CMPT-361
Introduction to Computer Graphics

- Tuesday 12:30-2:20
- Thursday 12:30-1:20
- AQ4150 & AQ4130

- Instructor:
  - Dr. Kori Inkpen
  - Office: ASB9997
  - Phone: 268-6605
  - Email: inkpen@cs.sfu.ca
  - Office Hours: Tuesday 11:30-12:30 or by confirmed appointment
- TA:
  - Colin Swindells
  - Email: swindell@cs.sfu.ca
  - Office Hours: in CSIL (ASB9804)
    - M 1:00-2:30
    - R 1:30-3:00
    - F 12:30-1:30

Course Objectives

- Computer graphics provides the tools required to interact with computers through graphical user interfaces, to visualize data and processes and to create animations for communication, education and entertainment. This course aims to provide an introduction to these tools and to apply them to some typical problems.

- Course Contents:
  - Graphics display and interaction hardware
  - Interaction Techniques
  - Basic algorithms for 2D primitives
  - Antialiasing
  - 2D and 3D geometrical transformations
  - 3D projections & viewing
  - Polygonal and hierarchical models
  - Hidden-surface removal
  - Basic rendering techniques (colour, shading, raytracing, radiosity)
  - TBA

Course Information

- Evaluation:
  - Assignments 35%
  - Midterm Exam 25%
  - Final Exam 40%
  - Students must attain an overall passing grade on the weighted average of exams in the course in order to obtain a clear pass (C or better)
  - Please read the Policy on Academic Misconduct (Cheating).
  - Late Penalty: 15% (of total assignment value) per day.
  - Missed midterm or exam – must notify the instructor within 24 hours.
- Text:
  - **Computer Graphics: Principles and Practice(2nd Edition)**, Foley, vanDam,Feiner & Hughes, Addison Wesley,
- URL:
  - http://www.sfu.ca/CC/361
- Prerequisites:
  - CMPT201 and MATH232 each with a minimum grade of C.

Lecture Schedule (tentative):

Sept.	5	Overview & History of Computer Graphics
	7	Raster Graphics hardware
	12	Interaction Techniques
	14	Graphics Software
	19	Basic Algorithms for 2D primitives
	21	Basic Algorithms for 2D primitives
	26	Clipping and Antialiasing
	28	2D geometric Transformations
Oct.	3	2D & 3D geometric Transformations
	5	3D geometric Transformations
	10	Viewing in 3D
	12	Viewing in 3D
	17	Curves & Surfaces
	19	Curves & Surfaces
	24	Polygonal and Hierarchical Modelling
	26	**Midterm Exam**
	31	Hidden Surface Algorithms
Nov.	2	Hidden Surface Algorithms
	7	Colour
	9	Illumination and Shading
	14	Illumination and Shading
	16	Illumination and Shading
	21	Illumination and Shading
	23	TBA
	28	TBA
	16	TBA
Dec.	12	**Final Exam (@12:00)**

What I Expect

- Good programming background - C/C++
- Good Unix Exposure - make files, etc.
- Basic Linear Algebra - Matrices, Vectors
- Basic Computer Science - data structures, grammars, etc.
- Sleep deprivation :)

What I am not Going to do ...

- Teach C/C++
- Teach data structures
- Teach Linear Algebra
- Questions about C/C++ are a low-priority
- Lab procedures are your responsibility

What is Computer Graphics?

- Graphical User Interfaces (GUIs)
- windows, icons, direct manipulation interfaces
- Viewing, analysing and iteracting with data
- 2D, 3D and N-Dimensional
- Scientific Visualization
- Engineering and Architectural design systems CAD
- Medical images and models
- Cartography & GIS
- Graphic Design
- Communication for Advertising
- Communication for Education
- Communication for Entertainment

History of Computer Graphics

HISTORY OF COMPUTER GRAPHICS

- Excepted from the book, "Becoming a Computer Animator" by Michael Morrison
- http://www.disney.go.com/DisneyVideos/ToyStory/about/history/_history.htm

