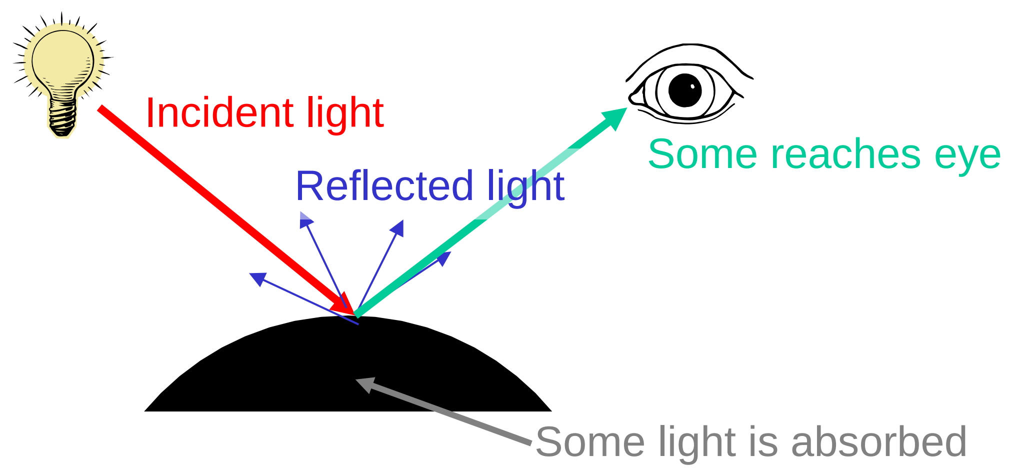
- **a form of EM radiation** — waves propagate from light source
  - characterized by wavelength λ and frequency $f = 2\pi / \lambda$
  - amplitude of wave determines intensity
  - We perceive limited section of the spectrum
    - each wavelength is a specific color
- **stream of particles** called photons — move along straight rays
- **tracing straight rays is computationally more convenient**

Modeling the Flow of Light in the World

Light is emitted from light sources and interacts with surfaces

- Absorbed, transmitted, reflected, scattered
- distribution of reflected light determines “finish” (matte, glossy, …)
- composition of light reflected into eye determines color we see





Composition of Illumination

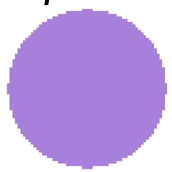
Generally a mixture of many wavelengths

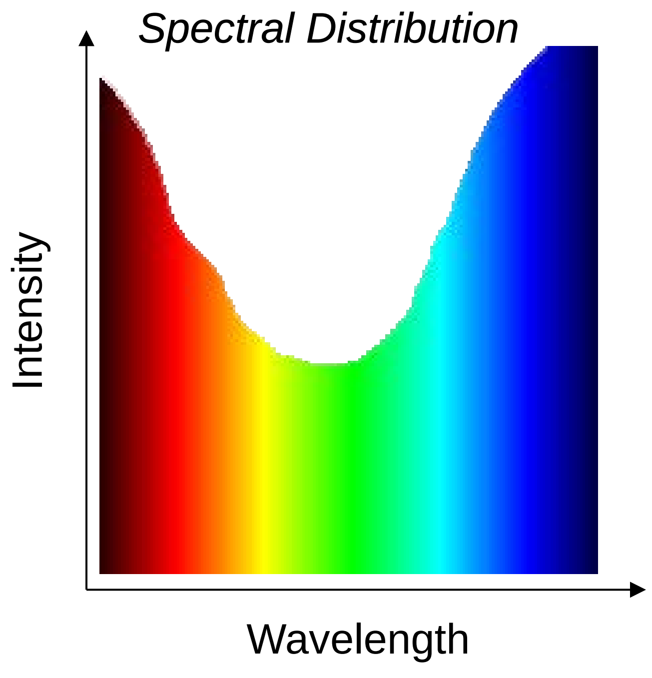
- each as some intensity
- *spectral distribution*: intensity as a function of wavelength over the entire spectrum

