

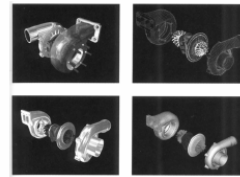
Introduction to Computer Graphics

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Applications

- Simulators (flight, driving) Simulators (flight, driving)
- Mechanical CAD (Computer Mechanical CAD (Computer Aided Design))



What is Computer Graphics?

Computer graphics deals with:

- Geometric modeling: creating mathematical models of 2D and 3D objects.
- Rendering: producing images given these models.
- Animation: defining/representing time dependent behavior of objects.



Applications

- Simulators (flight, driving)
- Mechanical CAD (Computer Aided Design)
- Architectural visualization
- Virtual reality Virtual reality
- Advertising



Applications

- Computer games
- Special effects
- Computer art



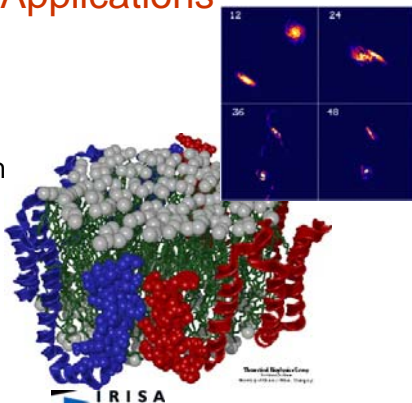
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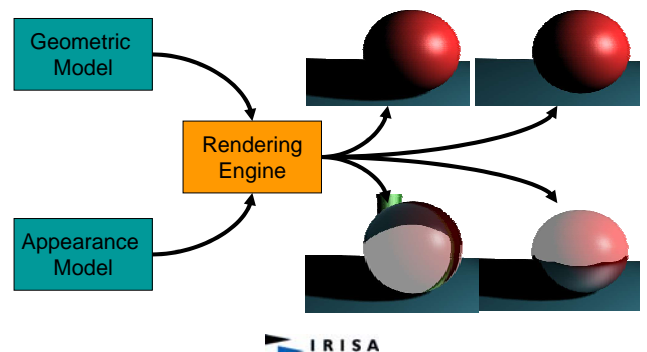


Applications

- Education
- Scientific visualization
- Medical imaging



Rendering Engine



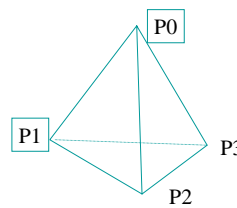
Modeling

- From a concept (or a real object) to a geometric model representable on a computer.
- Example: a sphere can be described by four real numbers: (x,y,z,r).
- Example: a polygon can be described by listing the coordinates of its vertices.



Modeling: polygonal facets

- Facets sharing vertices
- Avoids data duplication



LS=list of vertices
 LS = {P0, P1, P2, P3}
 F1 = (LS [0], LS [1], LS [2])
 F2 = (LS [0], LS [2], LS [3])
 F3 = (LS [3], LS [1], LS [0])
 F4 = (LS [3], LS [2], LS [1])
 Fi = Facet i
 Object = {F1, F2, F3, F4}



Modeling

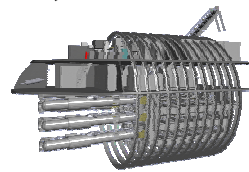
How to represent more complex shapes?

- Polygon meshes: a large collection of polygonal facets, connected with each other.
- Free Free-form surfaces: using low-degree polynomial functions.
- CSG: construct a shape by applying boolean operations on primitive shapes.

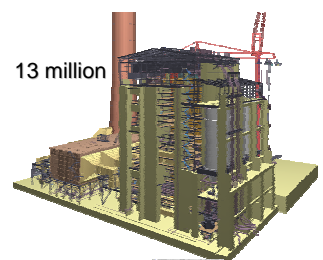


Huge models :

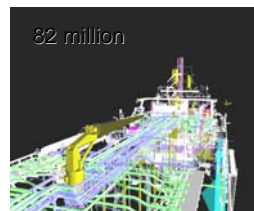
700,000



13 million



32 million

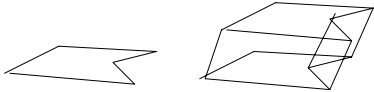


372,422,615

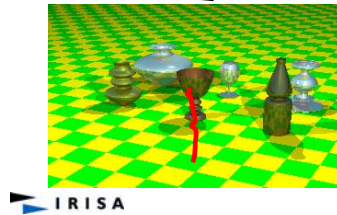


Modeling: Sweeping, revolution

- Extrusion



- Revolution

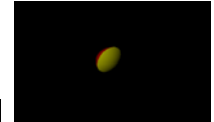


Modeling: CSG examples

- Union



- Intersection



- Difference



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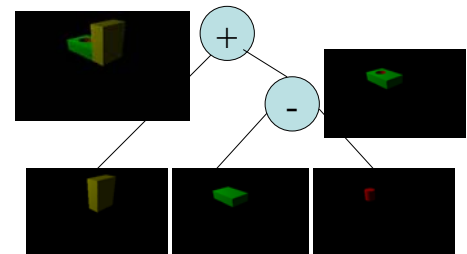
Objets CSG

- Description of complex shapes
- Definition
 - Object = set of points
 - Object = sphere, cylinder, cone, box, ...
 - Object = Obj1 bop Obj2
 - bop = union, intersection, difference

