COMPSCI 111 / 111G

Mastering Cyberspace:
An introduction to practical computing

Computer Graphics

Introduction

What is Computer Graphics?

- Definition
- Development

Creating an image

- Techniques

Applications

- Uses
- Social Implications

What is Computer Graphics?

A subfield of Computer Science

- Creating and manipulating digital images

Major subfields

- Representing and manipulating surfaces
- Representing and manipulating light
- Representing and manipulating motion

Description → **Computer Graphics** → **Image**

http://en.wikipedia.org/wiki/Computer_graphics

Development of Computer Graphics

Two-dimensional rendering

- Drawing algorithms
- Curves, 2D objects
- Vector graphics
- Typography

Three-dimensional rendering

- Surfaces, lighting, transformations
- Modelling 3D objects

http://en.wikipedia.org/wiki/2D_computer_graphics
http://en.wikipedia.org/wiki/3D_computer_graphics

Development of Computer Graphics

Animation

- Creating a sequence of 3D images
- Simulation
- CGI (Computer Generated Imagery)

Interactive Computer Graphics

- Fast enough to render in real-time
- Computer games, scientific visualization

http://en.wikipedia.org/wiki/Computer-generated_imagery

http://en.wikipedia.org/wiki/Computer_animation

http://en.wikipedia.org/wiki/Real-time_computer_graphics

Development of Computer Graphics

Virtual Reality

- "Virtual Immersion"
- Head mounted display
- Haptic feedback (touch)

Augmented Reality

- Enhanced experience of real world
- Combines real world and CG
- Interactive

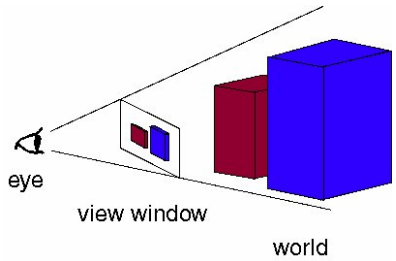
http://en.wikipedia.org/wiki/Virtual_Reality

http://en.wikipedia.org/wiki/Augmented_reality

Creating 3D Graphics

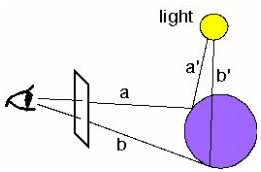
Need to model

- Object
- Camera (eye)
- Light source
- View window



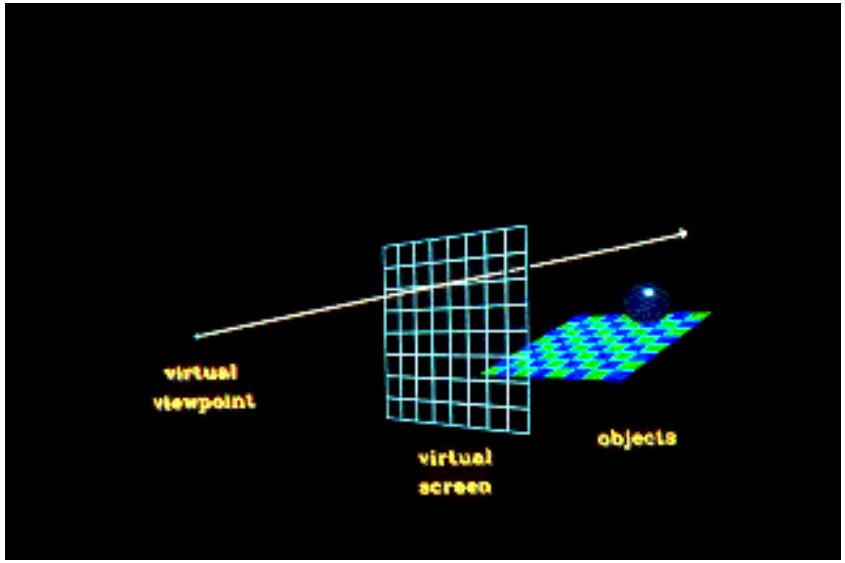
Ray Tracing

- Trace the path of light from camera
- Through each pixel
- When it hits an object
  - calculate colour of the object at that point

