Computer Graphics 2014

1. INTRODUCTION

Hongxin Zhang
State Key Lab of CAD&CG, Zhejiang University

2014-09-22

Why study computer graphics?

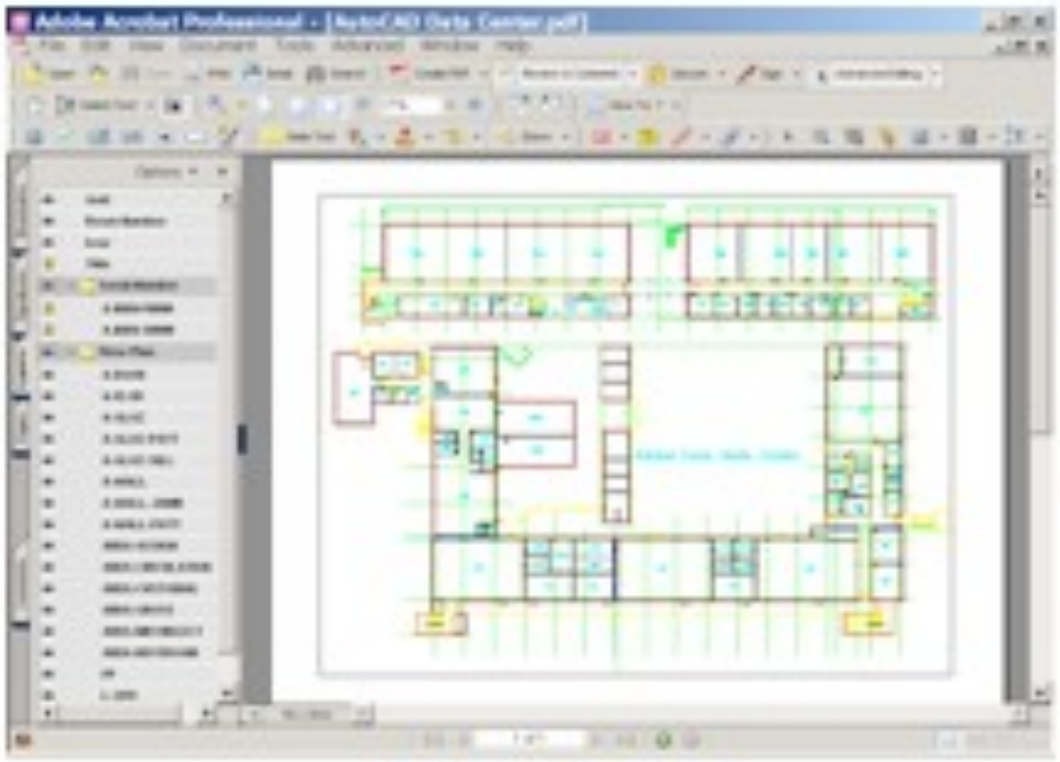
Entertainment

Movies
Toy Story 3
Pixar

Games
Spore
W. Wright, Elec. Arts

Computer-Aided Design

Mechanical CAD
Architectural CAD
Electronic CAD



AutoCAD

Sketchup

CS148 Lecture 1

Pat Hanrahan, Fall 2010

Visualization

Science, engineering and medicine

The Virtual Human
Karl-Heinz Hoehne

Outside-In
The Geometry Center

Visual Simulation and Training

Apollo spacecraft
Flight simulators
Driving simulators
Surgical simulation

davinci surgical robot
Intuitive Surgical

Boeing 747 flight simulator
NASA

Digital Media Technologies

Convert traditional analog media to digital media

- **Desktop publishing and printing**
- **Digital photography**
- **Digital video and HDTV**

Digital Media Technologies

Emergence of media

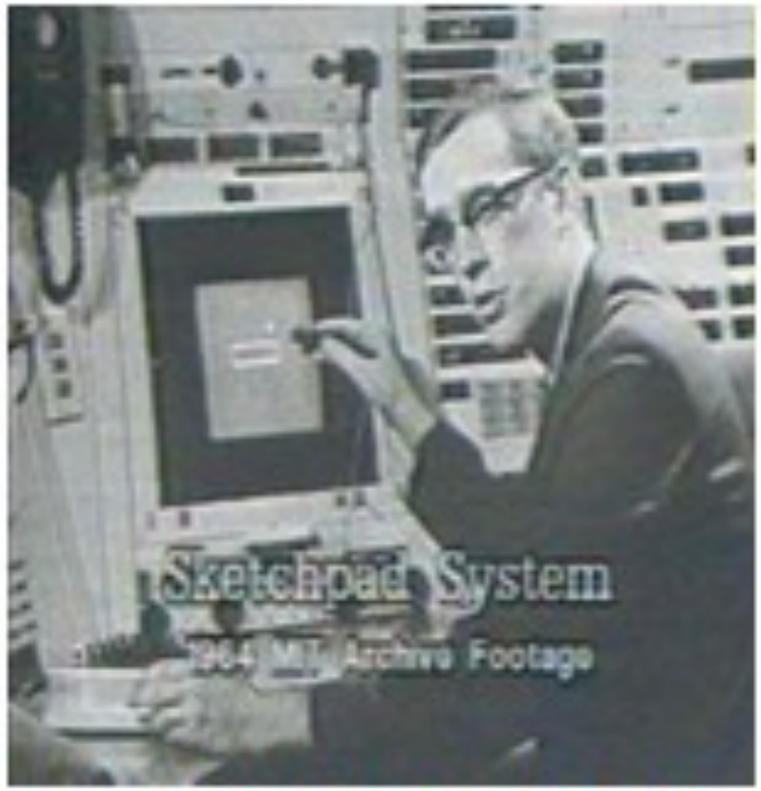
- **Multimedia computer and media servers**
- **Networked graphics and the WWW**
- **Electronic books, magazines and newspapers**
- **Sharing photos (flickr) and videos (youtube)**
- **Virtual worlds (Google Earth, Second Life)**

With new possibilities for creating and mixing content from different sources

Graphical User Interfaces

Desktop metaphor

- Input: Keyboard, mouse
- Output: Cathode-ray tube



Ivan Sutherland, Sketchpad
Light-pen, oscilloscope

Douglas Engelbart
Mouse

Emerging User Interfaces

Different scales: Small and large

Emerging sensors: Multi-touch, accelerometers, ...

Apple iPad

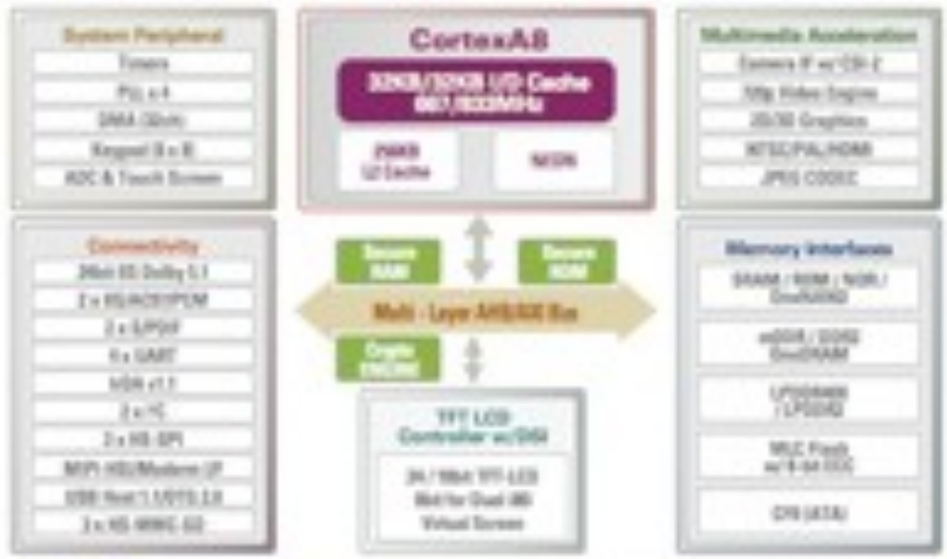
Microsoft Surface

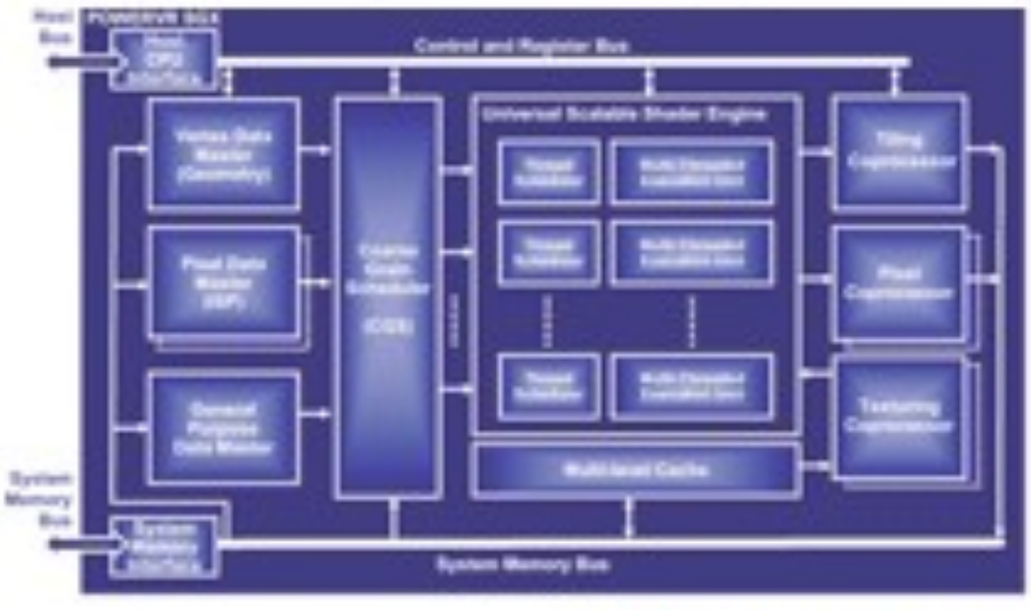
Innovation in Hardware & Software

iPhone and iPad

Apple A4 = CPU+GPU

S5PC100 Block Diagram



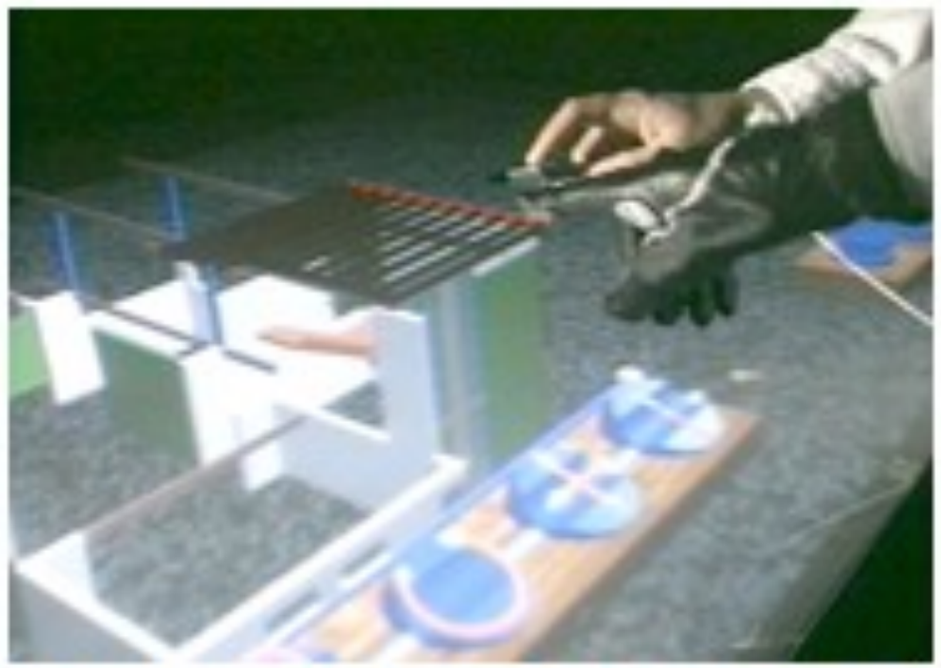


Ultimate Display: Virtual Reality

Immersive interfaces

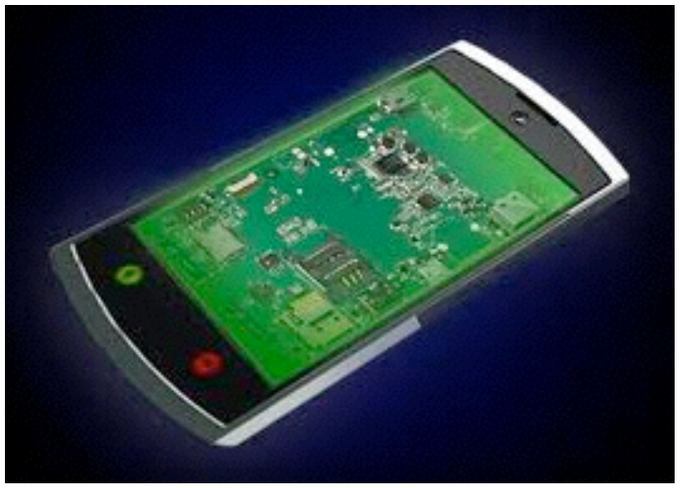
- Input: 3D 6-DOF tracking, gloves
- Output: Head-mounted and projection displays

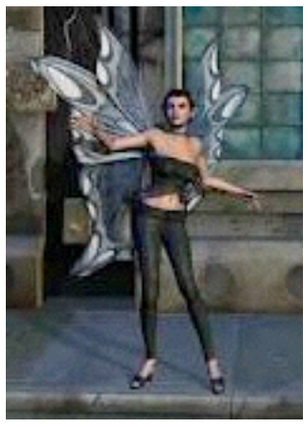
Ivan Sutherland
Head-mounted displays,
mechanical tracker



Wolfgang Krueger, Pat Hanrahan
Responsive Workbench
Projection display, magnetic tracker

Mobile Graphics





Theory and Practice

Science and Mathematics

- **Physics of light, color and appearance**
- **Geometry and perspective**
- **Mathematics of curves and surfaces**

Engineering

- **Hardware: Graphics processors, sensors**
- **Software: Graphics libraries, window systems**

Art and Psychology

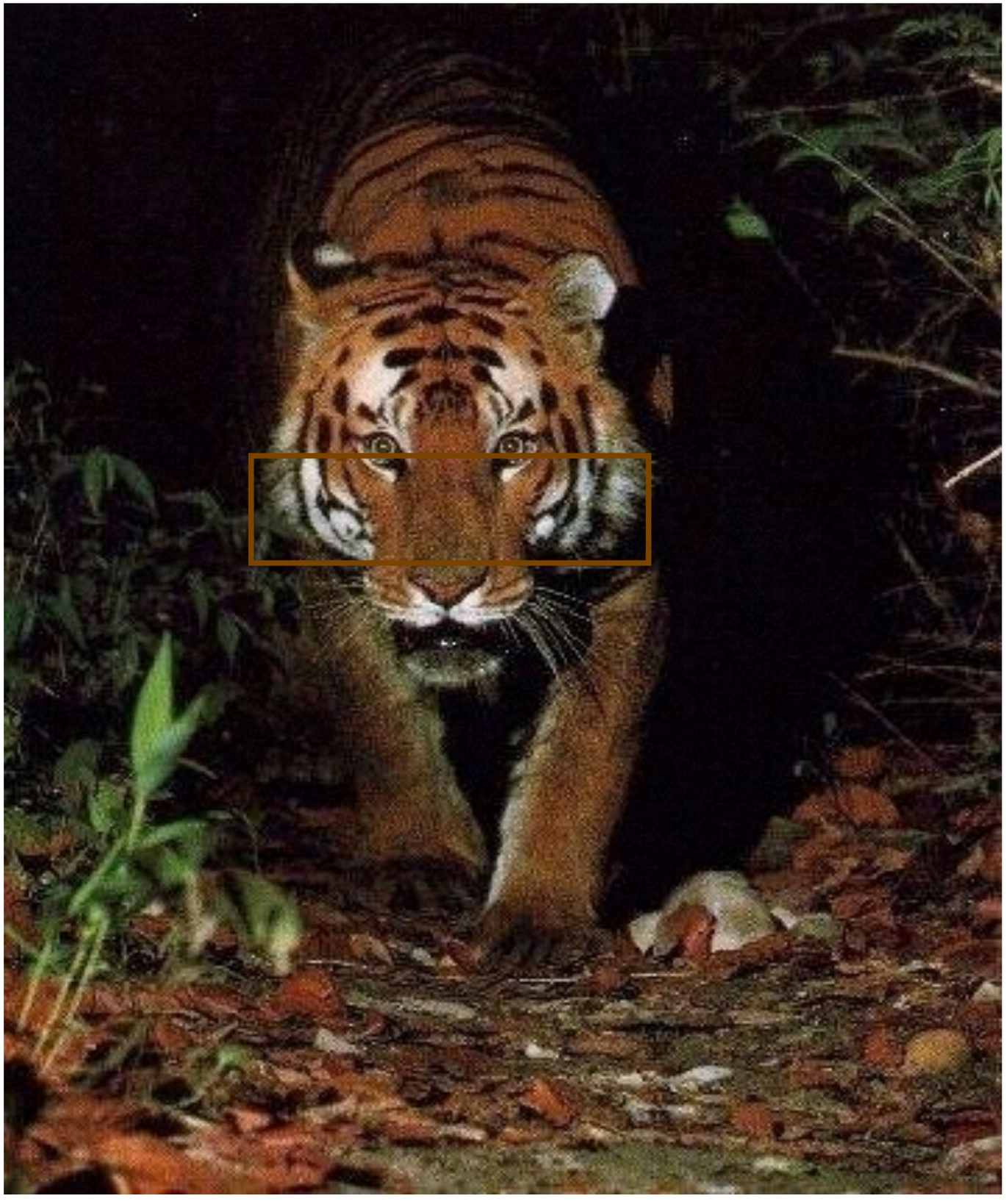
- **Perception: Color, displays, ...**
- **Art and design: Composition, form, lighting, ...**

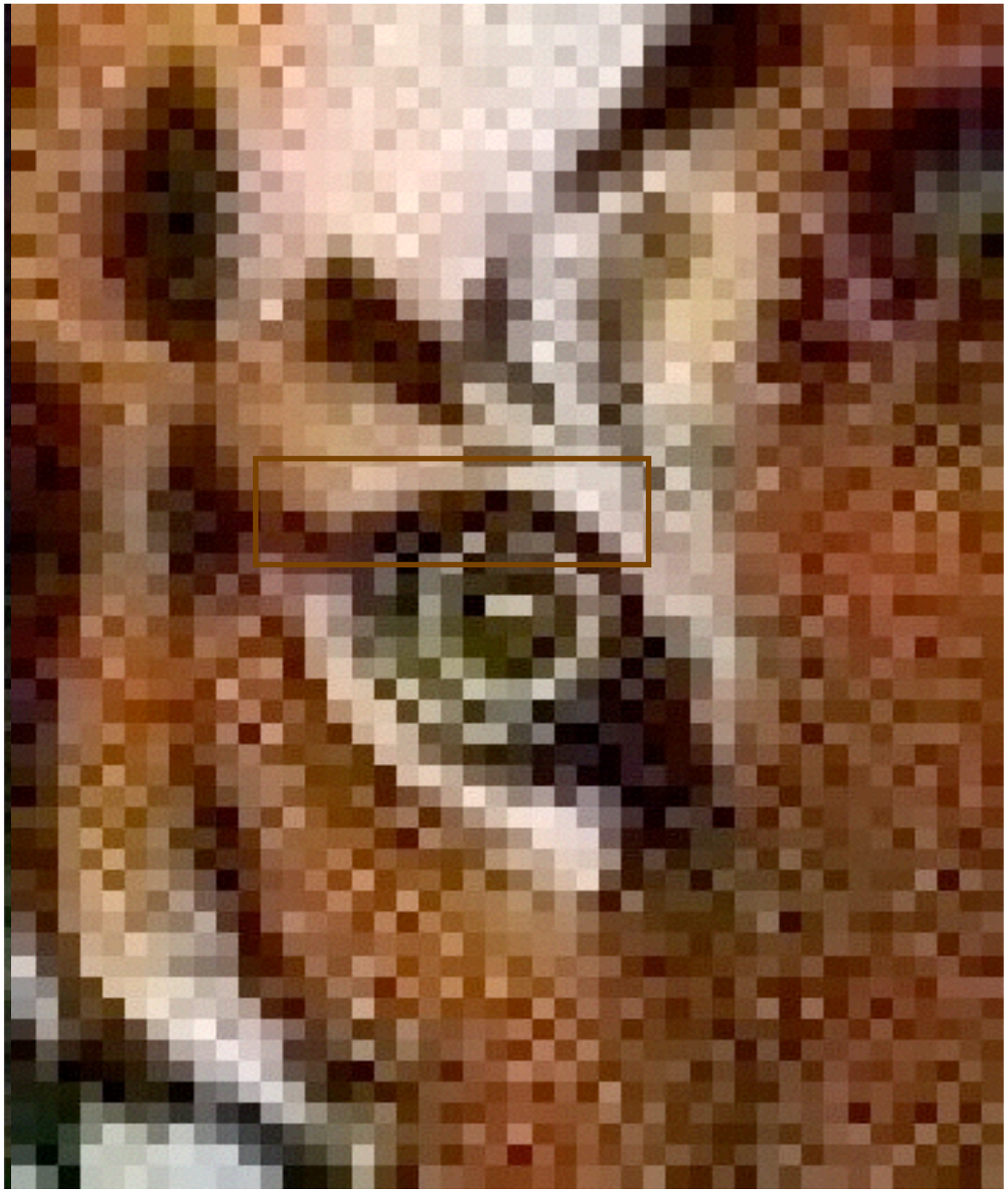
Can we give a definition for computer graphics?