- 1960's:
  - First computer drawing system, DAC-1 (Design Augmented by Computers) (1959)
  - PDP-11 the world's first small, interactive computer created by DEC (1960)
  - Ivan Sutherland – MIT – Sketchpad (1961)
  - Steve Russell - MIT - Spacewar (1961)
    - (first video game)
  - Doug Englebart - Xerox PARC (1963)
    - mouse, windows, hypertext, CSCW
  - Sutherland & Evans - University of Utah
    - hidden-surface algorithm - first major advance in 3D computer graphics
  - Hardware developments:
    - "low cost graphics terminals"
    - input devices such as data tablets
    - display processors capable of real-time manipulation of images

Ivan Sutherland - Sketchpad

- Ph.D. Thesis (1963) - “Sketchpad: A Man-machine Graphical Communications System”
- Software through which graphics could be manipulated in real-time
- Foundation for CAD and first GUI

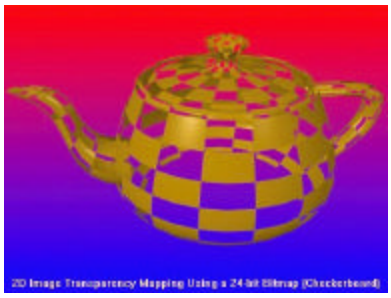
- Ideas and concepts presented:
  - hierarchical structure defined pictures and sub-pictures
  - constraints
  - icons
  - copying (pictures and constraints)
  - input techniques (light pen)
  - world coordinates (separation of screen from drawing coordinates)

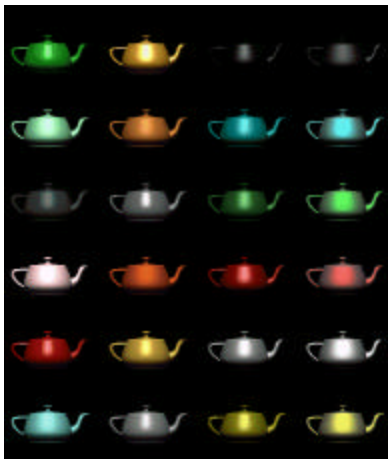
Ivan Sutherland at the TX-2 console, Sketchpad project, MIT, 1963

History of Computer Graphics

- 1970's:
  - introduction of computer graphics to the world of television
  - Gouraud shading - creating the appearance of a curved surface by interpolating the colour across the polygons (1971)
  - development of the microprocessor (1971)
  - "Westworld" - first use of computer graphics for motion pictures (1973)
    - pixellization computerized mosaic created by breaking up a picture into large colour blocks
  - Newell "teapot" (1975)
    - benchmark and icon for 3D computer graphics
    - on display at the Boston Computer Museum
  - Ed Catmull - University of Utah - texture mapping (1974)
    - apply 2D patterns and textures to a 3D computer generated object
  - Phong Bui-Toung - UU - Phong shading (1974)
    - accurately interpolates colours over a polygonal surface giving accurate reflective highlights and shading but was sig. Slower than Vouraud

Newell “teapot” (1975)





Newell teapot - Boston Computer Museum

Useful object to test computer graphics with. It's instantly recognizable, it has complex topology, it self-shadows, there are hidden surface issues, it has both convex and concave surfaces - as well as 'saddle points'. It doesn't take much storage space - it's rumored that some of the early pioneers of computer graphics could type in the teapot from memory.