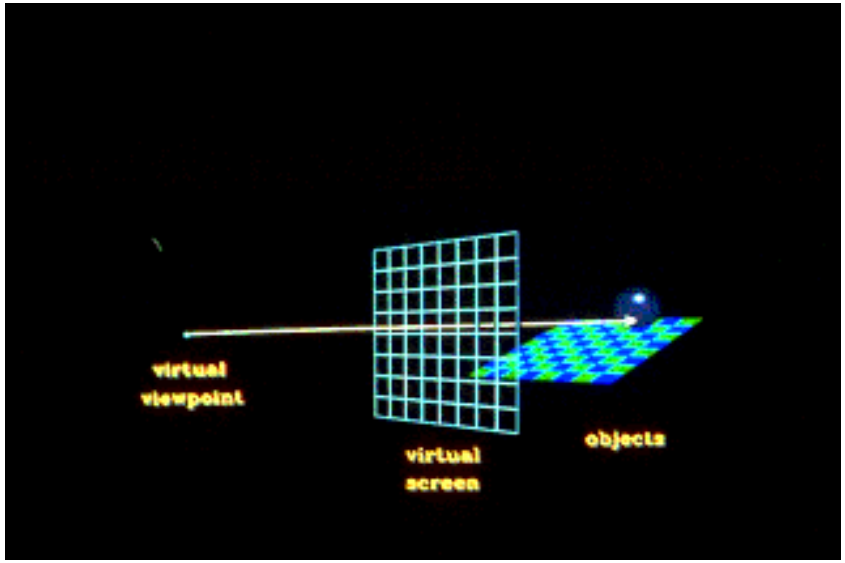


http://www.siggraph.org/education/materials/HyperGraph/raytrace/rtrace1.htm

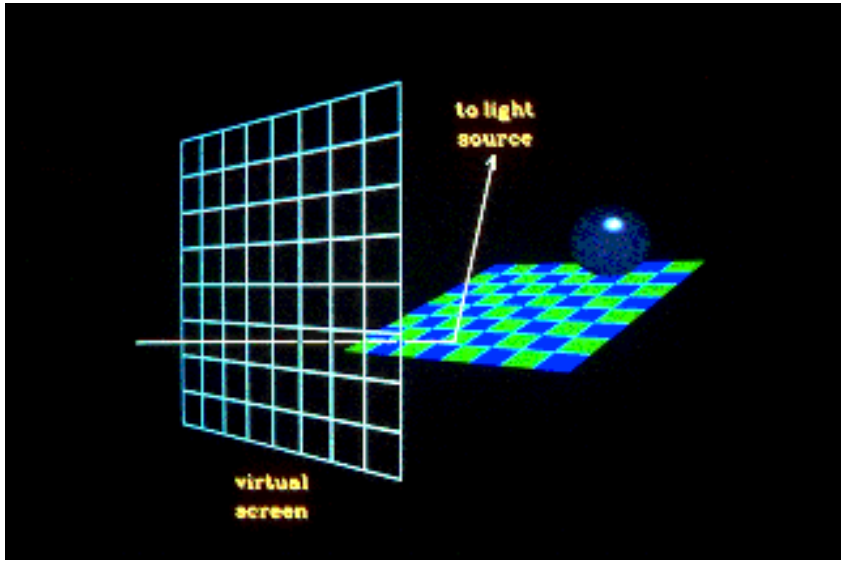
Projected ray misses all object



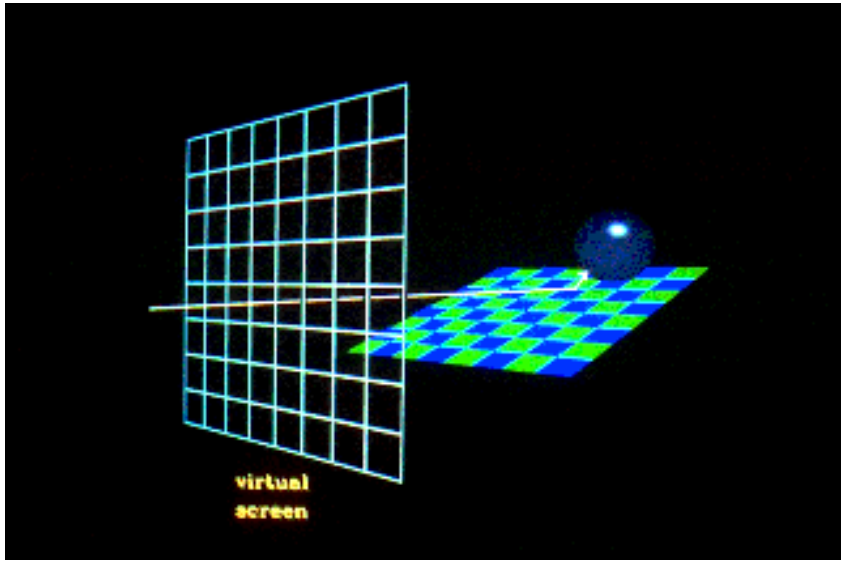
Projected ray hits an object



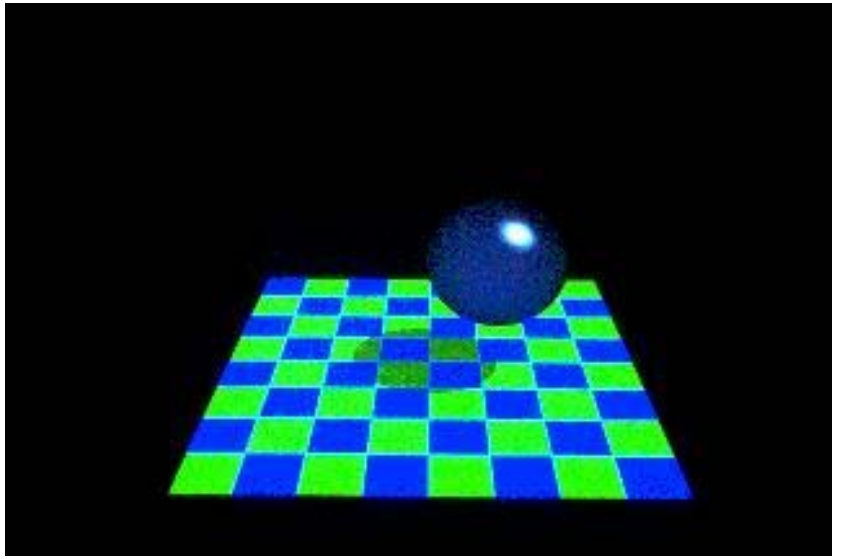
Create a secondary ray to light



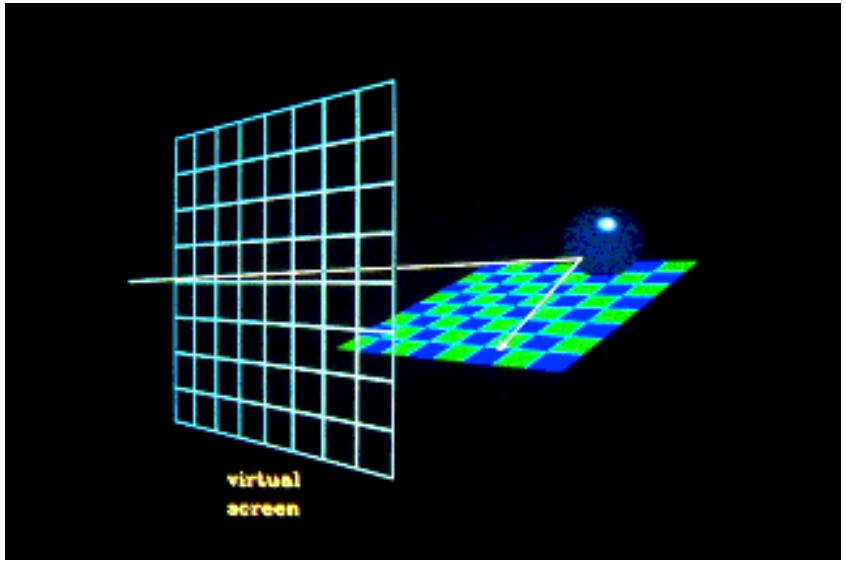
The ray can't reach the light



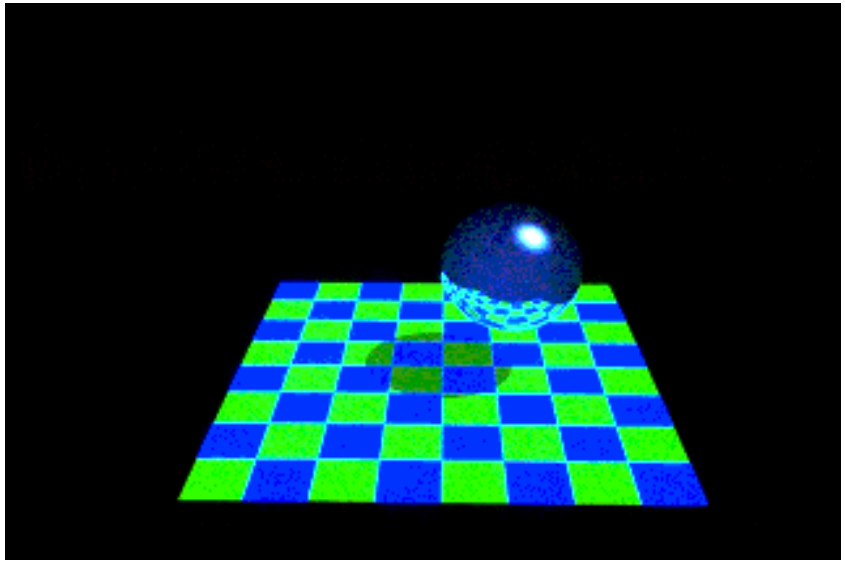
Creates a shadow



Project a ray bouncing off object



Creates reflections



Photorealistic Ray Tracing

http://en.wikipedia.org/wiki/Rendering_%28computer_graphics%29

Creating 3D Graphics

Uses a model of the object.

- Similar to Vector Graphics
- Based on objects described mathematically