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Modeling: CSG examples

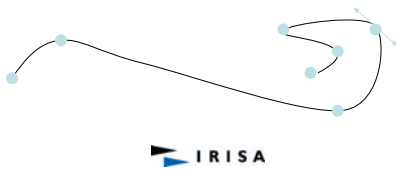
- Binary tree :



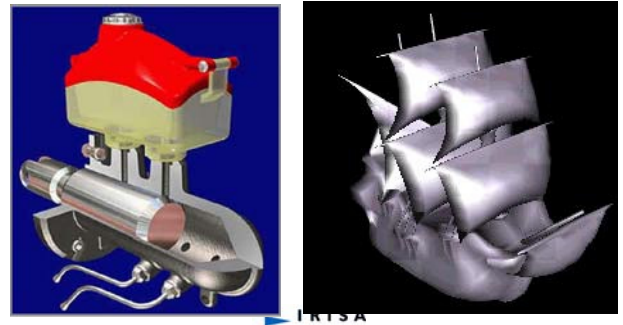
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Modeling: Parametric Surfaces

- Free form curves and surfaces
- Defined with control points



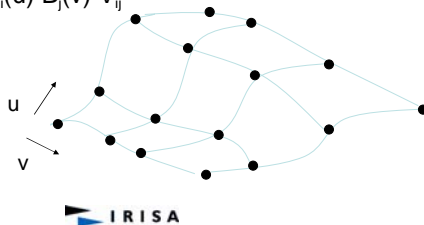
Surfaces splines



Modeling: Parametric Surfaces

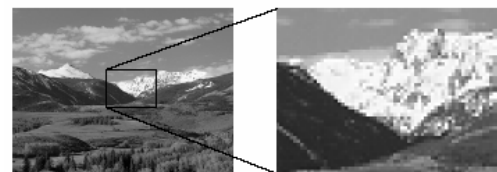
Tensor product of parametric curves, functions of u and v .

$$Q(u, v) = \sum_{ij} B_i(u) B_j(v) V_{ij}$$



Rendering

- Given a scene and viewing parameters, produce an image = a 2D array of pixels.



Rendering

Important sub-tasks:

- Scan conversion: Which pixels in the image are covered by each object?
- Visible surface algorithms: What is visible at each pixel of the image?
- Illumination and shading: What color should be assigned to each pixel?



Surface Appearance

- Surface: Appearance
 - What are the properties of material?
 - How the surface reacts to light?
 - In what direction and what part of the spectra is it reflecting?
 - Is it fuzzy?
 - Is the surface bumped like metal?
 - etc.



Animation

- How to define complex time-dependent behavior of objects?
- Examples:
 - Automatic inbetweening (interpolation key-frames).
- Physically-based simulation.



Summary

- How the image is created?
 - Put objects into the memory
 - Assign appearance and/or textures to their surfaces
 - Assign lights
 - Position camera(s)
 - Run the illumination algorithm: different techniques (scan conversion, ray tracing)
 - Display images

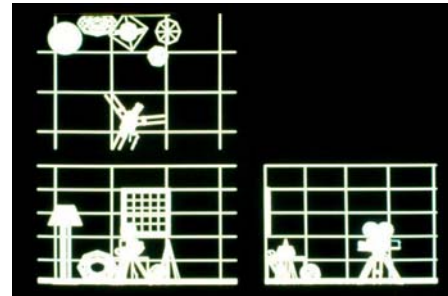


Context

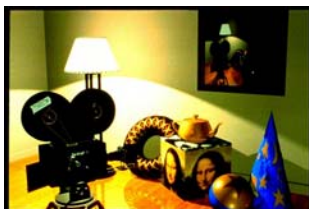
- Image Processing: from images to images
- Computer Vision: from images to models
- Computer Graphics: from models to images



Wireframe model – Orthographic views



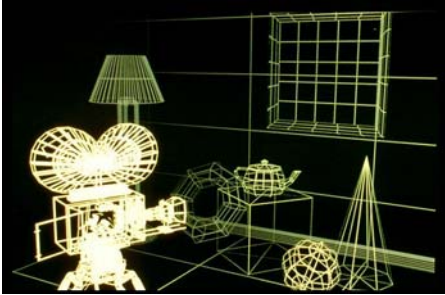
Examples of different effects



Perspective View



Depth Cue



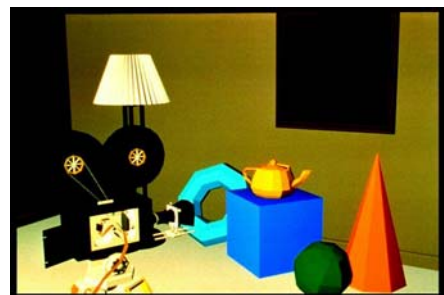
Constant Shading - Ambient



Hidden Line Removal – add colour



Faceted Shading - Flat



Gouraud shading, no specular highlights



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Phong shading



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Specular highlights added



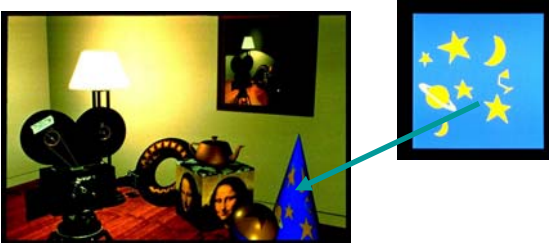
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Texture mapping



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Texture mapping



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Reflections, shadows & Bump mapping



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