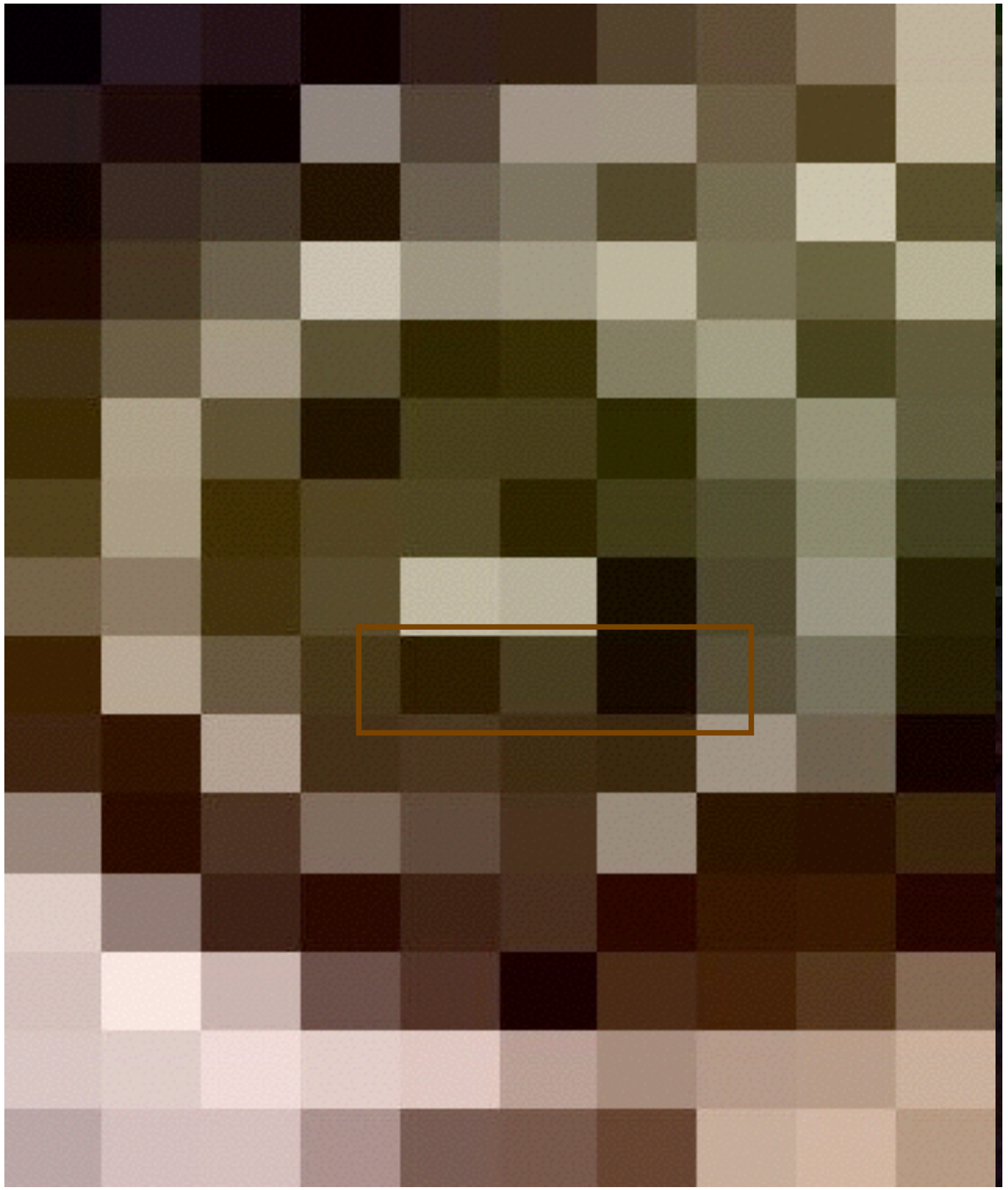
Computer Graphics

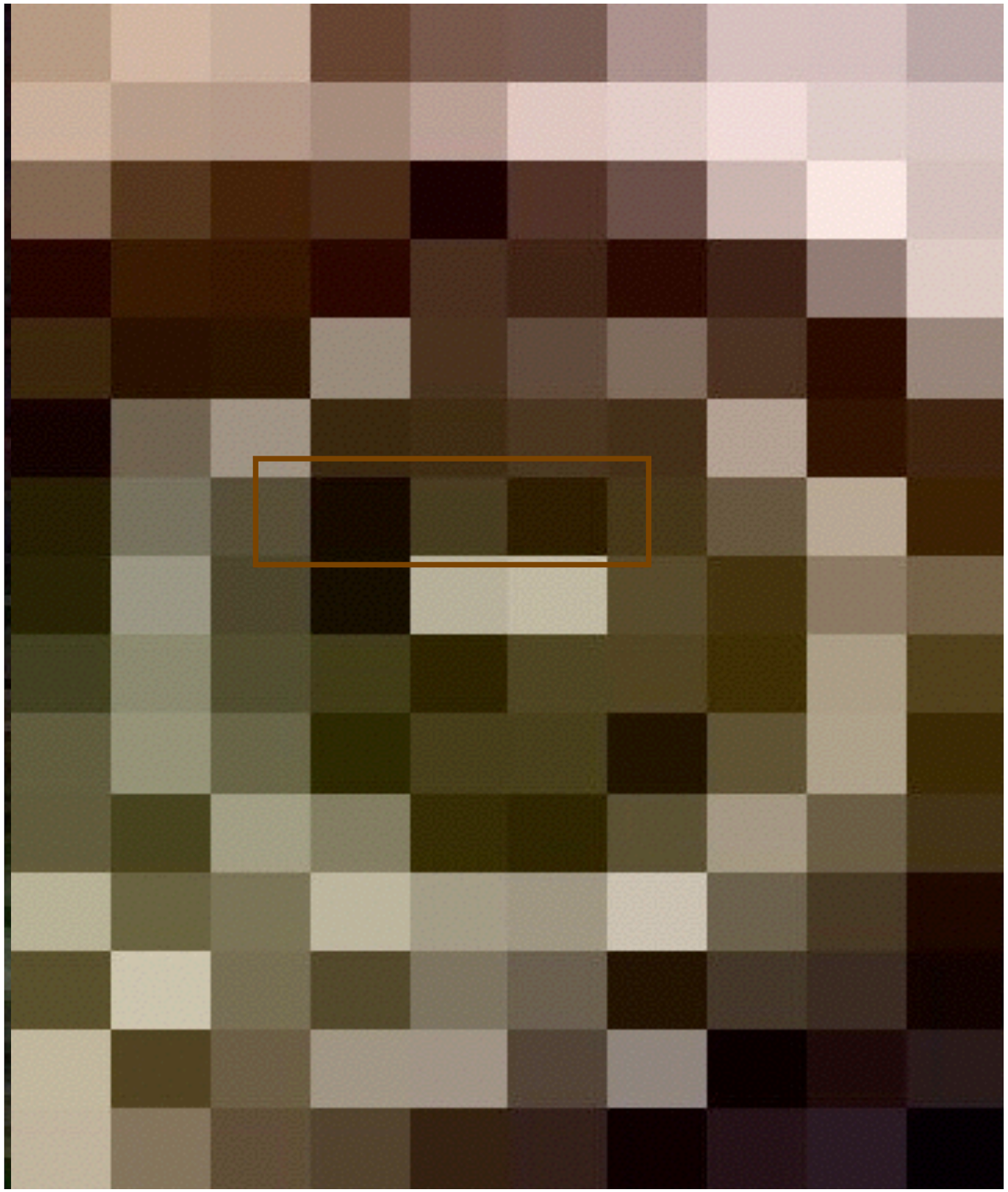
One of many different descriptions

- The science and technology of imaging the world in pixels, such that it provides the real experience (looks real, sounds real, feels real)

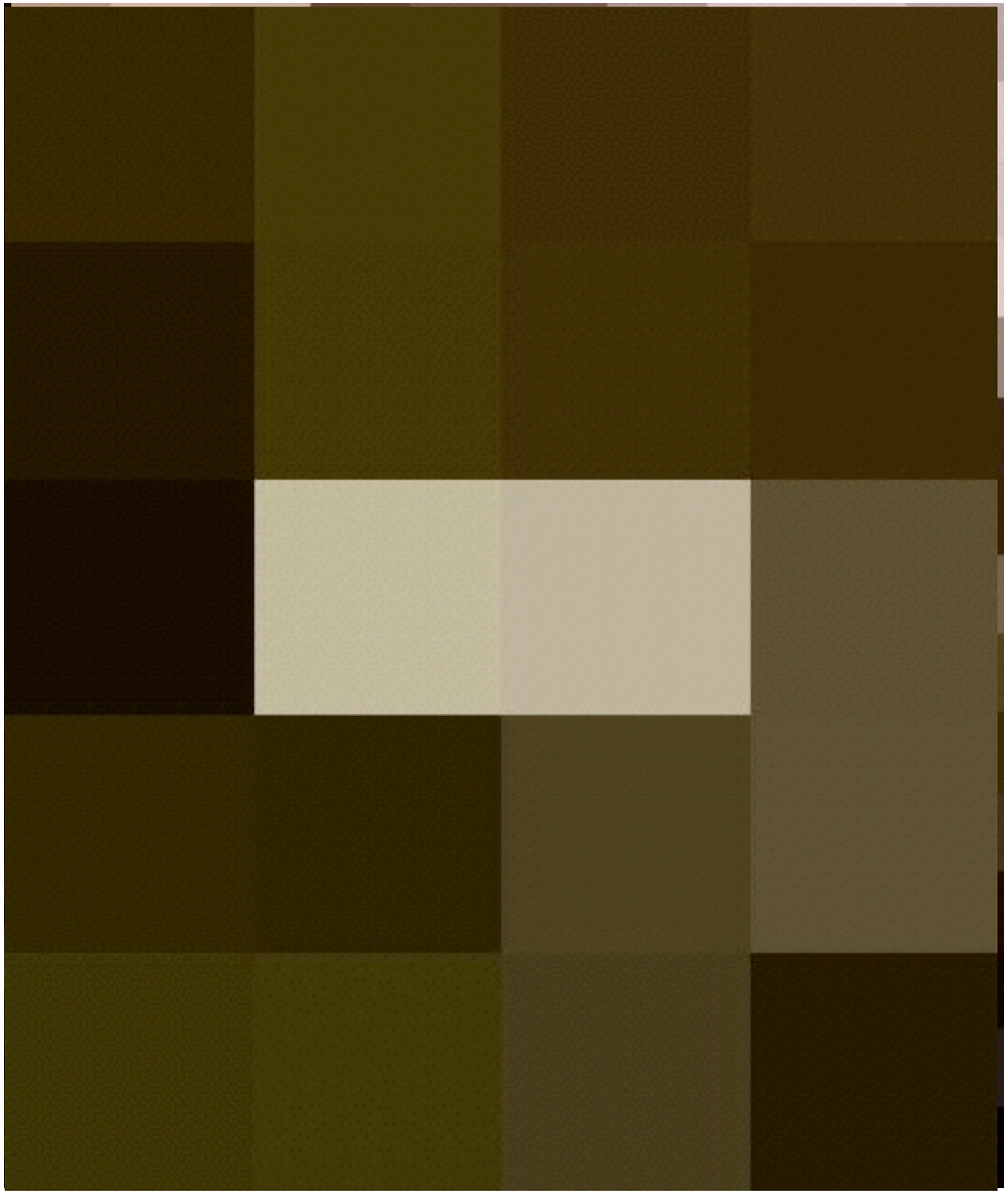








And last …



And last …

Pixel Representation Problem

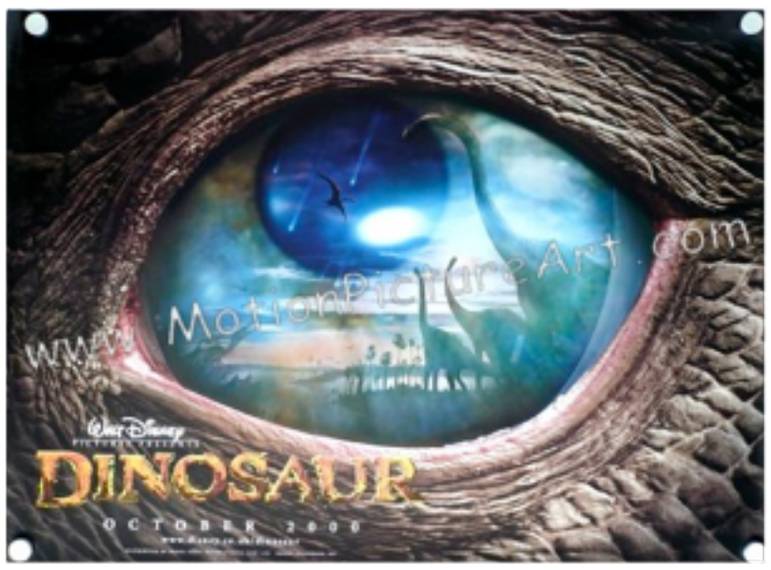
- The pixel has only two properties:
  - area of the pixel is fixed
  - color of the pixel is set under program control

- Image: array of pixels

Computer Graphics

recommended description

- The science and technology of modeling , processing and displaying objects in the world in a computer



Three Fundamental Tasks

Computer Graphics

- Modeling
- Animation (simulating)
- Rendering (displaying)

Three Fundamental Tasks

- Modeling the World (World Representation)
- Simulating the behavior of objects in the world
- Displaying the World

- Geometry and Physics are the traditional tools

Different Digital Representations of the World

- Digital Images
- 3D Geometric Objects (Graphics)
- Symbolic Descriptions

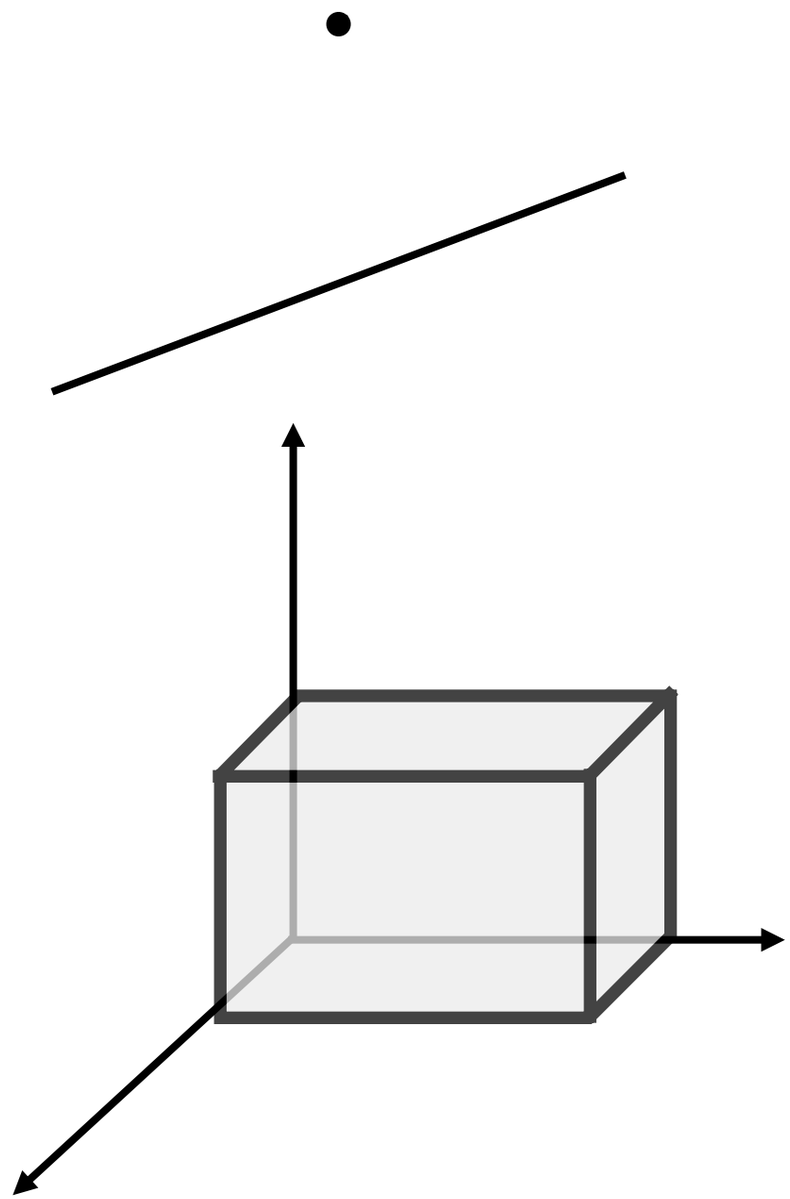
- Question:
  - Advantages and disadvantages ?

Different Digital Representations of the World

- Digital Images
- 3D Geometric Objects (Graphics)
- Symbolic Descriptions

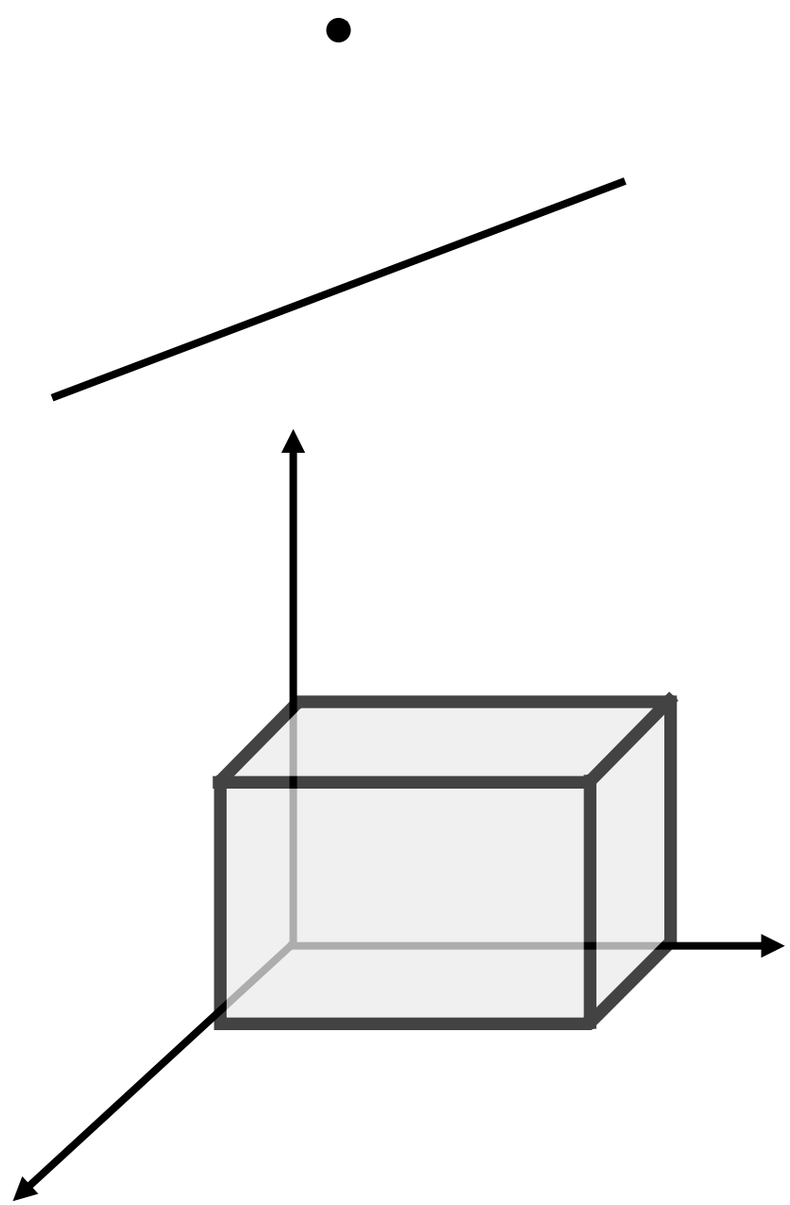
- Question:
  - Difference?
  - Advantages and disadvantages ?