We perceive these distributions as colors

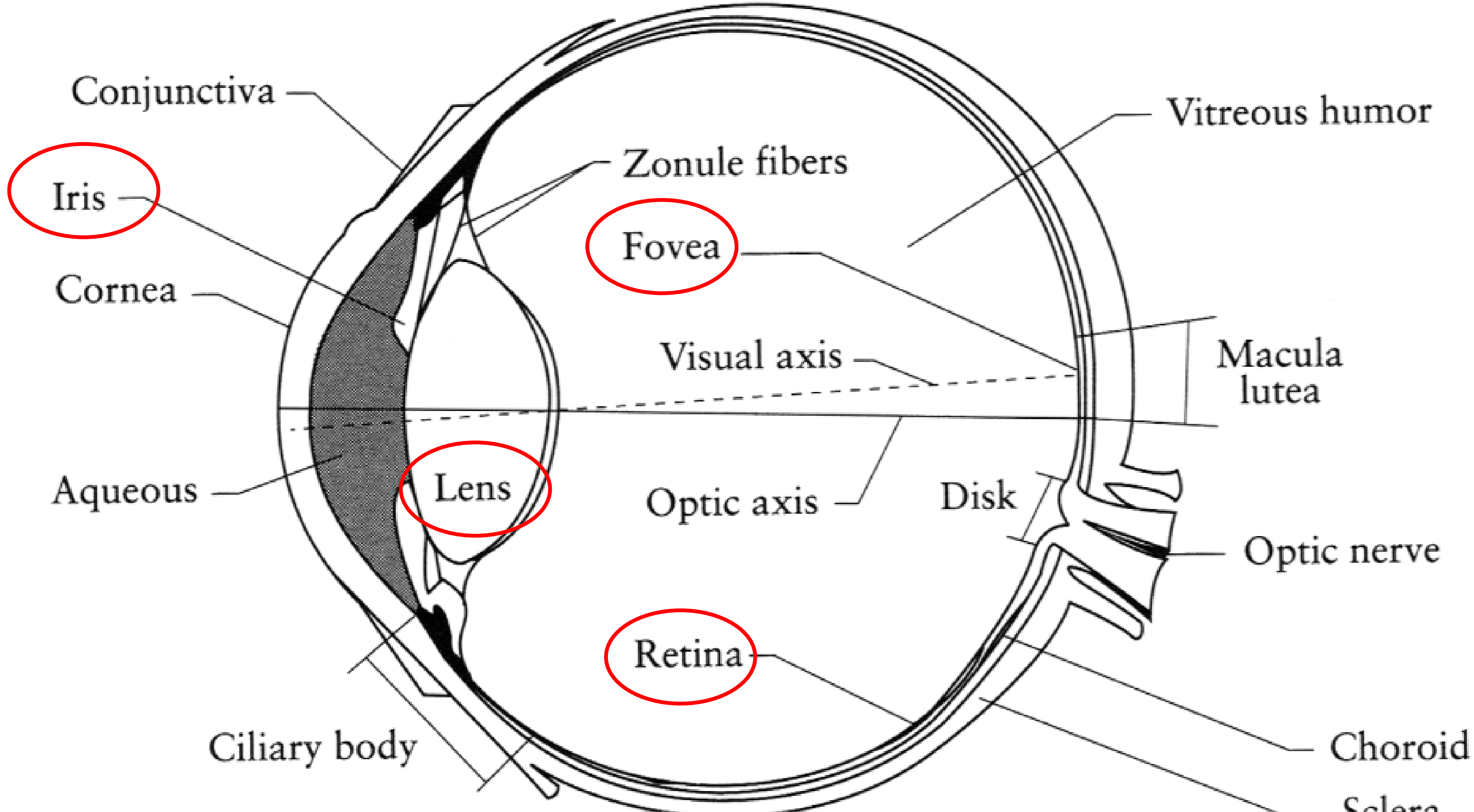
- largely an artifact of our visual system