- More accurate models -> more realistic images

2 Dimensional Objects	
Circle	
Radius	**100**
Center	**20, 45**
Appearance	
Line Thickness	**3**
Fill Pattern	**Plain**
Colour	**Blue**

3 Dimensional Objects	
Sphere	
Radius	**100**
Center	**20, 45, 30**
Appearance	
Surface Texture	
Surface Pigment	
Surface Finish	

Modelling and Simulation

Representing objects in three dimensions

- Must model properties of light (diffusion, refraction etc.)
- Dust, Fog, etc.
- Model surface properties of objects

Animation can be automated

- Provide laws describing interaction between objects
- Realistic animation requires physical laws (gravity, solidity etc.)

Simulation

- Requires and internal model, and physical laws
- Graphics and Simulation often work hand-in-hand

Some simple techniques

Modelling

- Wire-Frame
- Solid Object
- Polygon-Surface

Shading

- Lambert shading (flat shading)
- Gouraud shading
- Phong shading

Developing a Scene

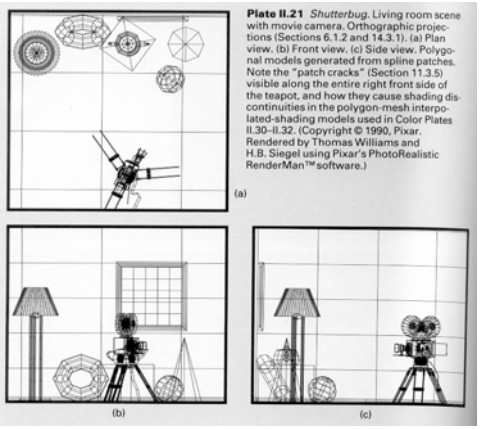


Plate II.21 *Shutterbug.* Living room scene with movie camera. Orthographic projections (Sections 6.1.2 and 14.3.1). (a) Plan view. (b) Front view. (c) Side view. Polygonal models generated from spline patches. Note the "patch cracks" (Section 11.3.5) visible along the entire right front side of the teapot, and how they cause shading discontinuities in the polygon-mesh interpolated-shading models used in Color Plates II.30–II.32. (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Orthographic projections
•Top View (Plan)
•Front View
•Side View

