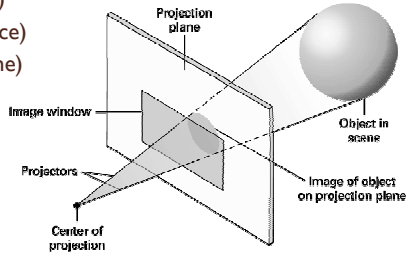
Computer graphics

Outline

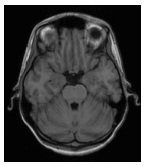
- The graphics pipeline
  - Model (description)
  - Transform (eye space)
  - Clip (viewing volume)
  - Rendering
    - Local lighting
    - Shading
    - Texture mapping
    - Global lighting
- Animation
  - Dynamic simulation
  - Kinematics simulation



3D to 2D projection

Data acquisition

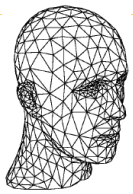
- Manual input
  - 3D max, AutoCAD
- 3D scanner/Range scanner
- Medical sensors
  - X-Ray
  - Ultrasound,
  - Magnetic Resonance Imaging (MRI)
  - Computed Tomography (CT)



http://www.mpi-inf.mpg.de/~ag4-gm/

Modeling – triangle meshes

- Modeling: use **planer** patches (usually triangles) to compose the desired shapes
  - Easy to render
- The finer mesh the better approximation



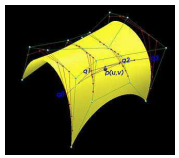
Triangulation: 計算幾何演算法

Bazier curves and surfaces

- Bazier curve (Pierre Bezier 1970) : can define 3D curves by few control points

http://en.wikipedia.org/wiki/B%C3%A9zier_curve

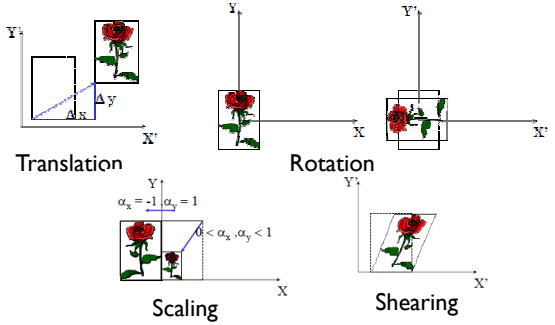
  - Many usages, such as vectored font
- Bazier surface



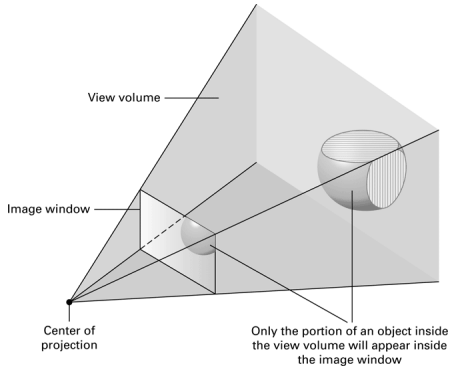
數值方法

Viewpoint transform

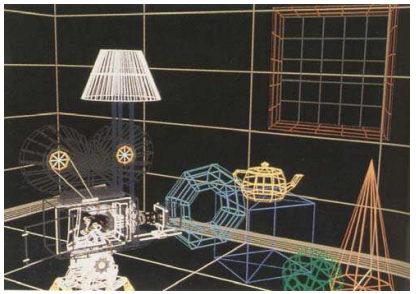
- To move objects to desired viewpoints
  - Use special matrices to do the transforms (線性代數)



View volume

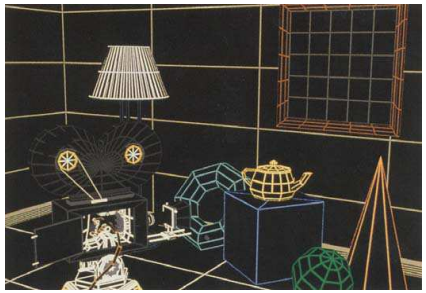


Colored wireframe



3D→2D:線性代數，construction of wireframe 資料結構

Colored visible wireframe



- Hidden surface removal
- Overlapped objects
  - Painter's algorithm
  - Z-buffer algorithm

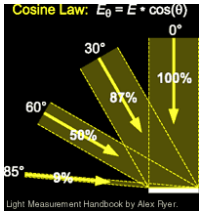
Hidden surface removal:: 線性代數, Depth sorting: 演算法