Graphics Representation



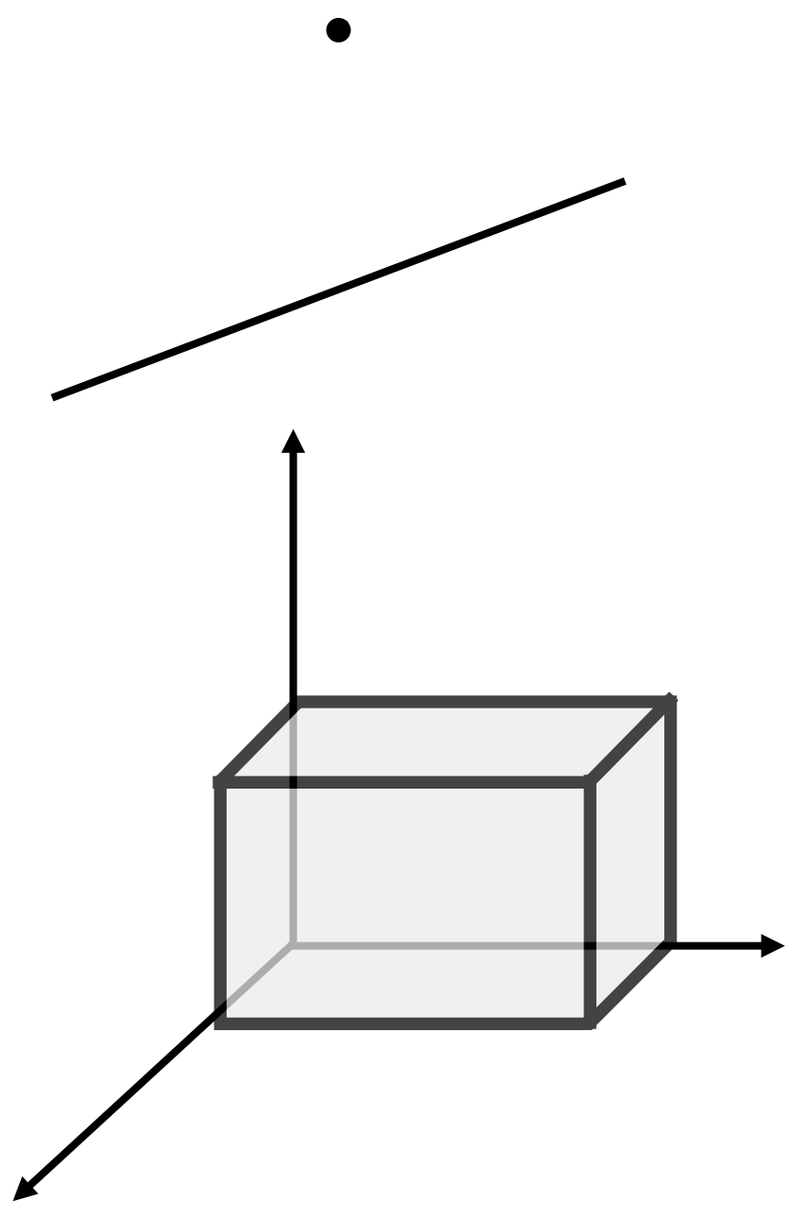
Graphics Representation

- find appropriate data structure to represent the object



Graphics Representation

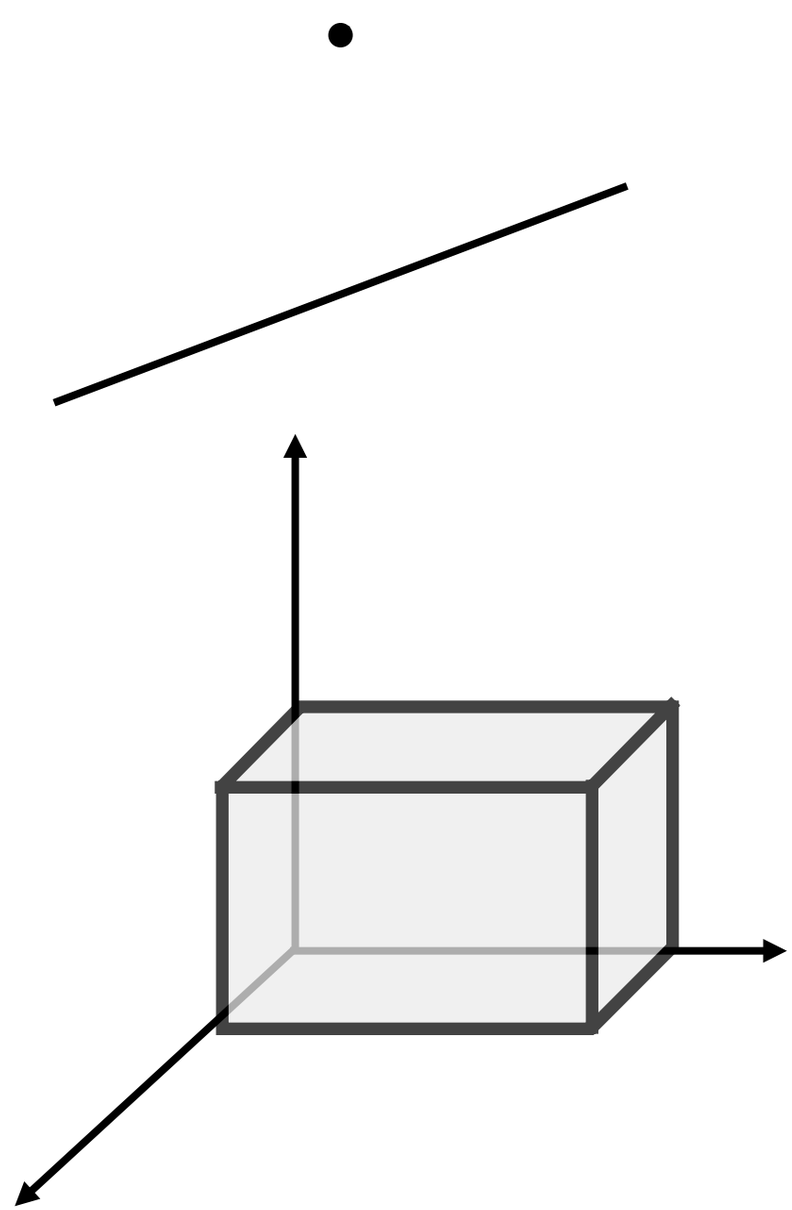
- find appropriate data structure to represent the object



Graphics Representation

- find appropriate data structure to represent the object

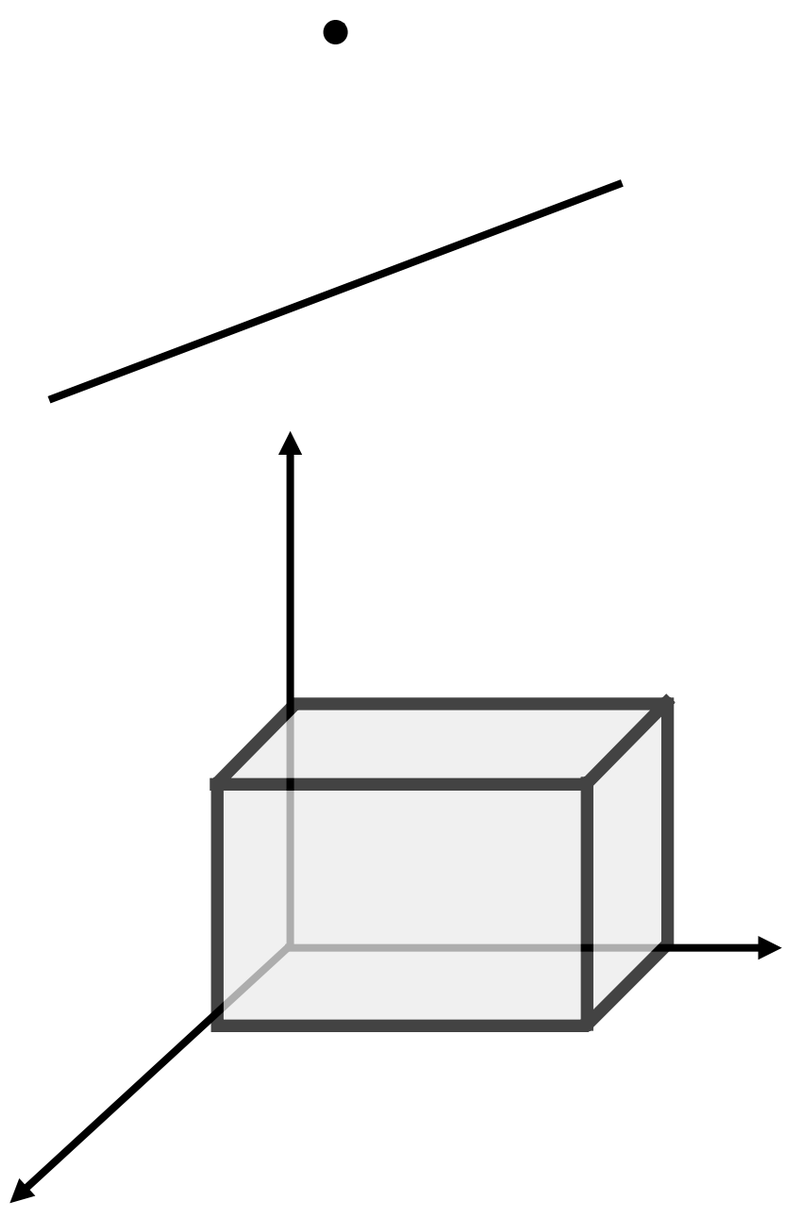
```
Point3D {
        double x;
        double y;
        double z;
```



Graphics Representation

- find appropriate data structure to represent the object

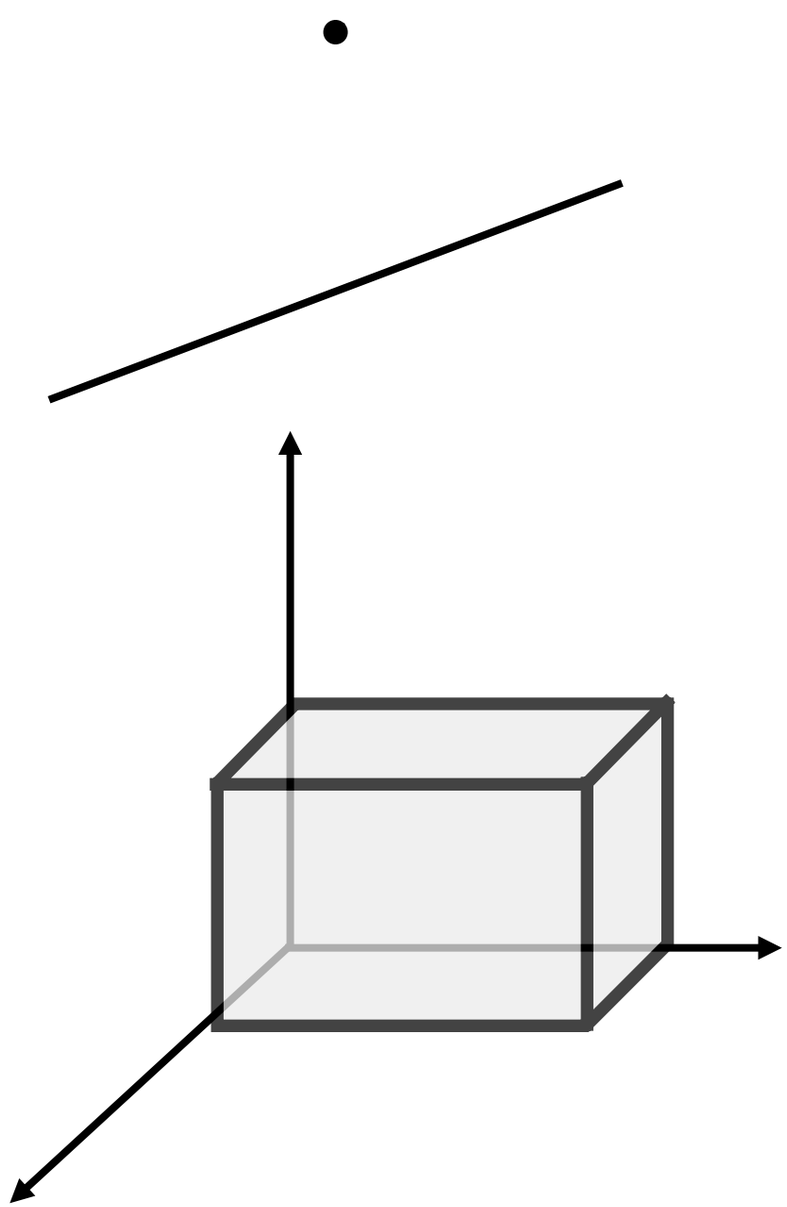
```
Point3D {
        double x;
        double y;
        double z;
}
```



Graphics Representation

- find appropriate data structure to represent the object

```
Point3D {
        double x;
        double y;
        double z;
}
```

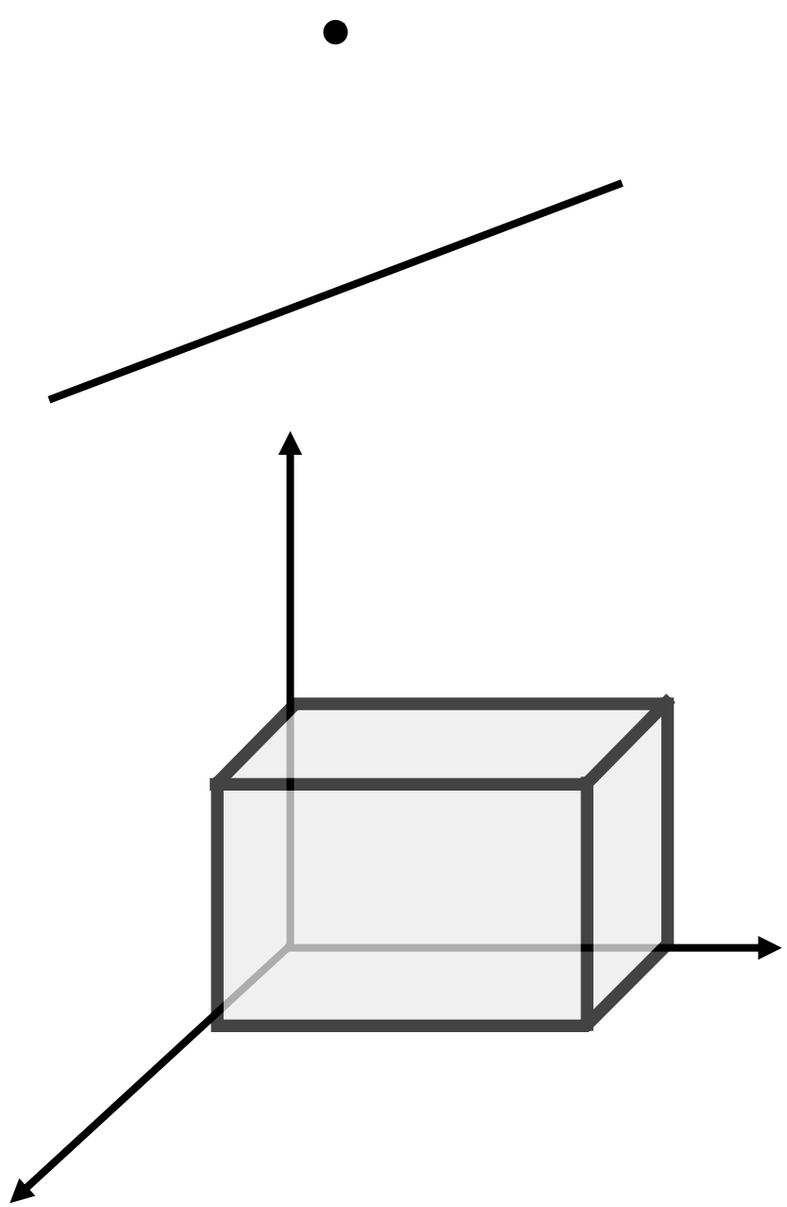


Graphics Representation

- find appropriate data structure to represent the object

```
Point3D {
        double x;
        double y;
        double z;
}

Cuboid {
        Point3D location;
        double x;
        double y;
        double z;
```

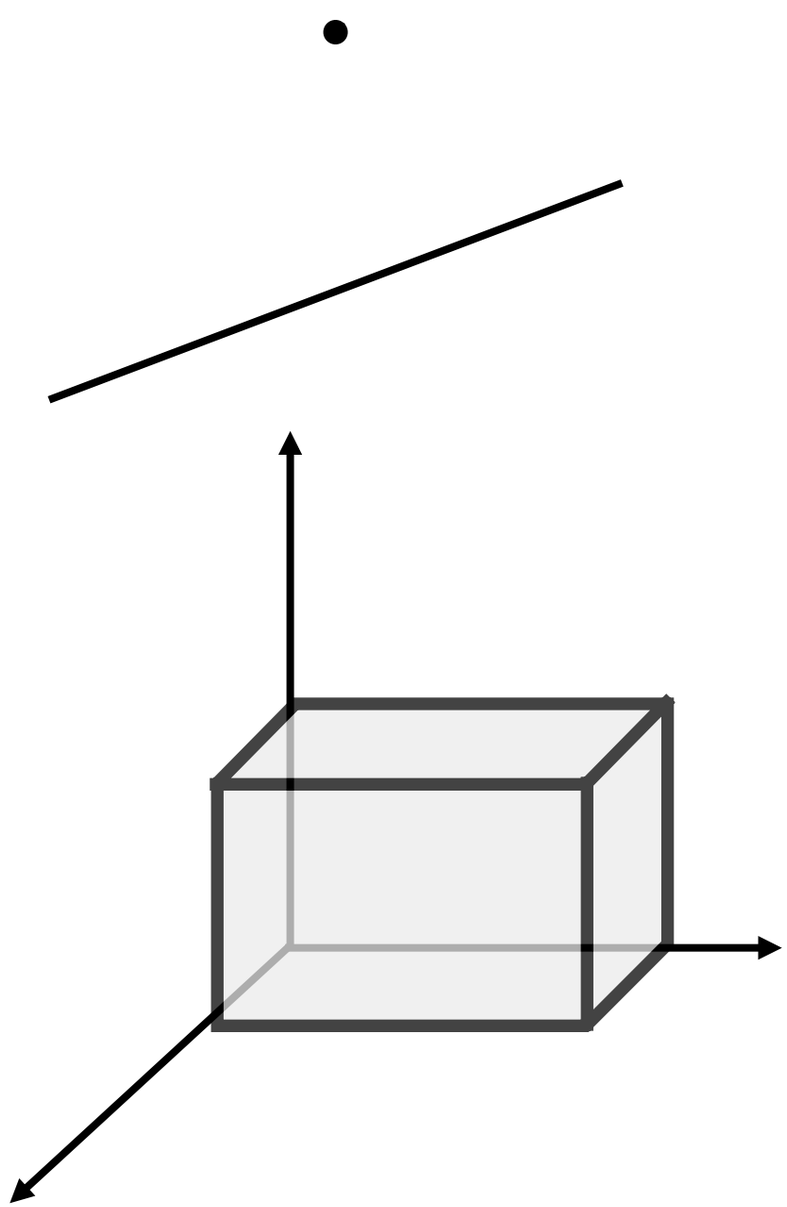


Graphics Representation

- find appropriate data structure to represent the object

```
Point3D {
        double x;
        double y;
        double z;
}

Cuboid {
        Point3D location;
        double x;
        double y;
        double z;
}
```



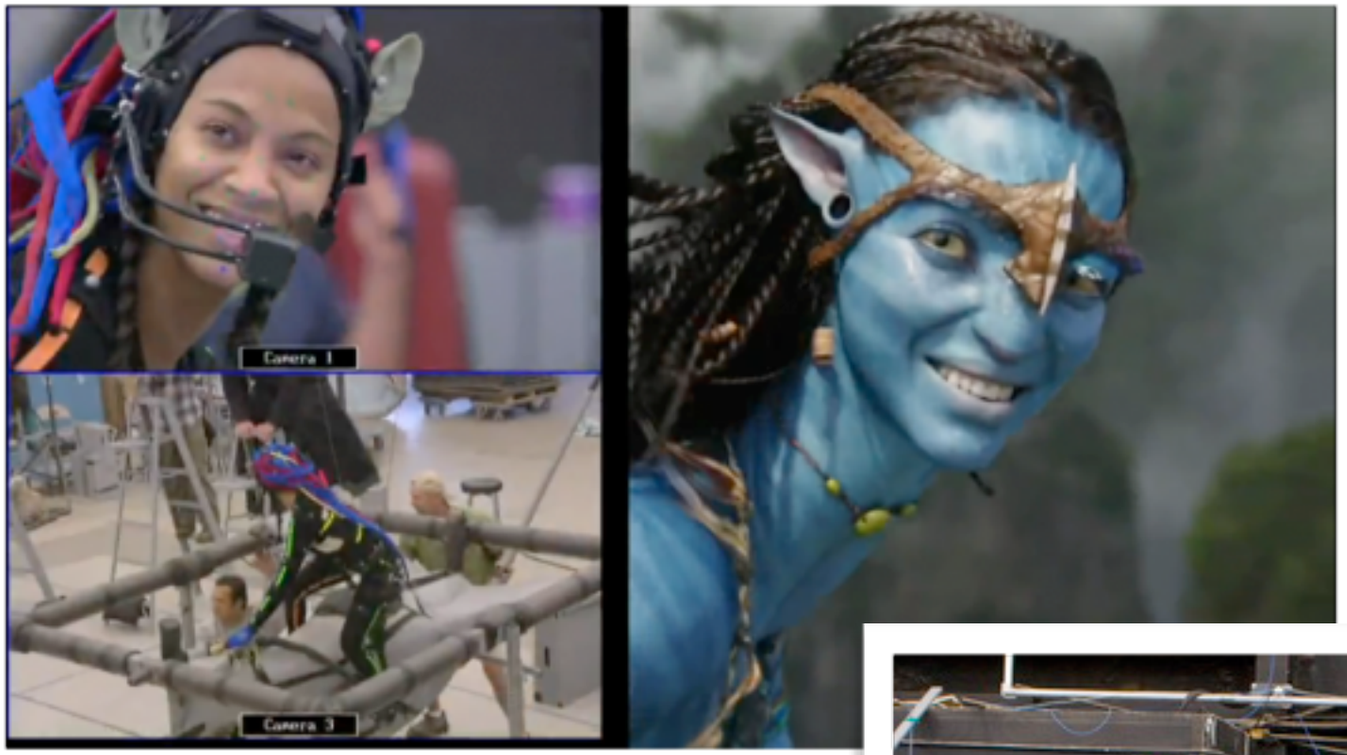
World Representation Problem

- Three very important and rather complex attributes:
  - complex shape (desk, tree, water, animal, people)
  - visual look or appearance due to lighting effects
  - dynamic behavior due to interaction with other elements of the world -- movement, sound, elastic effects, ...