Polygon Mesh used to represent objects. Note that spheres and other curved objects are represented with few points

Wireframe drawing with perspective

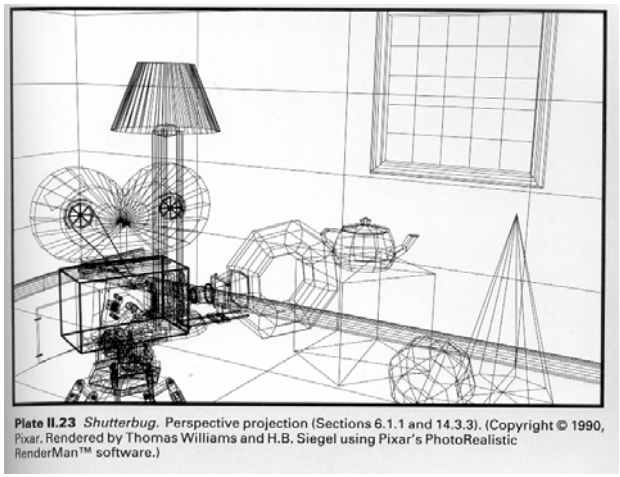


Plate II.23 *Shutterbug.* Perspective projection (Sections 6.1.1 and 14.3.3). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Determining visible lines

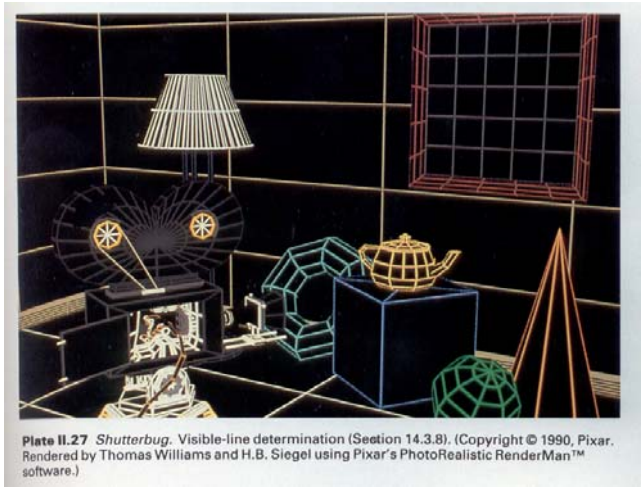


Plate II.27 *Shutterbug.* Visible-line determination (Section 14.3.8). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Flat Polygon Shading