Teapot History

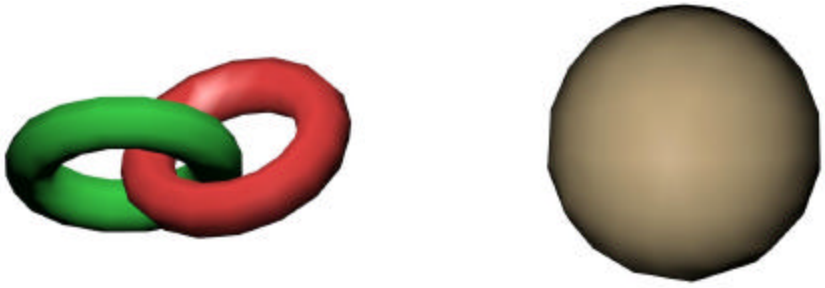
- Well, the teapot originally belonged to Martin Newell who originally purchased it from ZCMI, a department store in Salt Lake City. It turns out that the idea for modeling the teapot was brought up over concerns that he didn't have enough interesting computer models. His wife suggested the tea service (they were sitting down to tea at the time). He got some graph paper and a pencil, and he modeled the entire tea service by eye. Then, he went back to the lab and edited Bezier control points on a Tektronix storage tube, again by hand. Hence, he also digitized a spoon and a cup and saucer.

- Well, back in the early days, there were no 3D modelling packages and everything was digitized by hand or sketched on graph paper and the numbers typed in using a text editor. If you were working on texture mapping algorithms, ray tracing or some such work, then any source of free data was welcome.

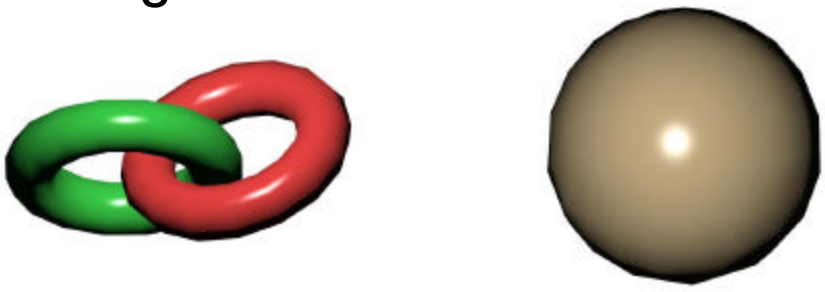
Shading

Flat Shading

Gouraud Shading



Phong Shading



History of Computer Graphics

- 1970's (continued)
  - Mandelbrot - fractal geometry (1975)
    - straight line (1D), plane (2D), if line curves around in such a way to cover the entire surface of the plane, it is no longer 1D but not quite 2D.
    - Fractional dimension between one and two
  - Ed Catmull director of NYIT (1974)
    - new hotbed for computer graphics
    - members would continue to lead the field of computer graphics for the next twenty years
    - first graphics applications focussed on 2D animation and creating tools to assist animators (tween and scan-and-paint)
  - Homebrew Computer Club
    - club of amateur computer enthusiasts
    - ideas about building personal computers
    - Steve Wozniak (HP) developed the first Apple computer in a garage with Steve Jobs which sold for $666.66 (1975)
  - William Gates III dropped out of Harvard at the age of 19 and started Microsoft
    - wrote a version of BASIC for the Altair 8800
    - five years later IBM approached them to develop an operating system for Intel 8080 microporcessors

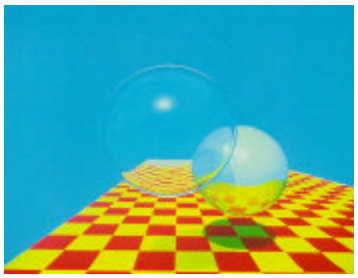
History of Computer Graphics

- 1970's (continued)
  - George Lucas interested in computer graphics for "The Empire Strikes Back"
    - Triple I produced a sequence that showed five X-Wing fighters flying in formation but disagreements over financial aspects caused Lucas to drop it
    - Later on Lucas assembled his own Computer Graphics department within his special effects company, Lucasfilm.
    - Catmull joined Lucas and eventually most left NYIT. Lucasfilm and a new graphics department at Cornell because the new focus of computer graphics
  - Jim Blinn - Bump Mapping

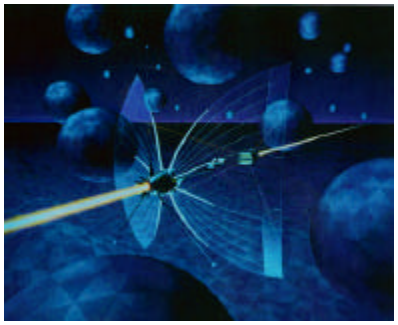
  - Don Greenberg - Cornell University
    - computer graphics lab for simulating realistic surfaces
    - Rob Cook, new lighting models to simulate objects like polished metal