Three Fundamental Tasks

- Modeling the World (World Representation)
- Simulating the behavior of objects in the world
- Displaying the World

- Geometry and Physics are the traditional tools


Camera 1
Camera 3

Three Fundamental Tasks

- Modeling the World (World Representation)
- Simulating the behavior of objects in the world
- Displaying the World

- Geometry and Physics are the traditional tools

Displaying the World

- I/O of Computer Graphics
  - Input : graphics : object (shape, material,...)
  - Output : image : array of pixels (RGB)

Different Digital Representations of the World

- Digital Images
- 3D Geometric Objects (Graphics)
- Symbolic Descriptions
- Region of Object in an Image

Visual Computing Fields

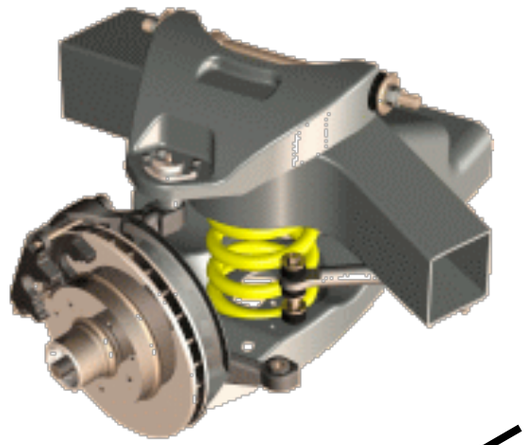
- Image Processing
  - Image$\Longrightarrow$image, image$\Longrightarrow$region
- Pattern Recognition
  - Image$\Longrightarrow$symbolic descriptions
- Computer Vision
  - Image$\Longrightarrow$graphics
- Computer Graphics
  - Graphics$\Longrightarrow$image, graphics$\Longrightarrow$graphics

Computer Graphics Applications

- Use is all pervasive (No computer application domain untouched by Computer Graphics)
  - CAD
  - GIS
  - Movie, Animation
  - Game
  - Scientific visualization
  - Virtual Reality
  - User interface

Computer Graphics Applications

Computer Graphics Applications



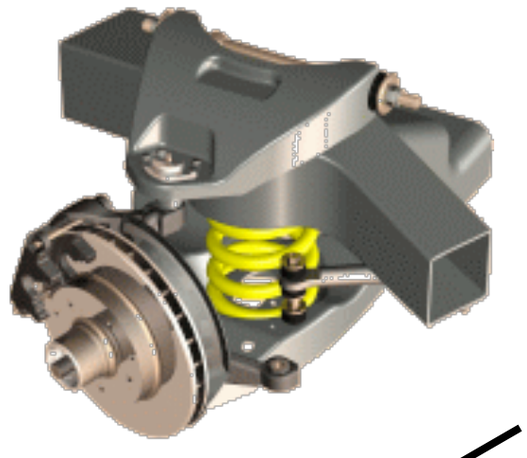
CAE

2D Drawing
(AutoCAD)

3D modeling
(Pro/E, UG, CATIA)

CAM

Computer Graphics Applications



CAE

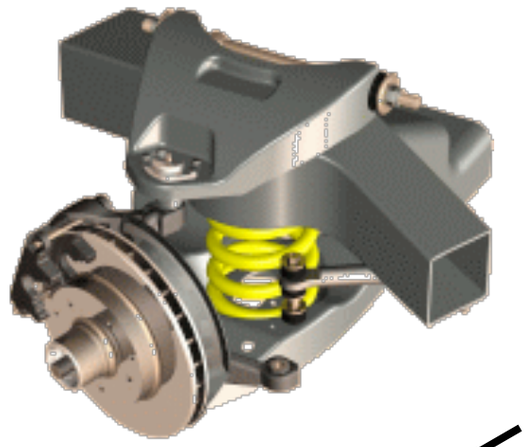
2D Drawing
(AutoCAD)

3D modeling
(Pro/E, UG, CATIA)

Computer Aided Drawing

CAM

Computer Graphics Applications



CAE

2D Drawing
(AutoCAD)

3D modeling
(Pro/E, UG, CATIA)