Ambient lighting

- 背景光，環境光
- Not associated with any source or direction

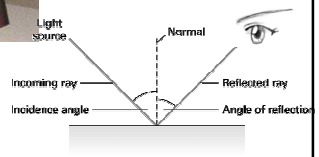
Diffuse lighting

- The scattered light by non-smoothed surface
- Lambert's cosine law: (普物)



Specular lighting

- Used to simulate metallic, shiny surfaces
- Consider the reflected light and the viewing angle



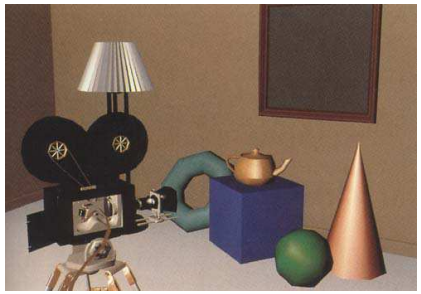
Flat shading (with diffuse lighting)

- One **normal** per triangle
- Constant color per triangle

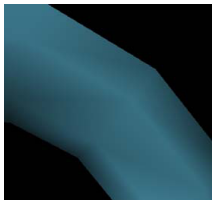
Gouraud shading (with diffuse lighting)

- After Henri Gouraud (1971)
- One **normal** per vertex
- Compute color per vertex
- Interpolate color per pixel

Gouraud shading (with specular lighting)



- Problem: Mach Bands



Phong shading (with specular lighting)

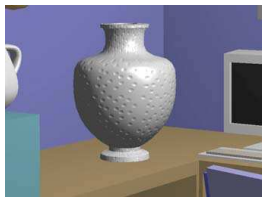
- After Bui-Tuong Phong 裴祥風 (1975)
- One normal per vertex
- Interpolate normal per pixel
- Compute color per pixel
- Good for curved and shiny surfaces

Texture mapping

- Introduced by Catmull in 1974
- Map images to geometry
  - Simulate surface detail

Bump mapping

- Introduced by Blinn (1978)
- Perturb the surface by a bump map



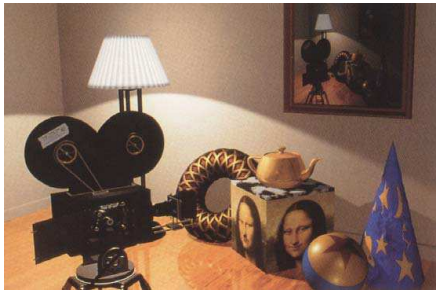
Environment mapping

- Introduced by Blinn & Newell (1976)
  - Compute the reflection vector at each mesh vertex
  - Interpolate the reflection vector across the triangle
  - Use the reflection vectors to index the environment map

Image by Jim Blinn via debevec.org

Image by Aravind Kalaiah & Amitabh Varshney

Global lighting: Ray tracing



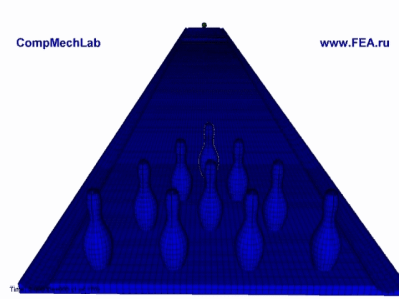
- Treat light as a pencil of rays, and trace their reflecting trajectory (普物)
- Most of the time is spent in intersection computations (資料結構，演算法)

Global lighting: Radiosity

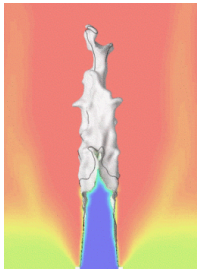
- Assumes area light sources
- Based on conservation of light energy (普物)
  - Light energy per unit time per unit area
- Need to solve a large linear system (線性代數，數值方法)

Dynamics simulation

- Applies laws of physics to determine position of objects



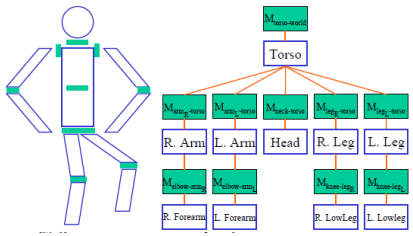
http://www.eng.fea.ru/



http://www.aices.rwth-aachen.de/organization/institutes/combtech/

Kinematics simulation

- Applies characteristics of joints and appendages to determine position of objects
- Hierarchical transformations



From Amitabh Varshney's lecture notes.