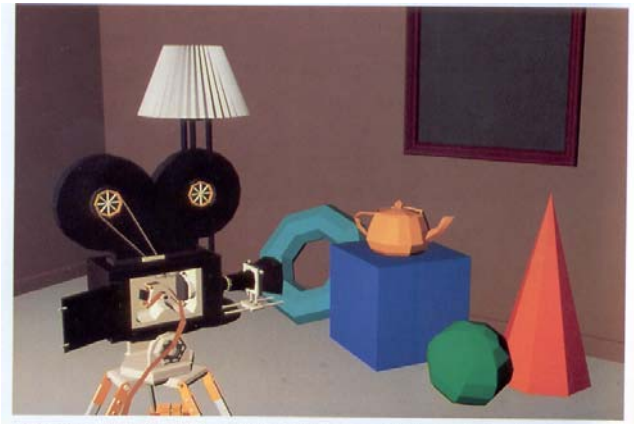


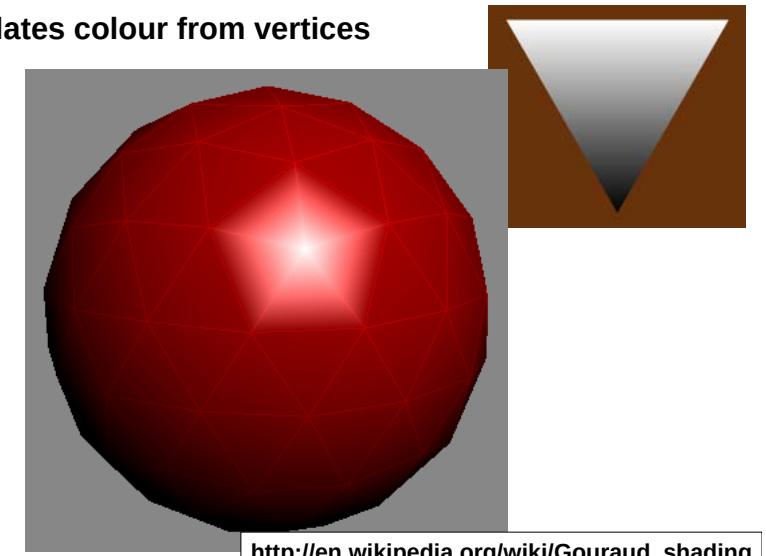
Plate II.29 *Shutterbug.* Individually shaded polygons with diffuse reflection (Sections 14.4.2 and 16.2.3). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Gouraud Shading

Plate II.31 *Shutterbug.* Gouraud shaded polygons with specular reflection (Sections 14.4.4 and 16.2.5). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Gouraud Shading

Interpolates colour from vertices



http://en.wikipedia.org/wiki/Gouraud_shading

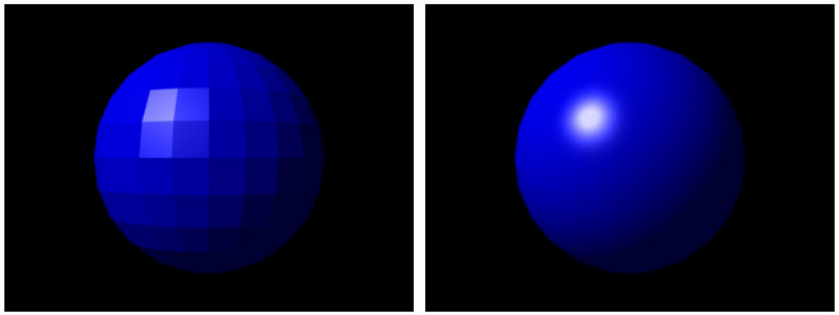
Phong Shading

Plate II.32 *Shutterbug.* Phong shaded polygons with specular reflection (Sections 14.4.4 and 16.2.5). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Phong Shading

Interpolates normals from vertices

- Normal used to calculate the colour value



FLAT SHADING PHONG SHADING

http://en.wikipedia.org/wiki/Phong_shading

Curved Surfaces

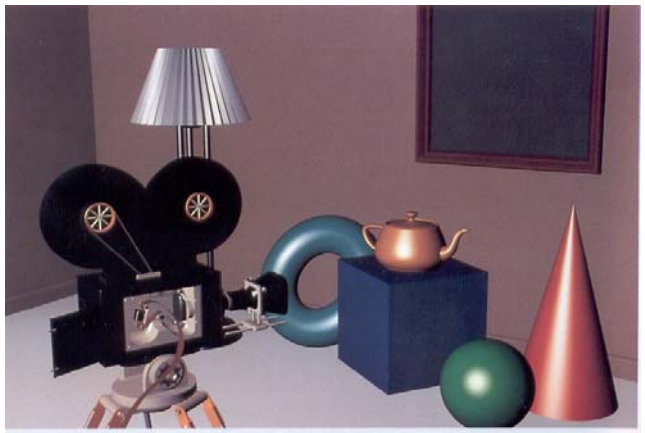


Plate II.33 *Shutterbug.* Curved surfaces with specular reflection (Section 14.4.5). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Texture Mapping

Plate II.35 *Shutterbug.* Texture mapping (Sections 14.4.7, 16.3.2, 17.4.2, and 17.4.3). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Shadows