CAM

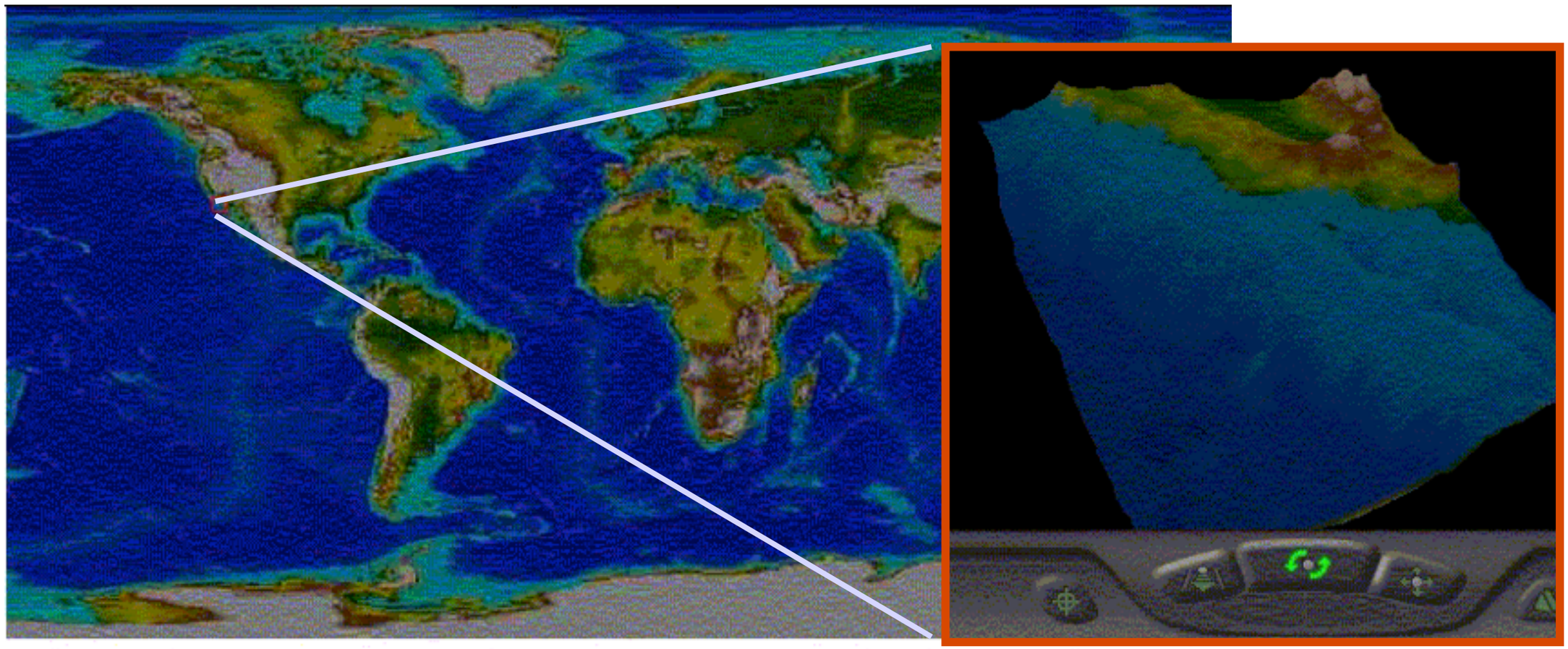
Computer Aided **Design**

Computer Graphics Applications

GIS: Geography information system

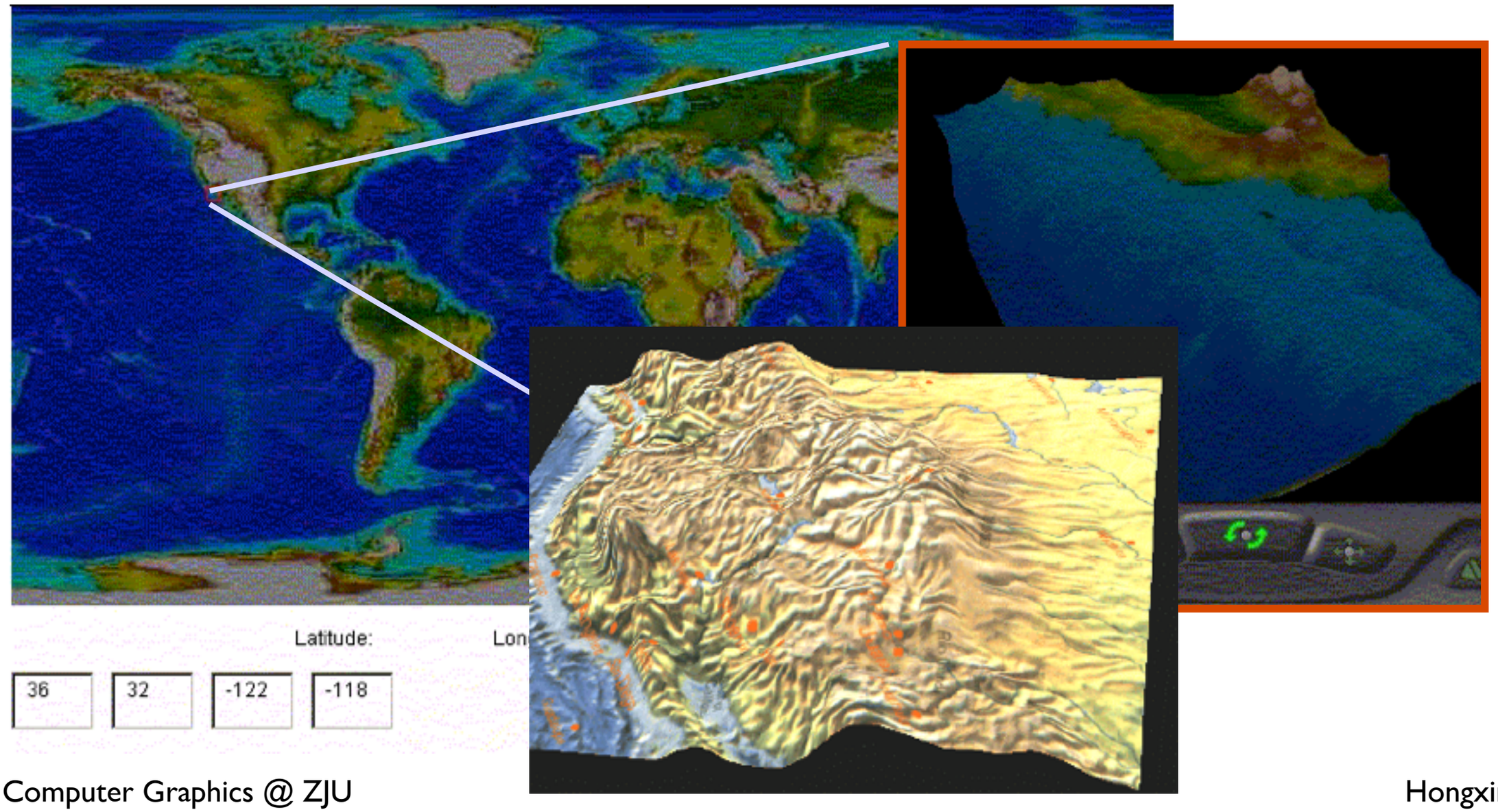
Computer Graphics Applications

GIS: Geography information system



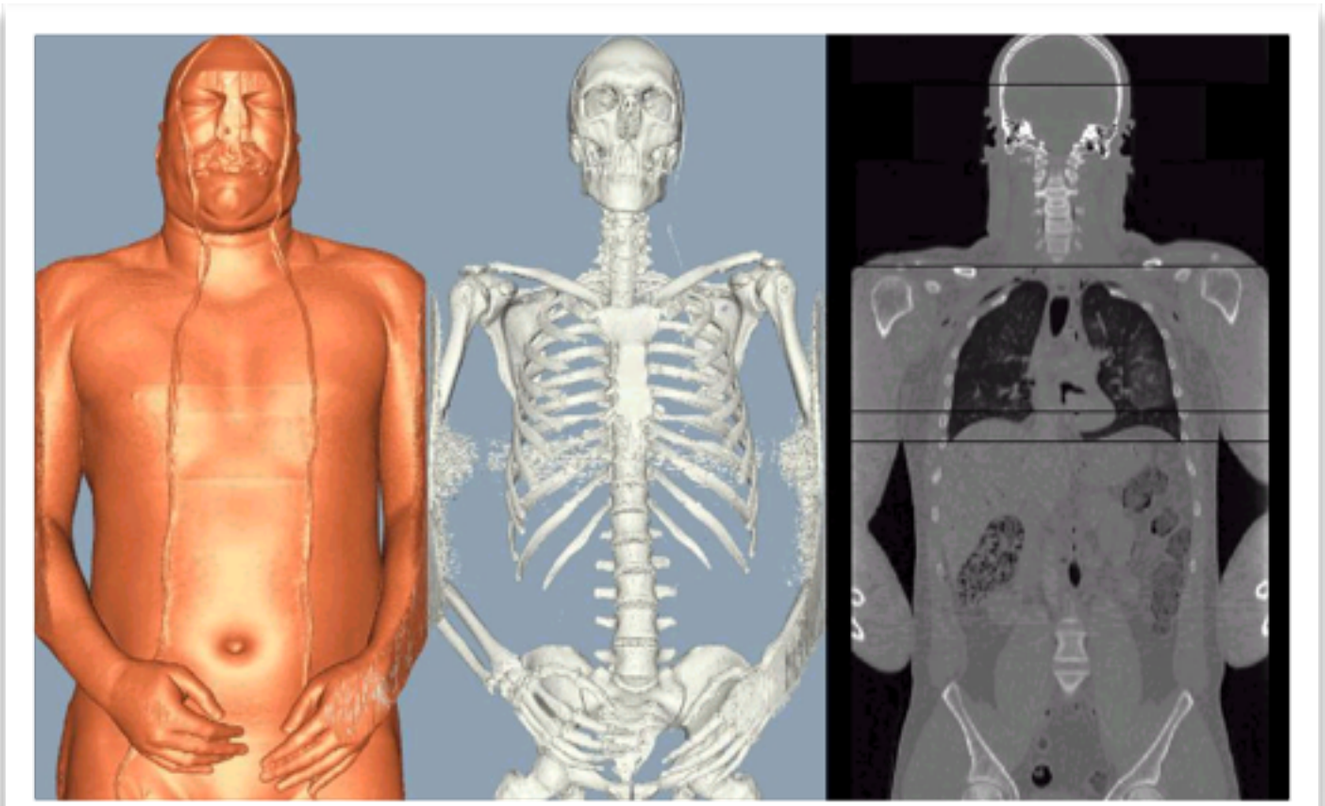
Computer Graphics Applications

GIS: Geography information system

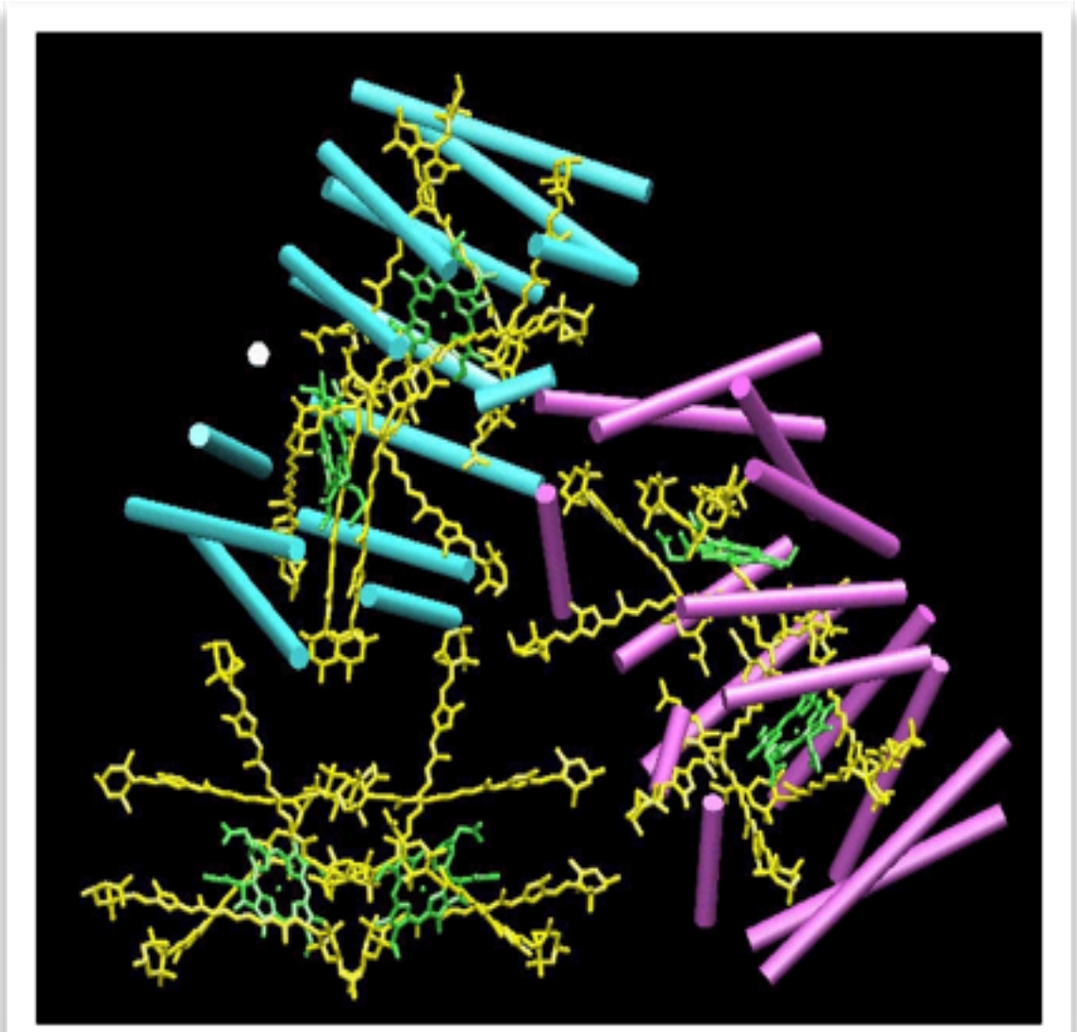


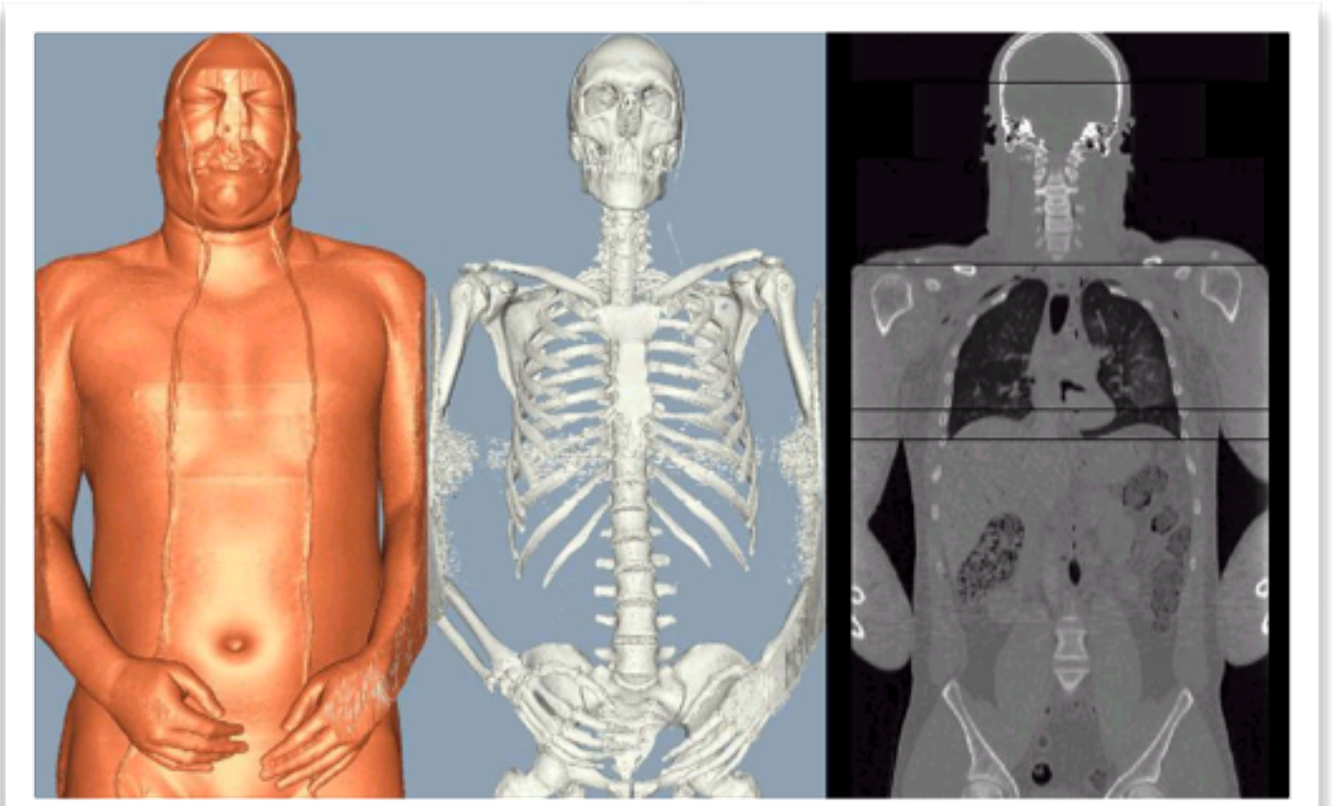
Visualization

Visualization

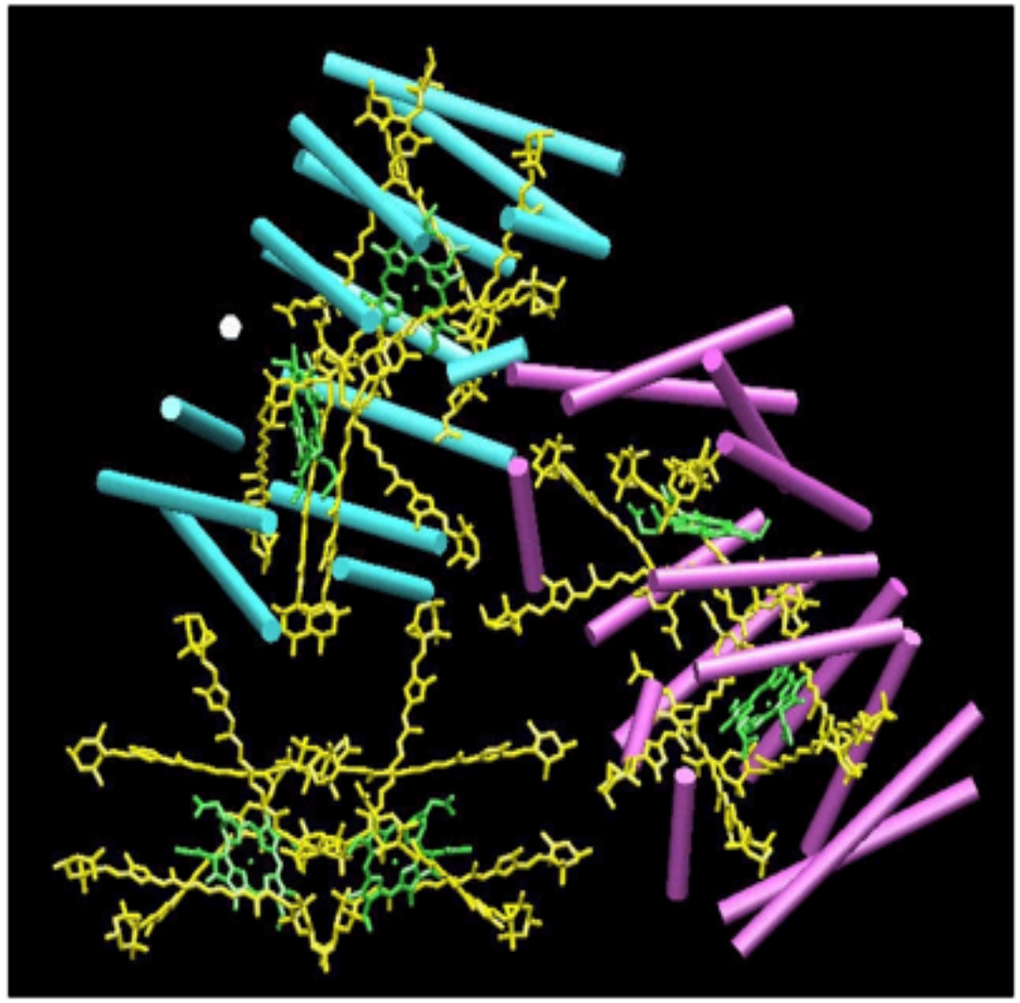


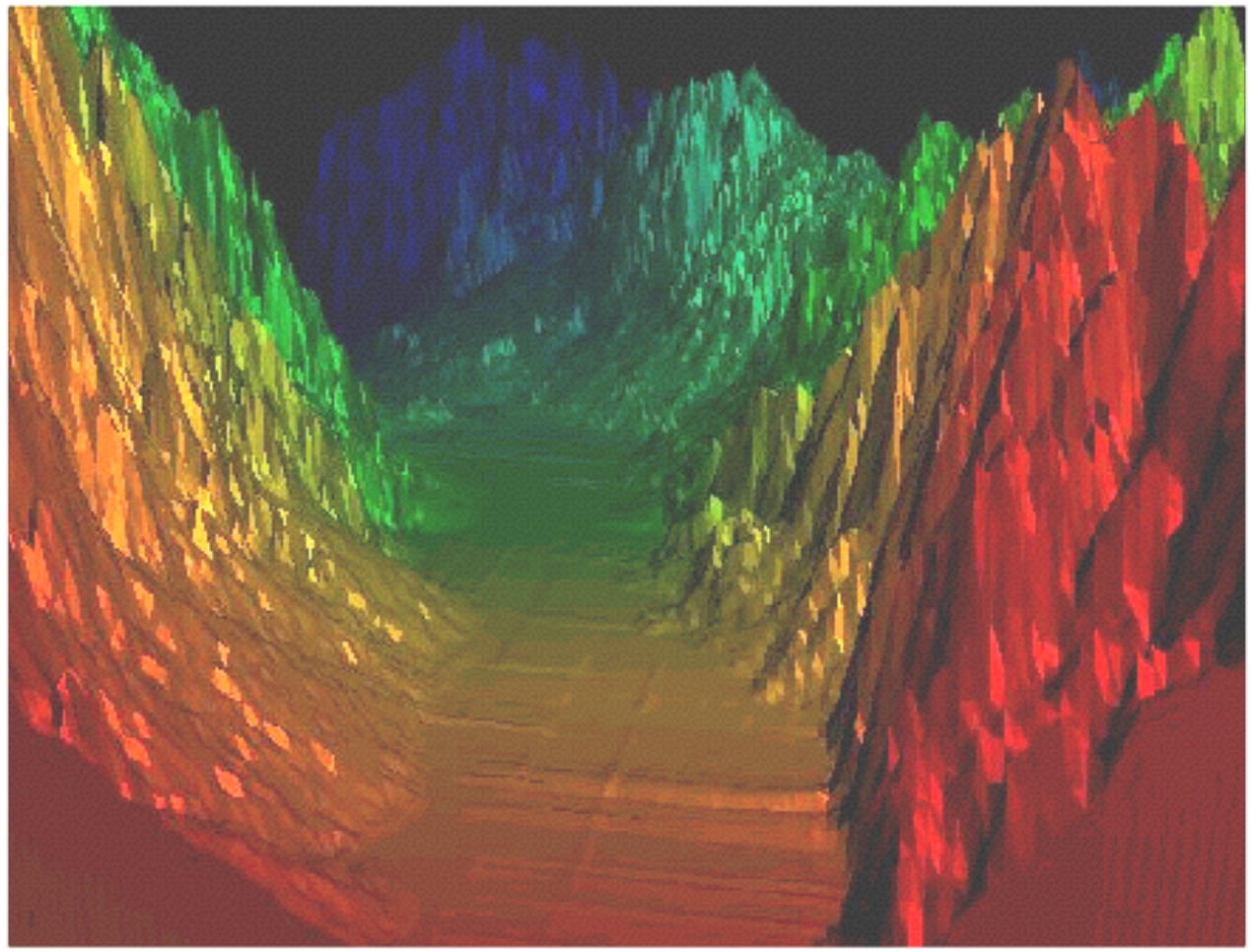
Visualization

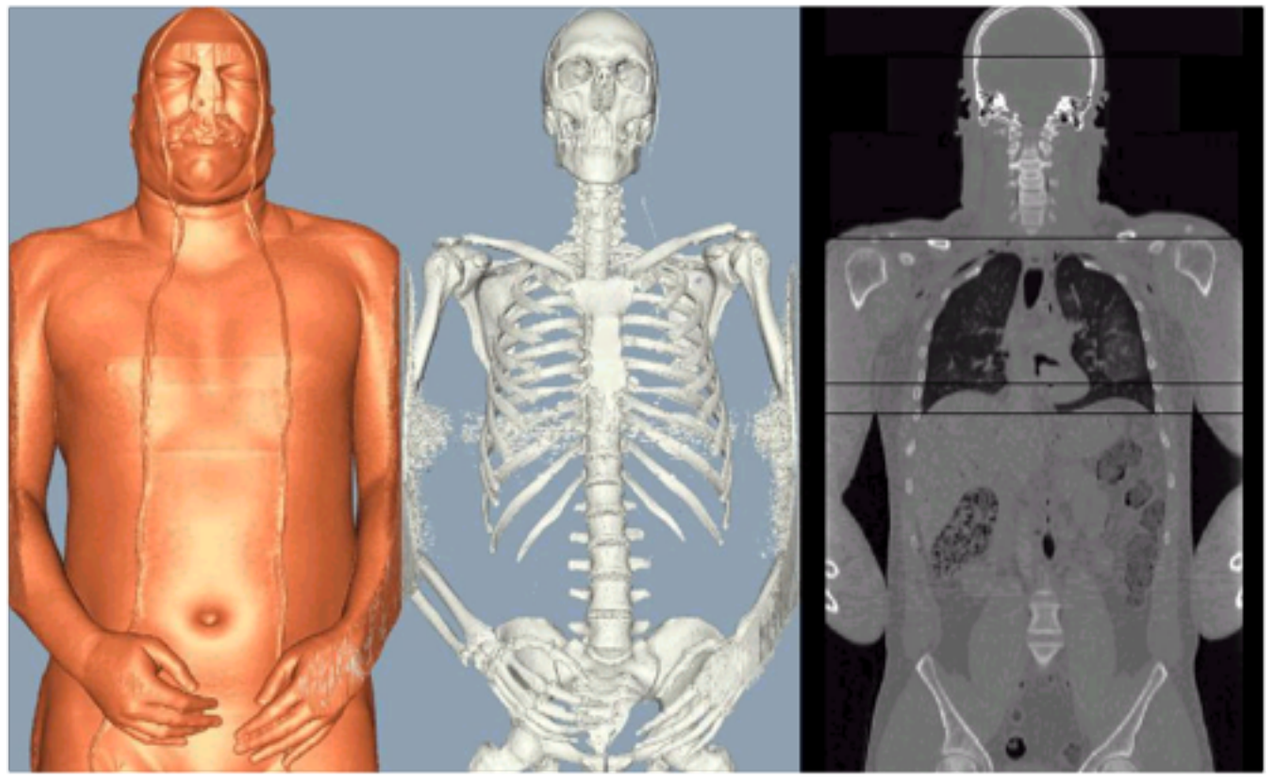




Visualization

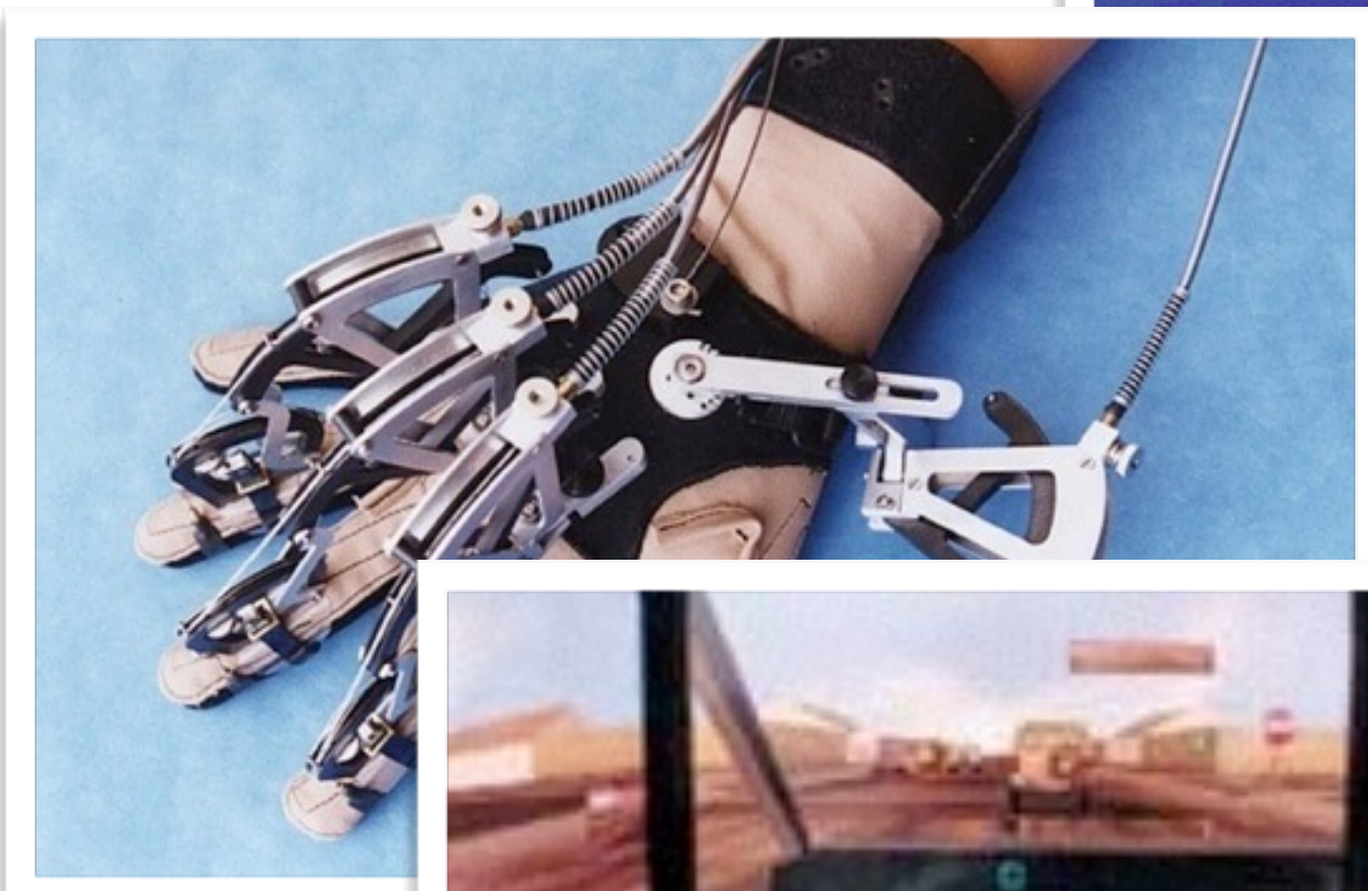






Virtual Reality

Virtual Reality



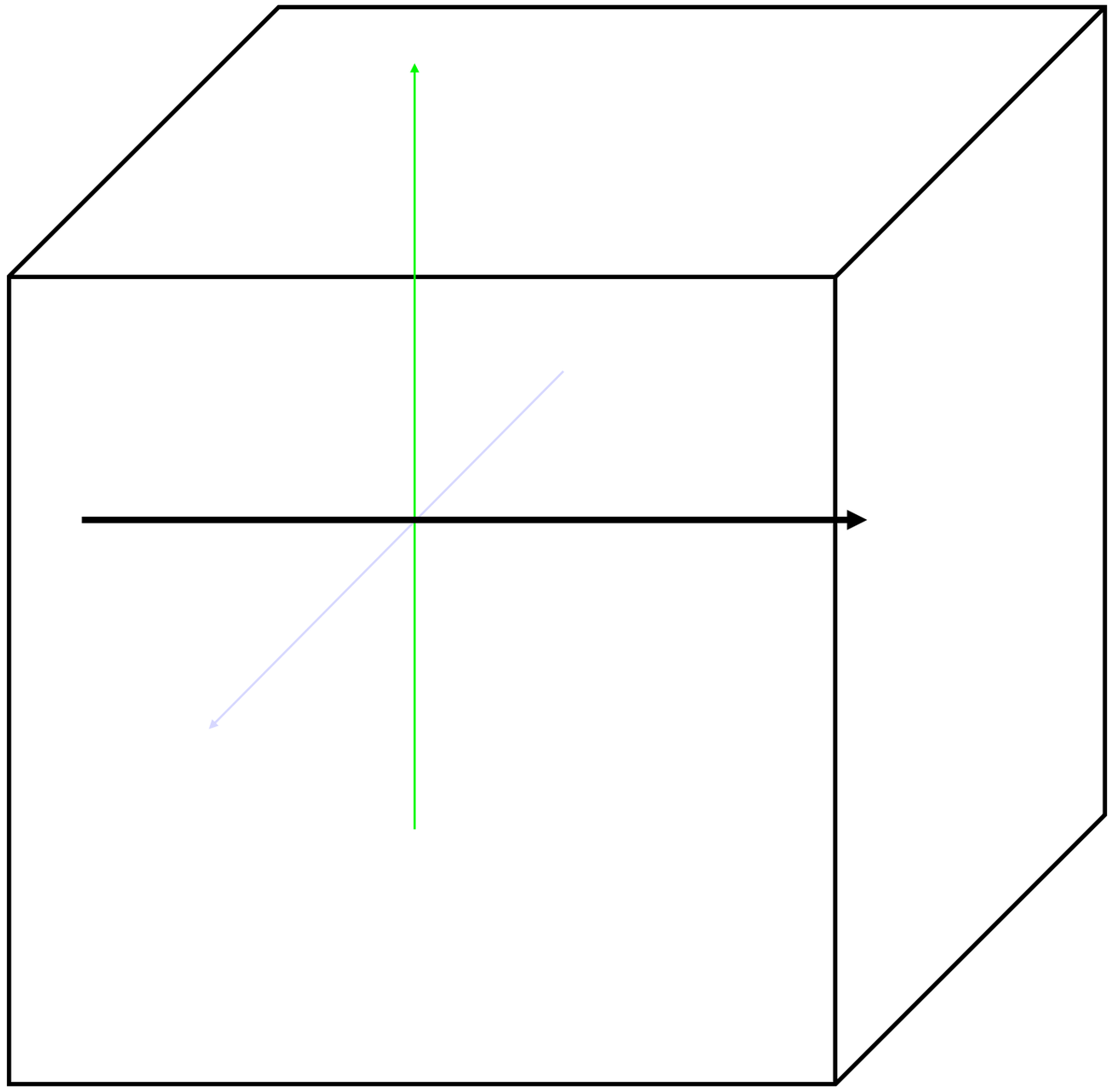
Technology Developments

- 1962 : Sutherland's Sketchpad
- 1970s: Special Hardware
- 1980s: Raster Graphics
- 1990s: Reality Engines
- 2000s: 3D acceleration