History of Computer Graphics

- 1980's
  - Hardware developments
    - Cheaper/faster more accessible hardware (mainframes to PC)
    - High-level, device independant graphics
    - Tablets, mouse, keyboard
  - ACM SIGGRAPH
  - Turner Whitted - Ray Tracing (1980)



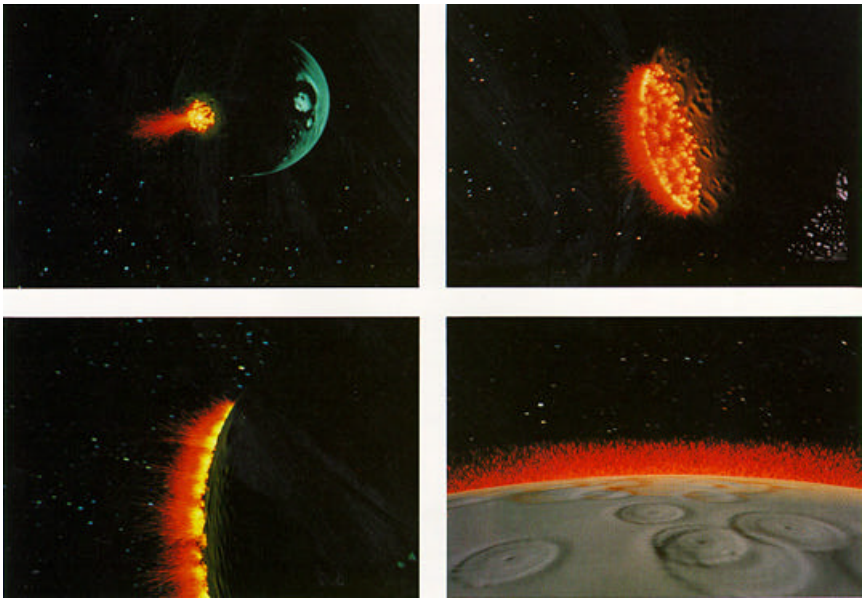
    - rendering method for simulating highly reflective surfaces (including reflections, refraction, antialiasing and shadows)
  - Tron - Disney feature movie with 30 minutes of computer graphics (1980)



  - Silicon Graphics Inc. (1982)
    - high performance graphics computers with built-in 3D graphics capabilities

History of Computer Graphics

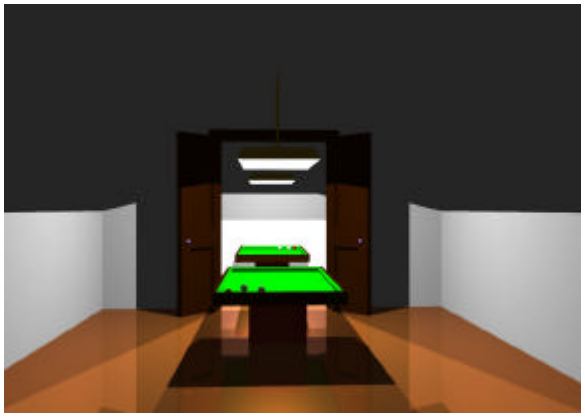
- 1980's (continued)
  - Industrial Light and Magic
    - division of Lucasfilm for special effects
    - not interested in computer graphics group