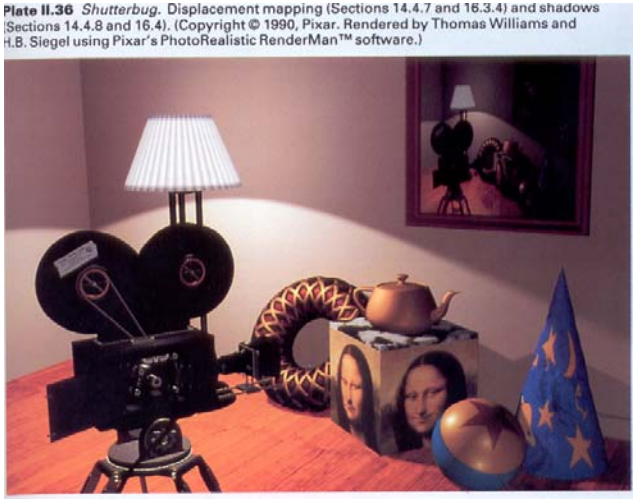


Plate II.36 *Shutterbug.* Displacement mapping (Sections 14.4.7 and 16.3.4) and shadows (Sections 14.4.8 and 16.4). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Reflection

Plate II.37 Shutterbug. Reflection mapping (Sections 14.4.9 and 16.6). (Copyright © 1990, Pixar. Rendered by Thomas Williams and H.B. Siegel using Pixar's PhotoRealistic RenderMan™ software.)

Complexity in Computer Graphics

Plain colour

Reflection

Transparency

Refraction

Translucency

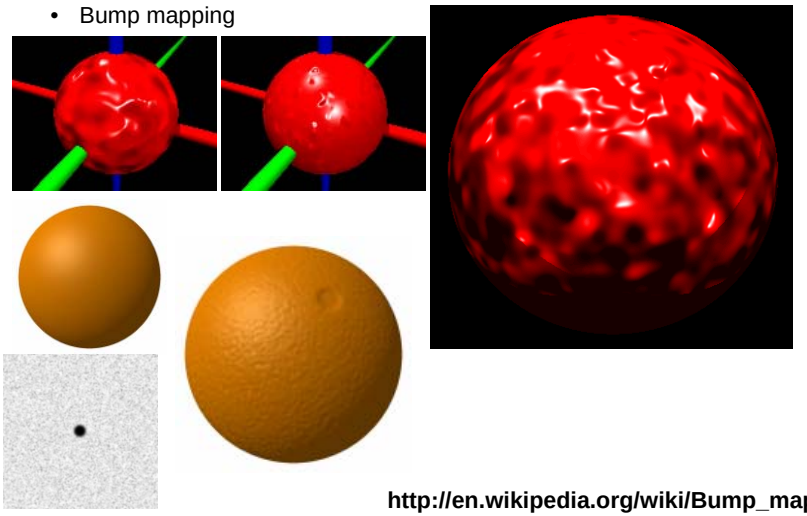
Irregularity is often difficult

- Animated motion is often too regular and smooth
- Objects are often simplified (regular), textures are too clean / crisp

The normal determines reflected light

Introducing some irregularity into smooth objects

- Bump mapping



http://en.wikipedia.org/wiki/Bump_mapping

Applications

Entertainment

- Movies (CGI - Computer Generated Imagery)
- Computer Games

Engineering/Science/Medicine/Education

- CAD (Computer Aided Design)
- Visualization
  - Biomedical Imaging (CT, MRI)
  - Scientific visualization
  - Information Visualization

Architectural Design / Planning

Advertising / Commerce

Military

Machinima

Using a game engine to create animated story

http://rvb.roosterteeth.com/home.php

http://en.wikipedia.org/wiki/Machinima

Virtual Worlds

Second Life

- 9 Million "residents"
- Free to play
- Create new objects, sell them
- Spend USD 1 million per day

World of Warcraft

- 8 million subscribers
- Subscription $12-15 USD per month

MMORPGs

- Claimed that about 40% of players are addicted
- Buy items / gold / power levelling services

http://www.nickyee.com/daedalus/gateway_intro.html