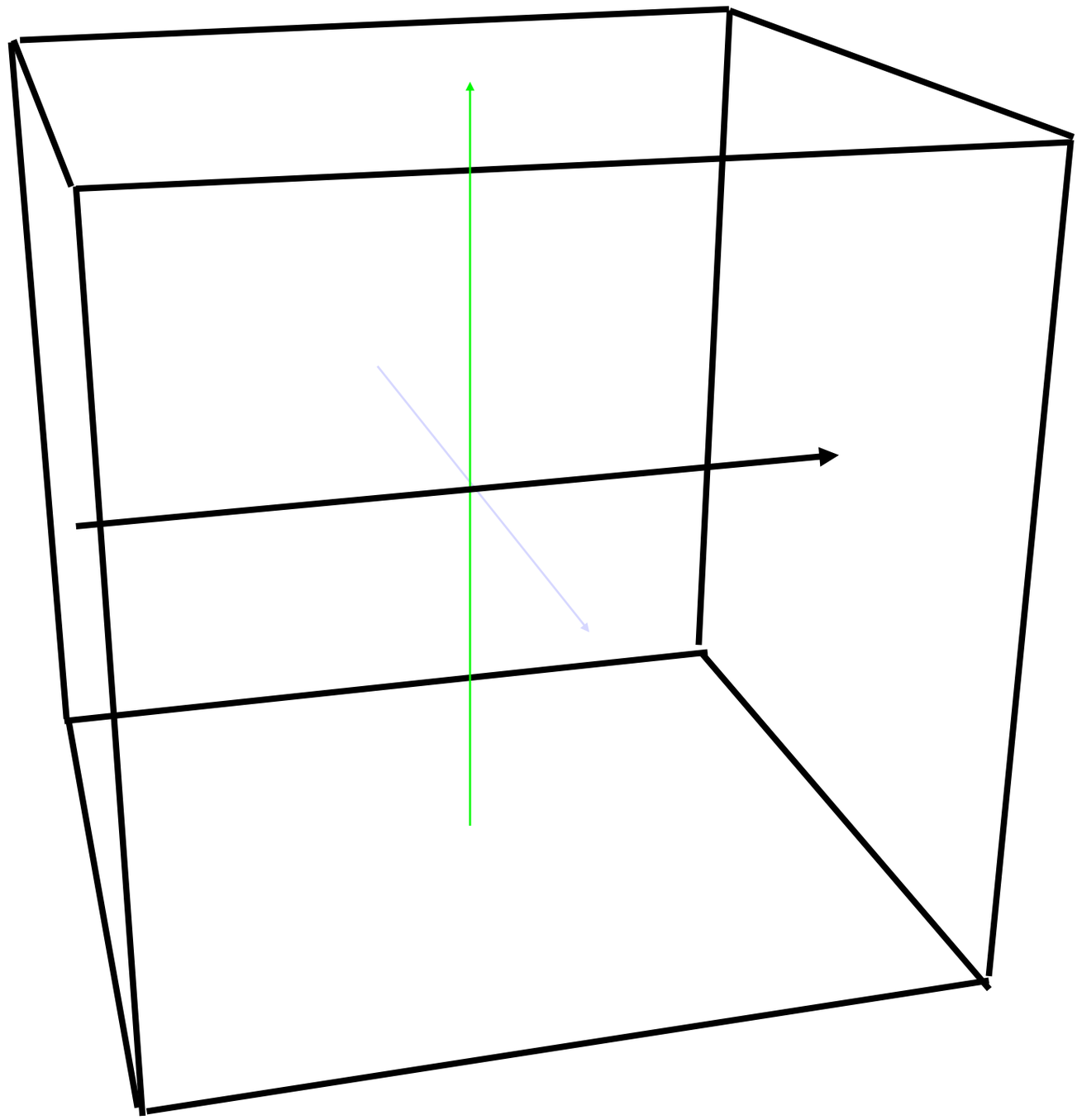
Topics Addressed in this Module

- Basics - Transformations and Synthetic Camera for Viewing the World

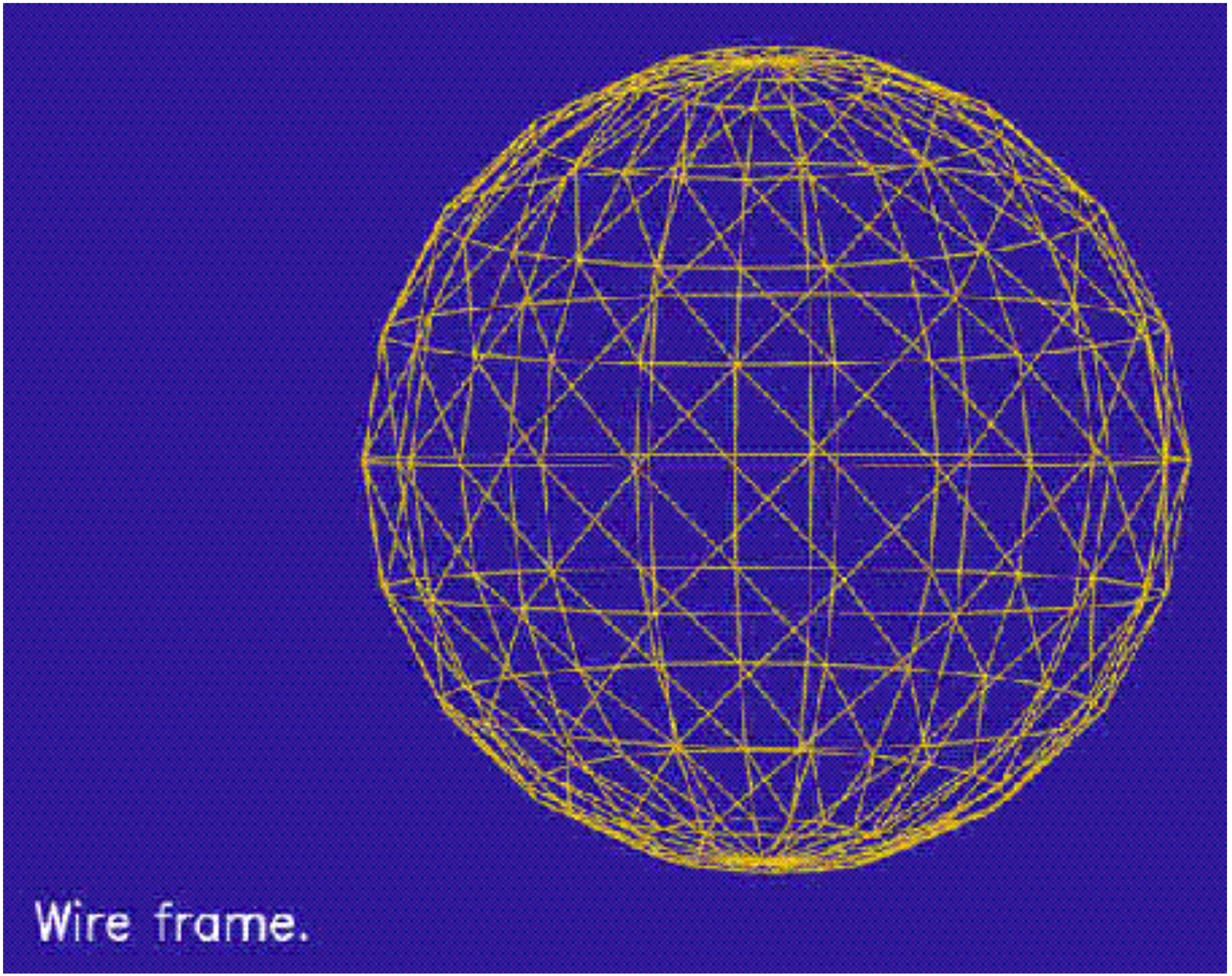
- Modeling techniques and tools - Meshes, Surfaces and Solid Objects

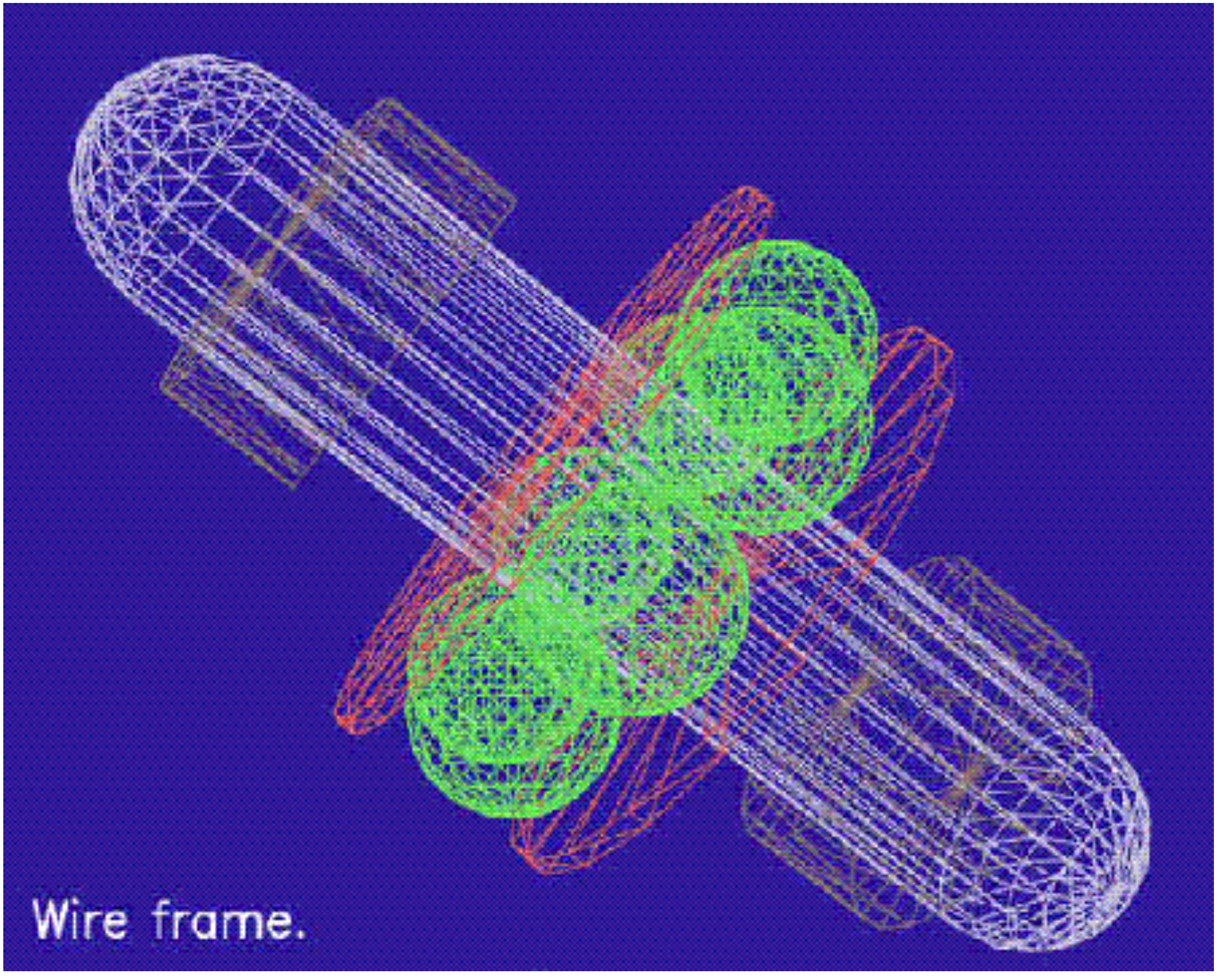


Parallel Projection



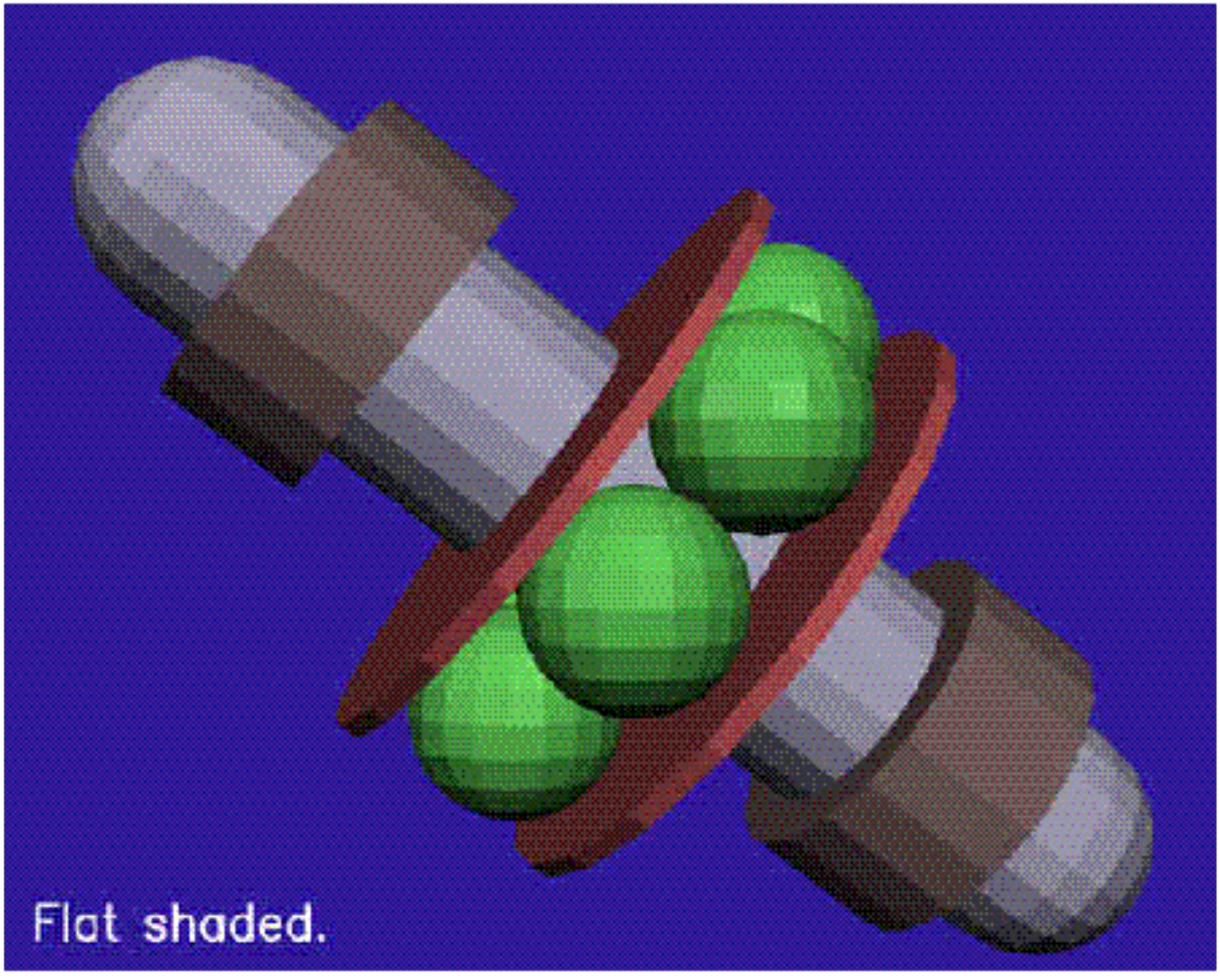
Perspective Projection

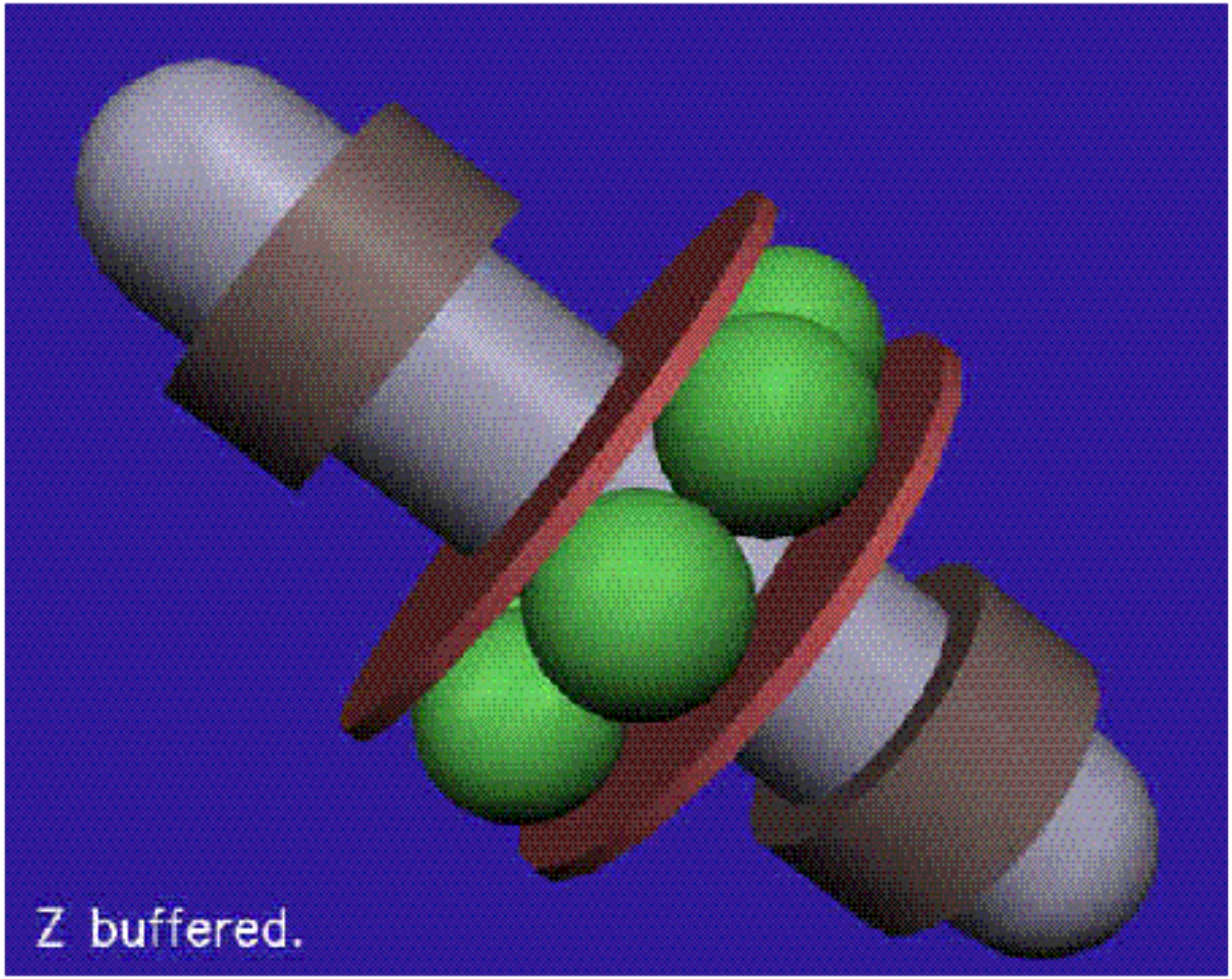

Wire frame.

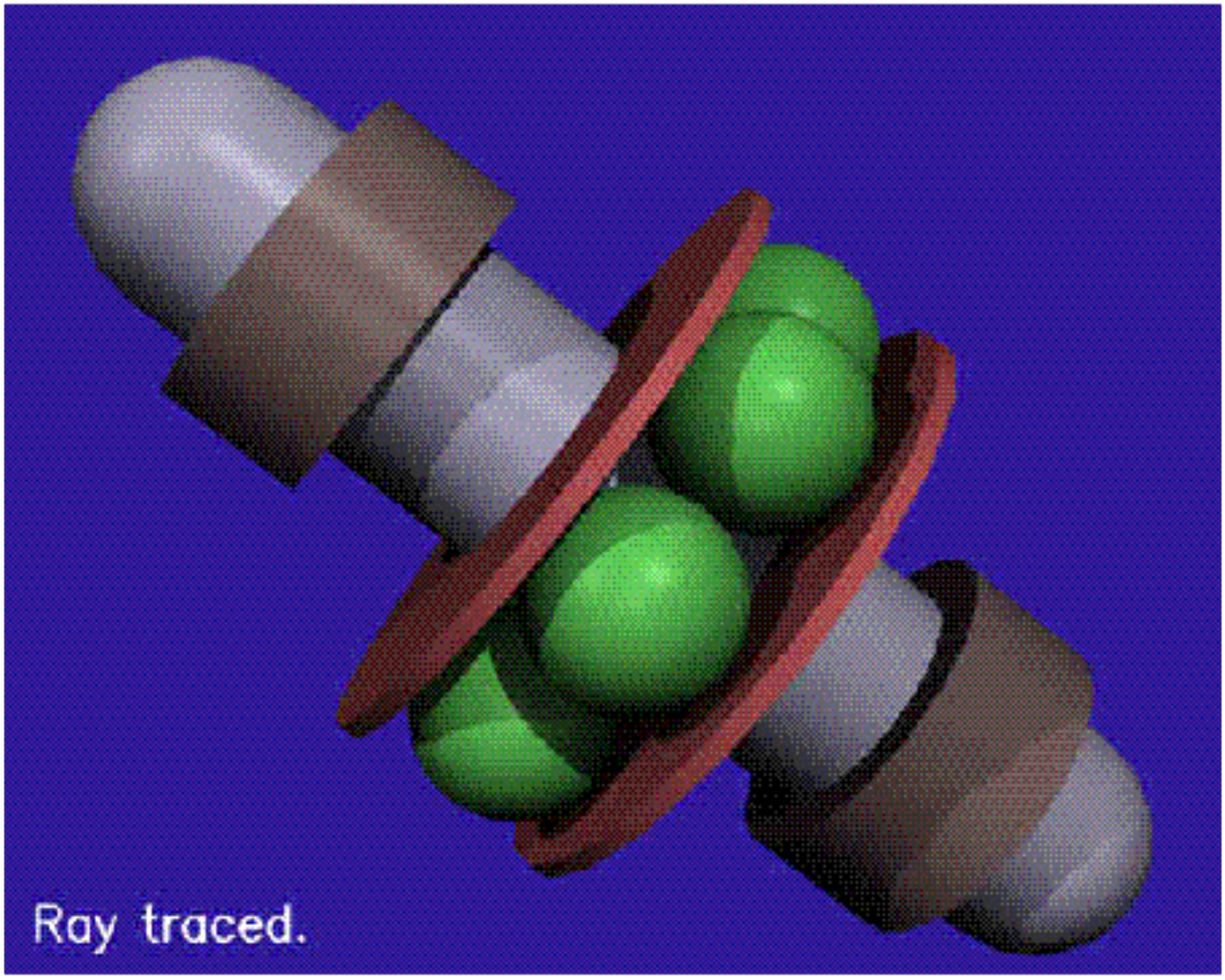

Wire frame.