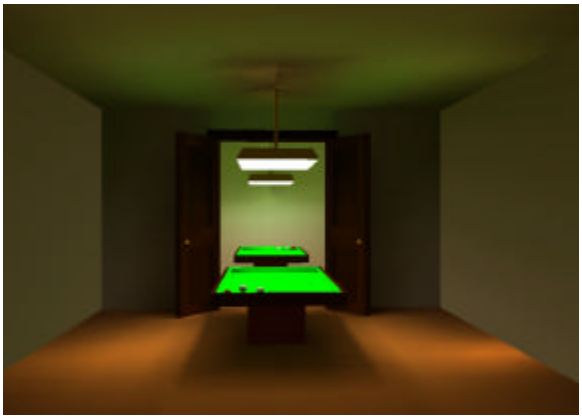


  - Tom Brigham - NYIT - morphing (1982)
    - Willow (1987)
  - Jaron Lanier - Atari - data glove (1983)
    - first commercial virtual reality product
  - Wavefront (1984)
    - first commercially available 3D animation system

History of Computer Graphics

- 1980's (continued)
  - Cornell University - Radiosity (1984)
    - model the interaction of light between diffuse surfaces





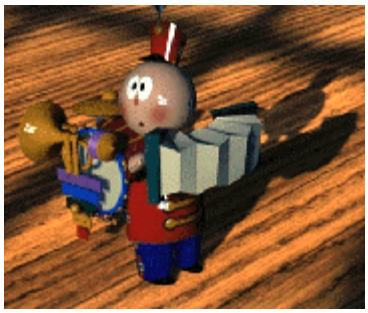
  - Apple Computer releases first Macintosh (1984)
    - first personal computer to use a graphical user interface
  - Jim Henson - Muppets - creating a digital puppet
    - approached Brad DeGraf at Digital Productions
    - Waldo (1986)
    - idea of motion capture was born
  - Crystal Graphics, TOPAS (1986)
    - first high-quality 3D animation program for PCs
  - Forensic Animation (1986)
    - computer graphics in the courtroom
    - geared towards technical accuracy

History of Computer Graphics

- 1980's (continued)
  - "The Great Mouse Detective" - Disney (1986)
    - Disney's first use of computer graphics in film
    - A computer generated imagery (CGI) department was formed for future films
  - Lucasfilm - CG & ILM
    - computer graphics division wanted to do feature length computer animated films
    - ILM was interested in the potential of computer graphic special effects
    - Lucas felt the company was getting too wide
    - CG division spun off Pixar (1986) with Steve Jobs as the major stockholder
    - new CGI group grew until it became ILM
  - Renderman - Pixar renderer (1988)
    - standard for describing 3D scenes
    - Waldo (1986)
    - idea of motion capture was born

History of Computer Graphics

- 1980's (continued)
  - "Tin Toy" - Pixar (1988)
    - short animated film created completely with 3D CG using Renderman
    - first computer animated film to win an Academy Award



  - The Abyss - director James Cameron (1989)
    - water snake special effect
    - felt it couldn't be done without computer graphics
    - convinced Cameron that CGI could created a major character in his next film "Terminator 2"

History of Computer Graphics

- 1990's
  - Microsoft - Windows 3.0 (1990)
    - GUI similar to the Macintosh
  - Disney and Pixar (1991)
    - announced agreement to create three films, including the first computer animated full-length film "Toy Story"
  - "Terminator 2" (1991)
    - new standard for CGI special effects
    - produced on time and under budget

  - PDI - Digital Opticals Group
    - 'slights of hand' for computer generated images
    - one of the leaders in digital cleanup work

History of Computer Graphics

- 1990's (continued)
  - "Beauty and the Beast" - Disney (1991)
    - in terms of beauty, colour and design, Disney did things not possible without computers

  - "Jurassic Park" - Steven Spielberg (early 90's)
    - Spielberg originally went traditional route
    - hired Stan Winston to create full scale models/robots of the dinasaurs and Phil Tippett to create stop-motion animation and go-motion
    - result wasn't very good and the scene was cut
    - ILM began experimenting and was able to generate it and the scene was put back in
  - ILM - photorealism
    - Forrest Gump
    - Saving Private Ryan
    - The Mask

History of Computer Graphics

- 1990's (continued)
  - Pixar
    - Toy Story (1995) - wins Academy Award
    - A Bug's Life (1998)
    - Geri's Game (1998) - wins Academy Award
    - Toy Story 2 (1999)

  - 3D Video Games
    - Quake (1996)