Sample Color

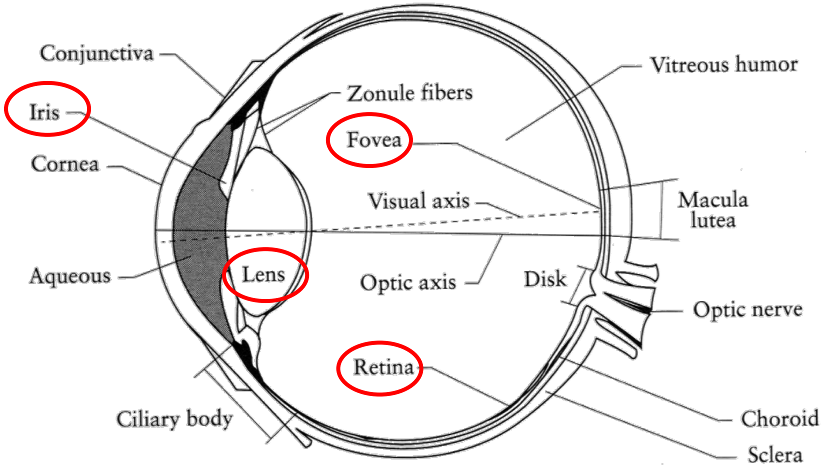




The Anatomy of the Eye



The Anatomy of the Eye



Iris lets light into eye

- contracts and dilates in response to brightness
- the hole in the iris is the pupil

Lens focuses light on retina

- dynamically reshaped by surrounding muscles to control focus

Cells in retina react to light

- sends signal via optic nerve to visual cortex in brain
- fovea is the region of highest acuity

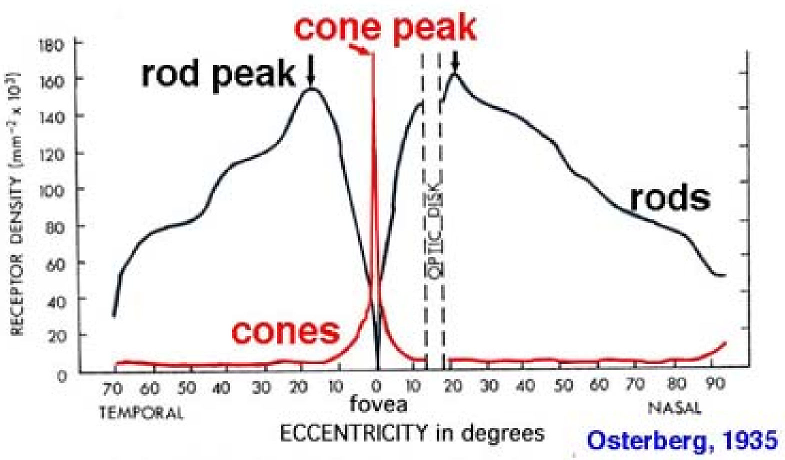
Retinal Composition: Two Kinds of Cells

Cones are concentrated in fovea

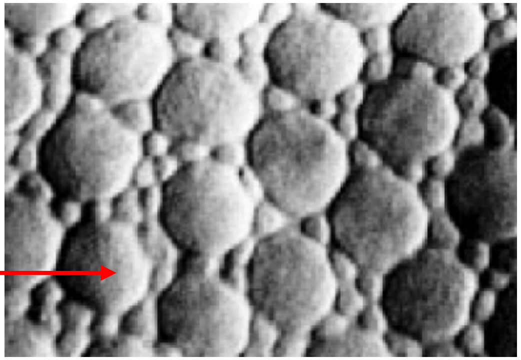
- high acuity, require more light
- respond to color

Rods concentrate outside fovea

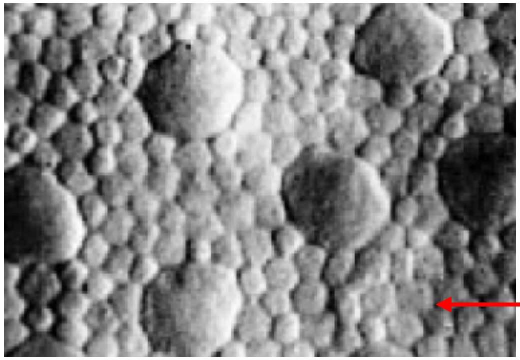
- low-acuity, require less light
- respond to intensity only
- notice that you can't see color in low lighting very well



near fovea



away from fovea



cones (larger cells)

rods (smaller cells)

The Response of Cones to Color

Three kinds of cones: S, L, and M

- S cones respond to blue
- M cones respond to green
- L cones respond to red

Response levels to illumination are

$$s = \int S(\lambda)P(\lambda)\,d\lambda$$

$$m = \int M(\lambda)P(\lambda)\,d\lambda$$

$$l = \int L(\lambda)P(\lambda)\,d\lambda$$

- where s, m, l are scalars
- this implies that we humans perceive light as a 3-D space