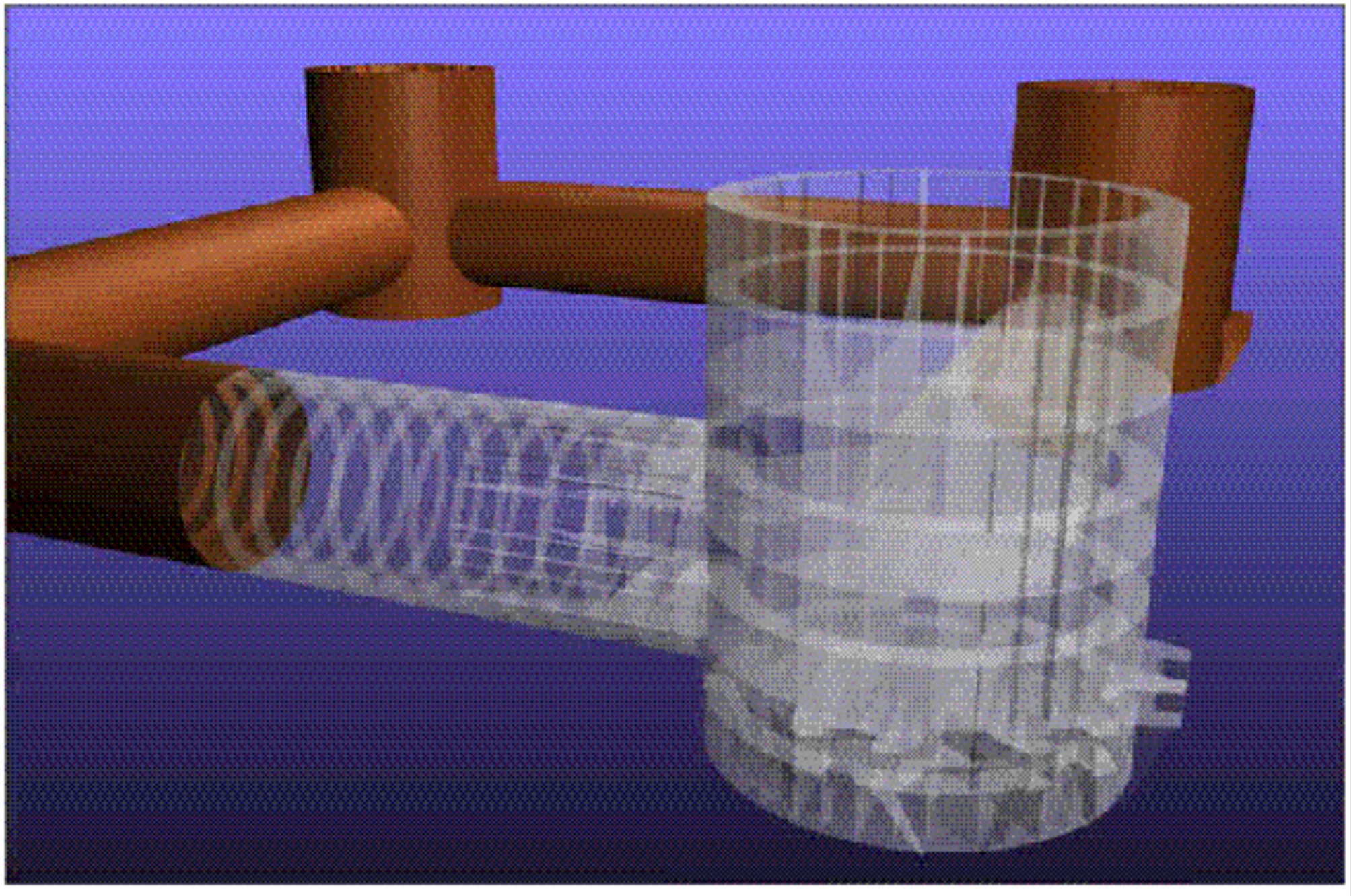
Topics Addressed (contd)

- Rendering techniques - visibility computation, illumination models, realistic imaging algorithms


Flat shaded.

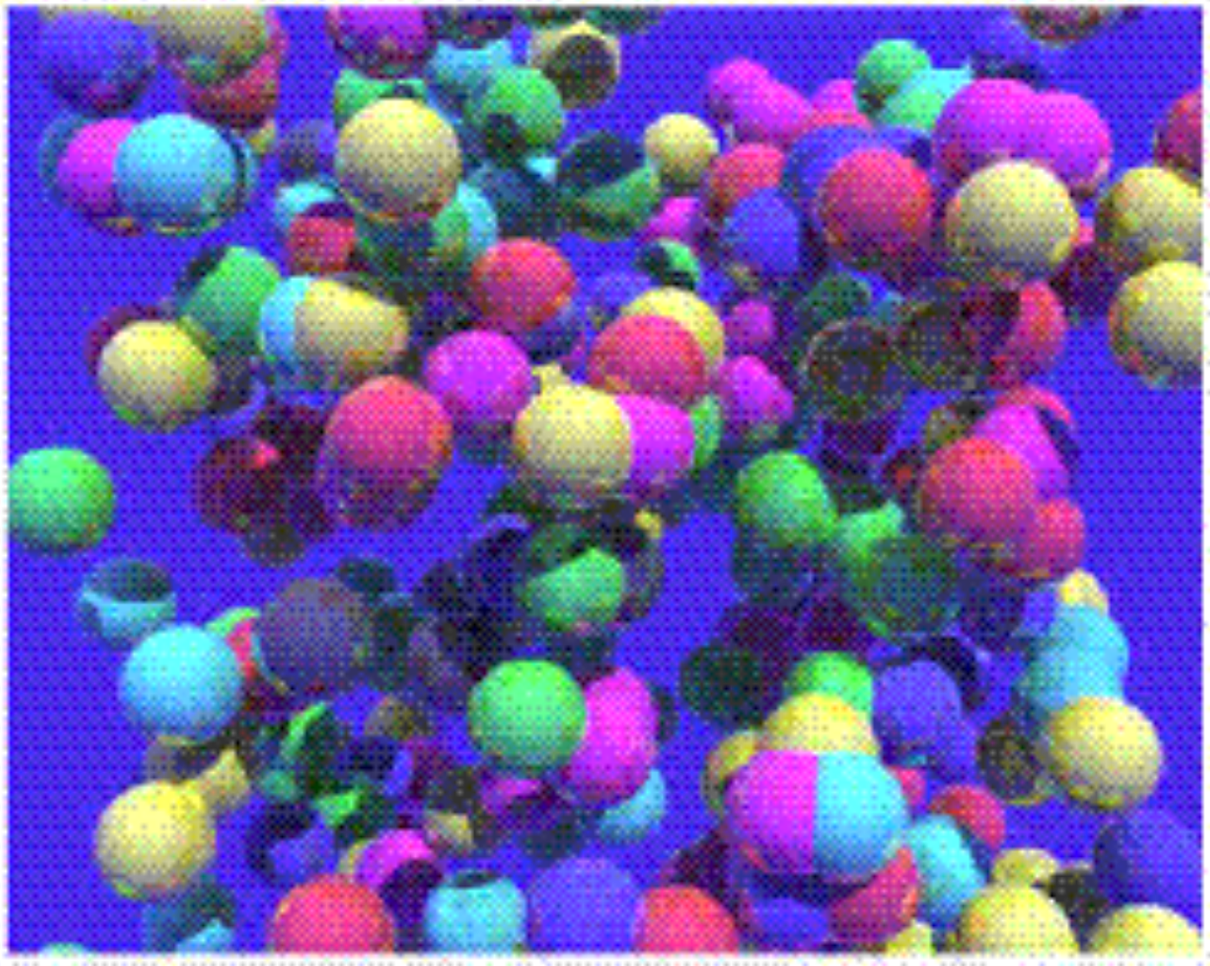

Z buffered.


Ray traced.



Texture Mapping
(Only Brief Overview)

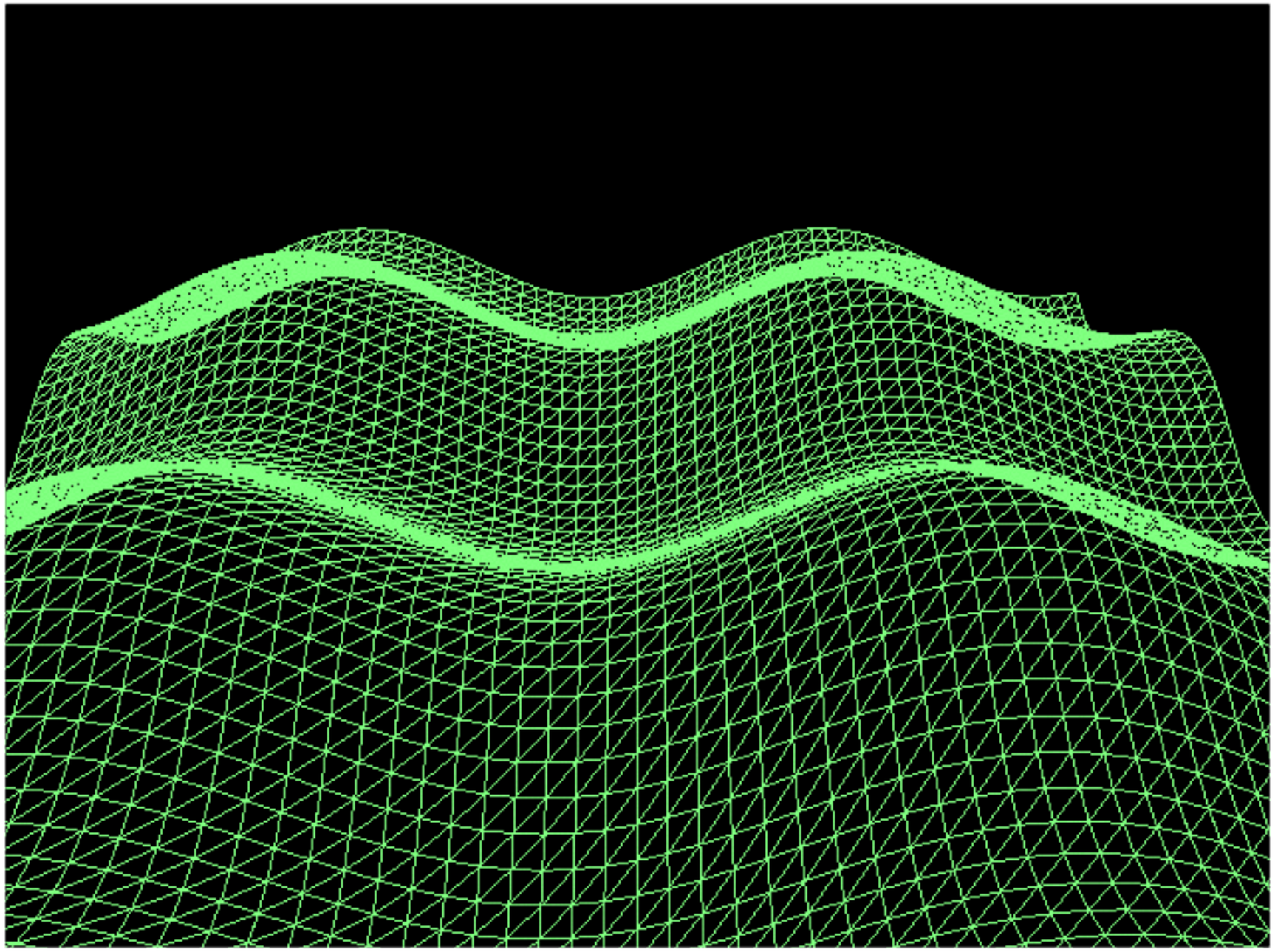
SPHEREO's

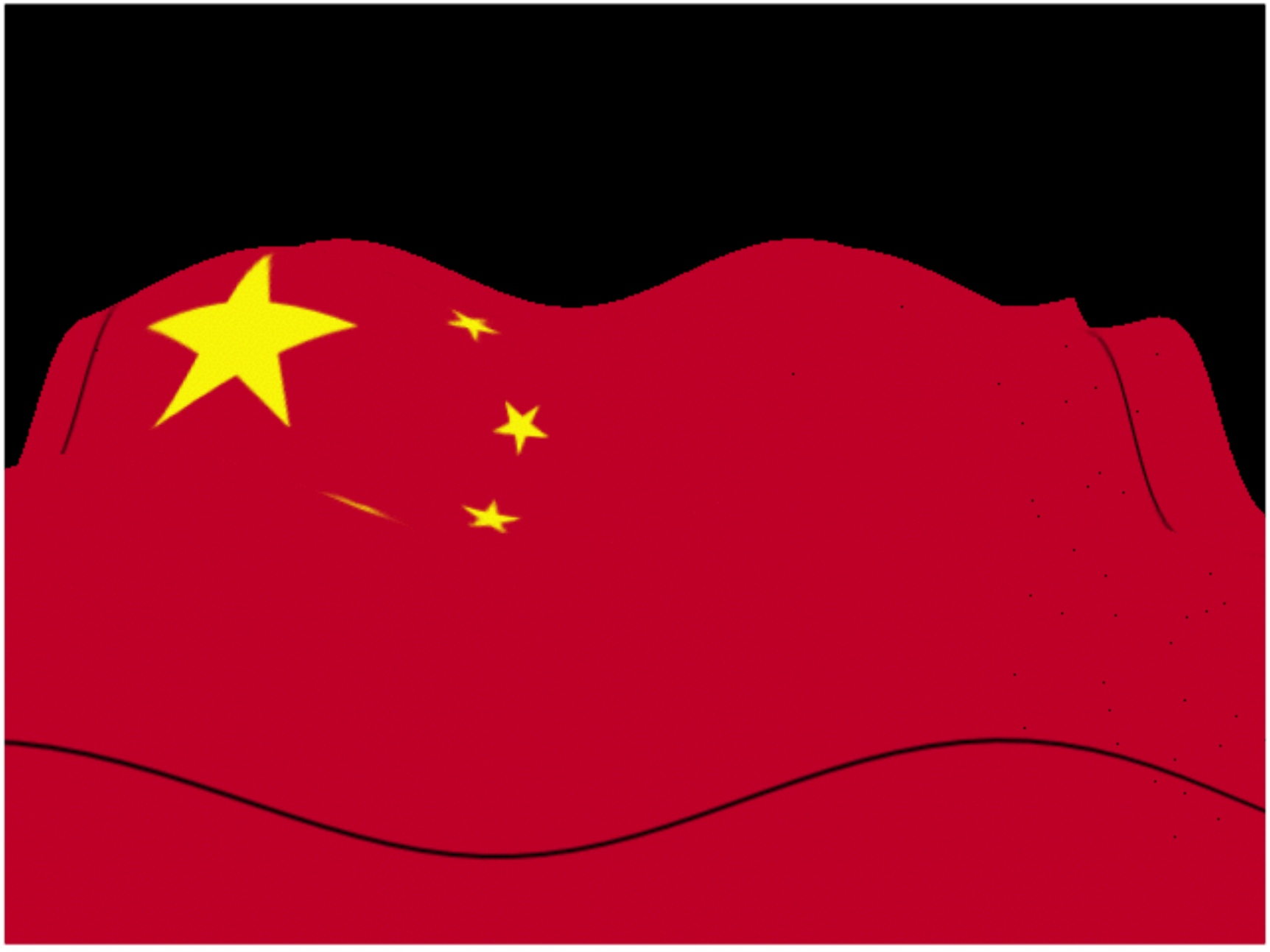


A different color
in every byte

INGREDIENTS: Ray traced spheres, FD&C blue back-
ground No.7, directional light sources, contains no
more than 1/2 of 1 percent actree remants.
Specular highlights added to preserve richness.


PHEREO'S
different color
in every byte



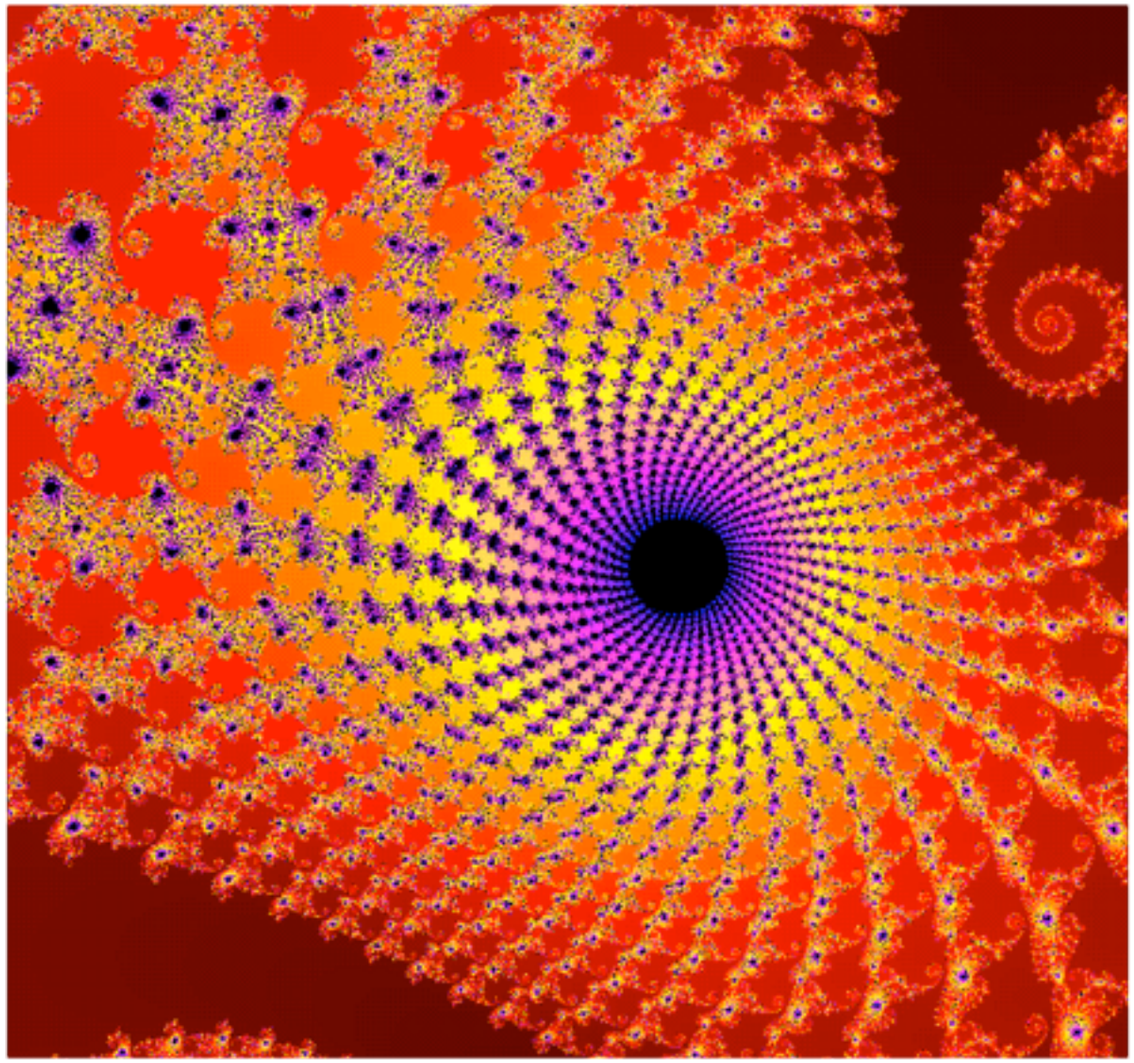


Topics Not Addressed

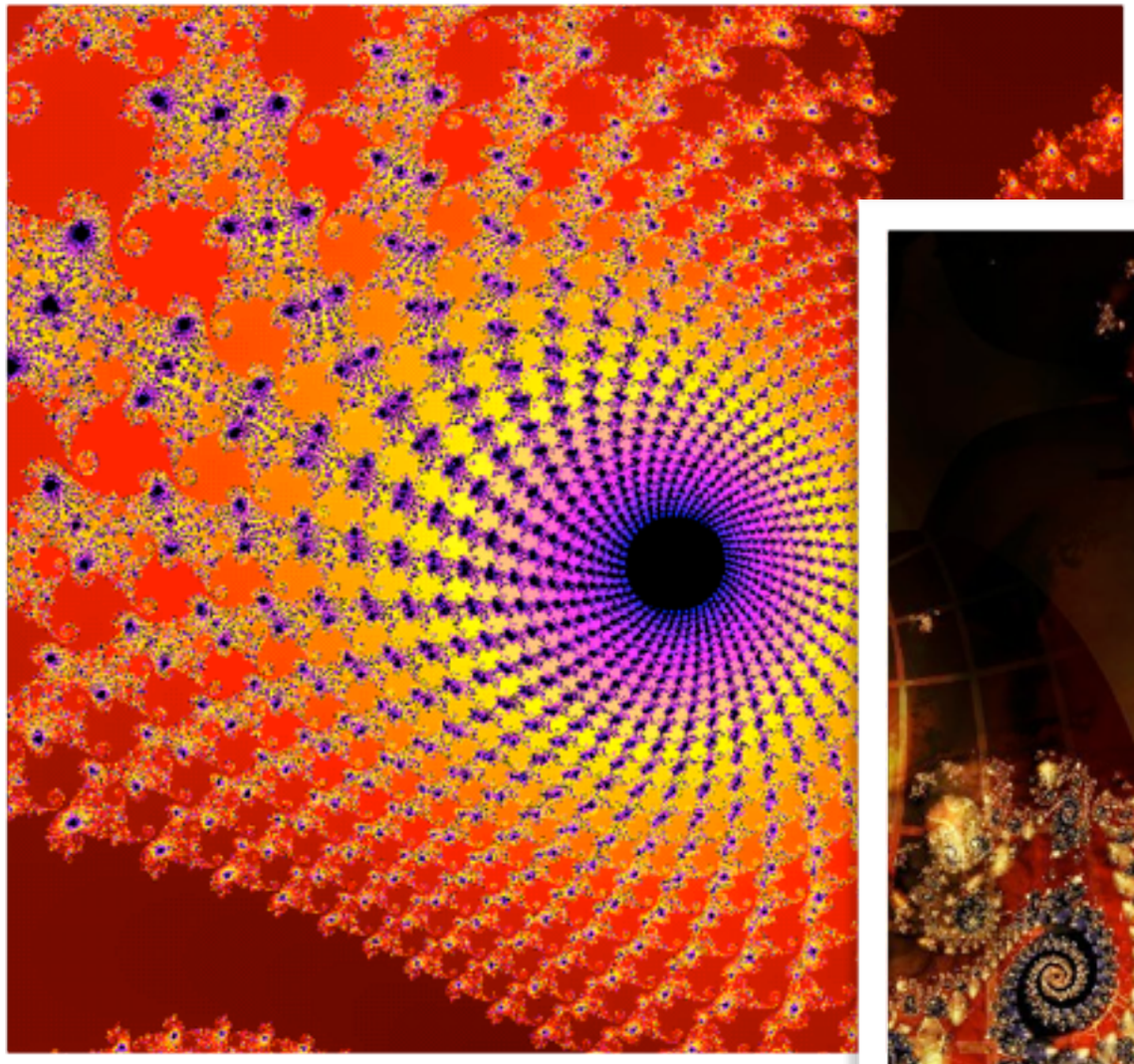
- Advanced modeling and rendering methods
  - complex lighting effects,
  - natural objects (fractals), and
  - volumetric objects

Museum simulation with progressive radiosity
by Eric Chen, Michael Cohen, 1989

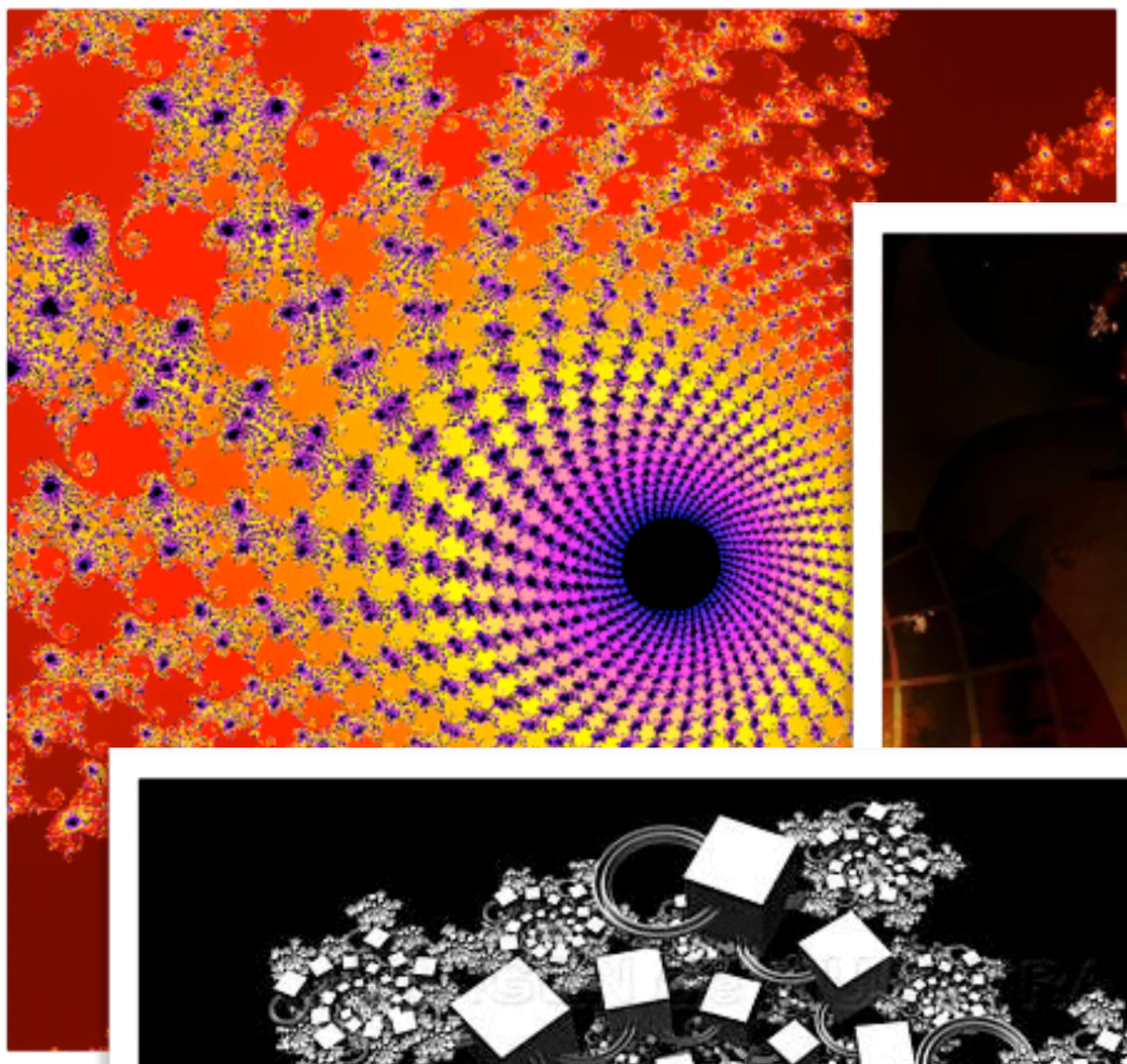
fractal images

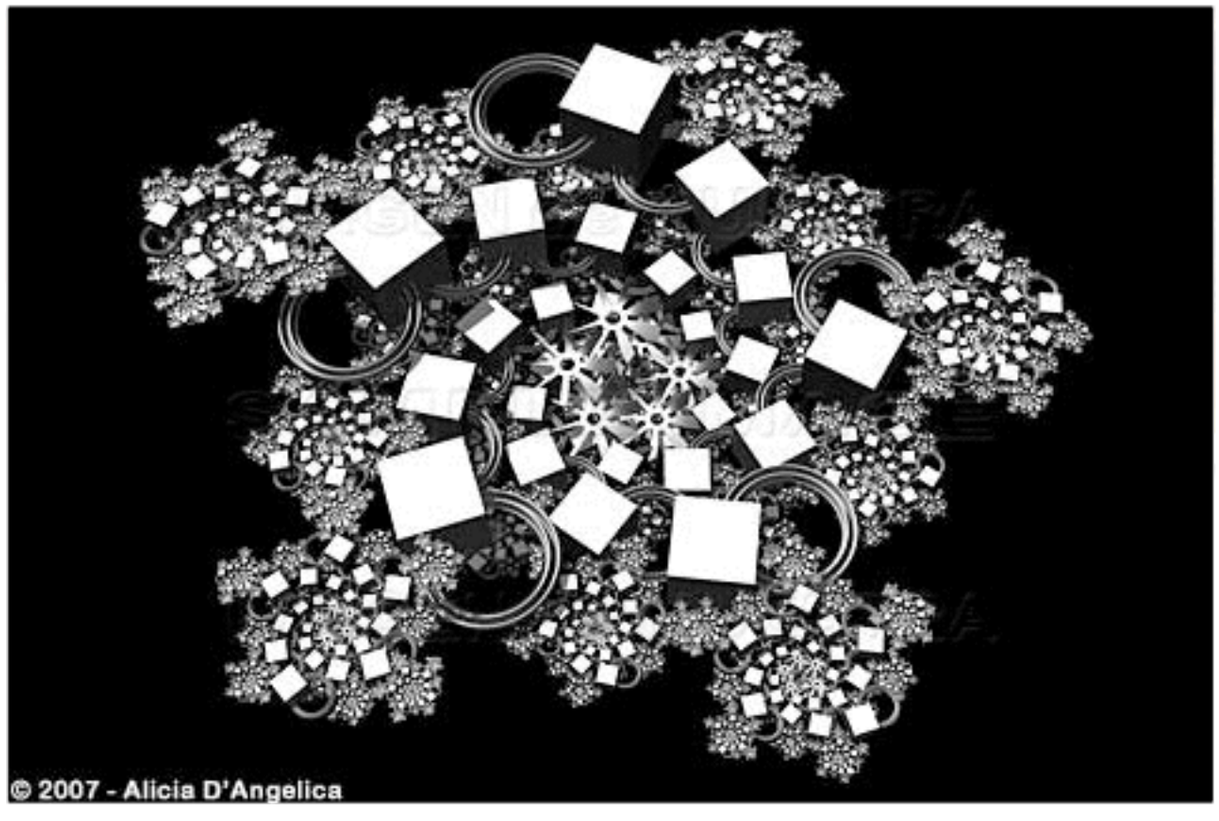


fractal images



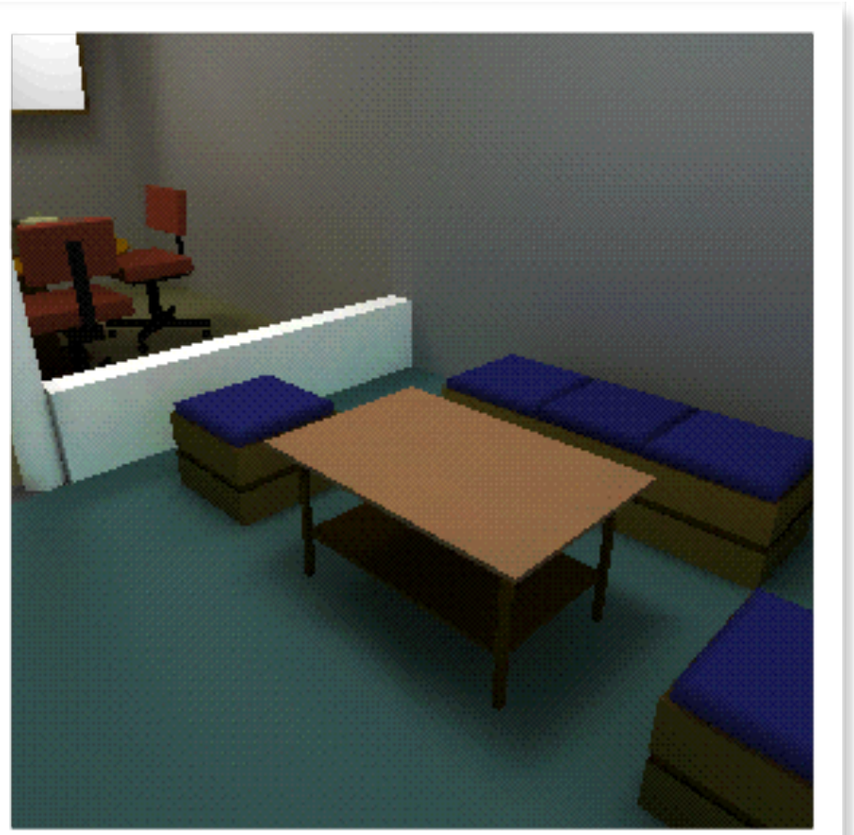
fractal images





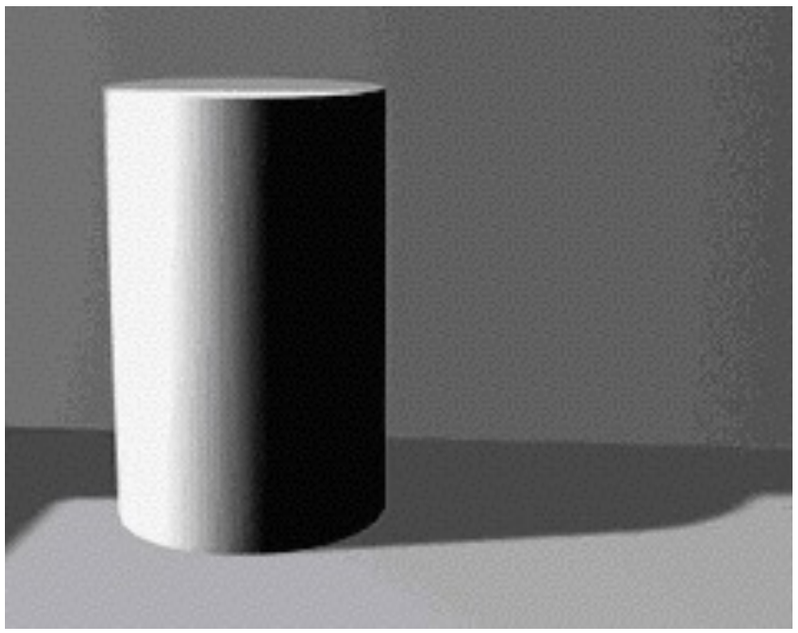
fractal images

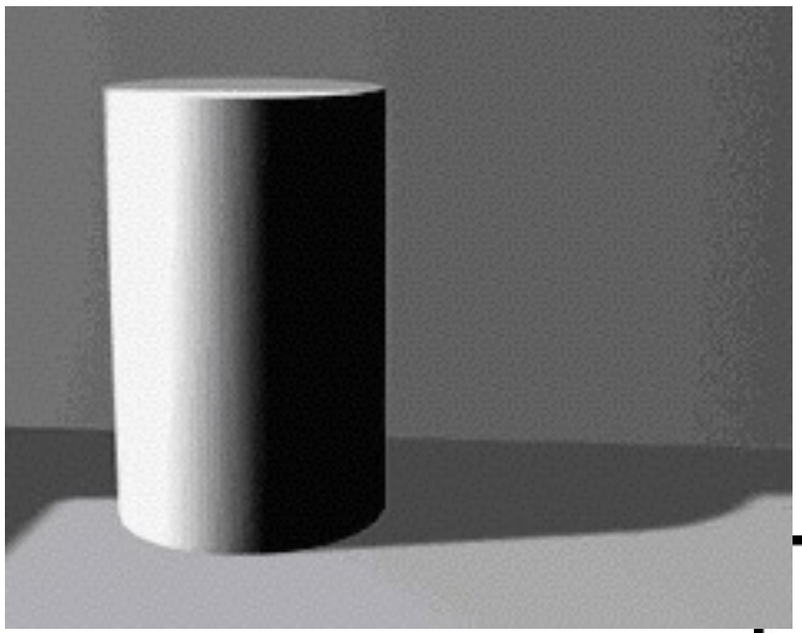

© Ken
Musgrave

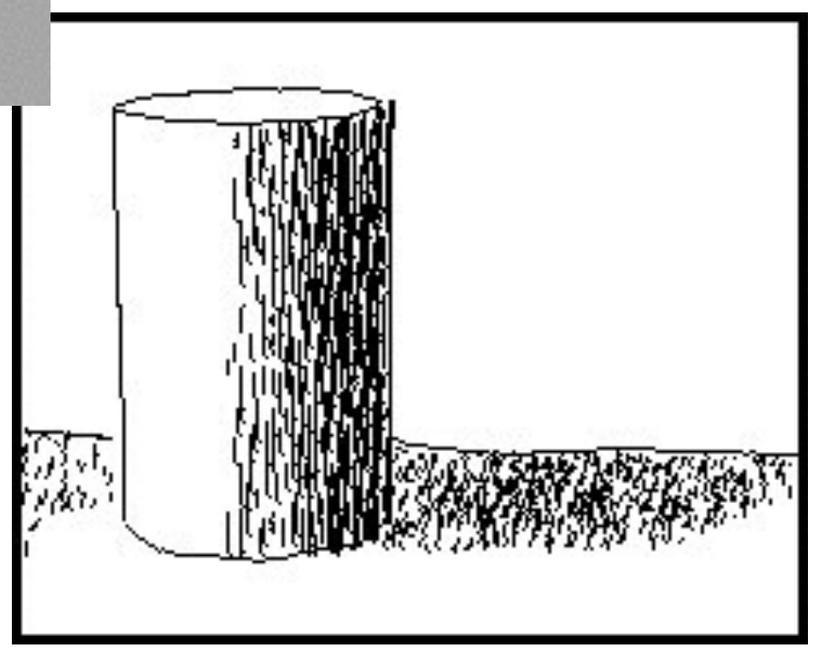


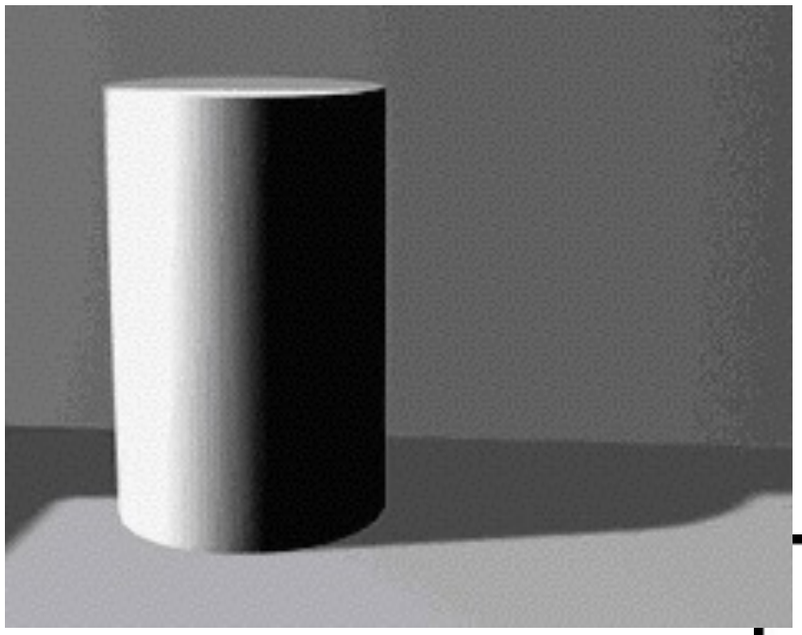
3D Graphics and Visualization

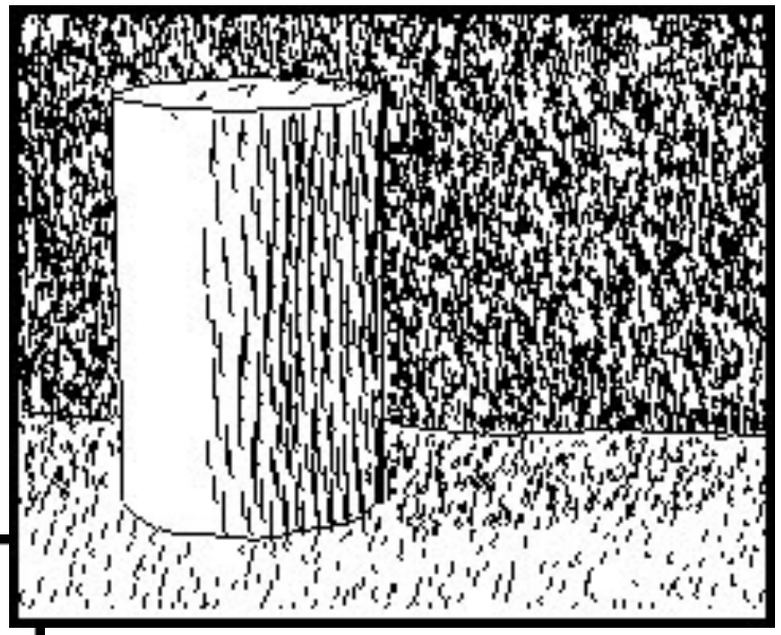
Non-Photorealistic Rendering

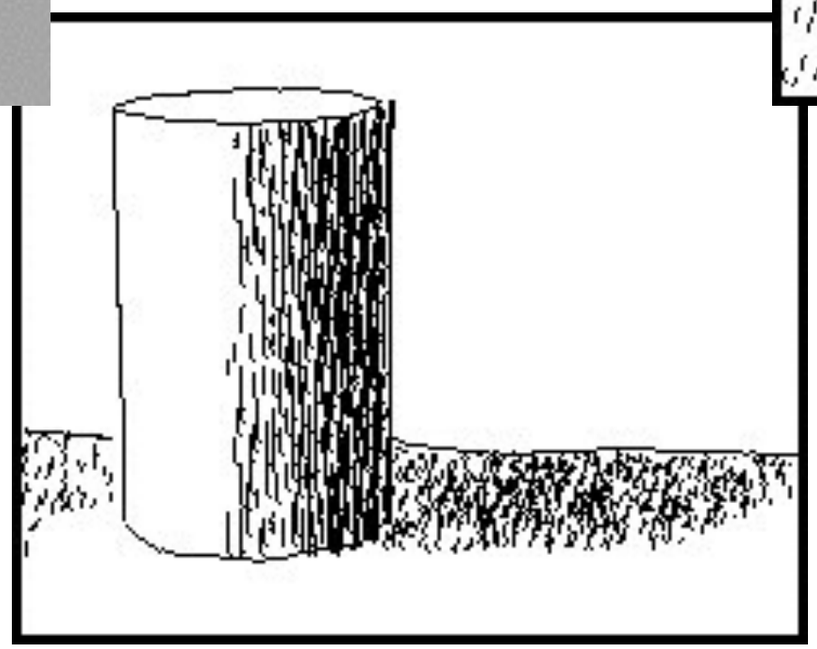




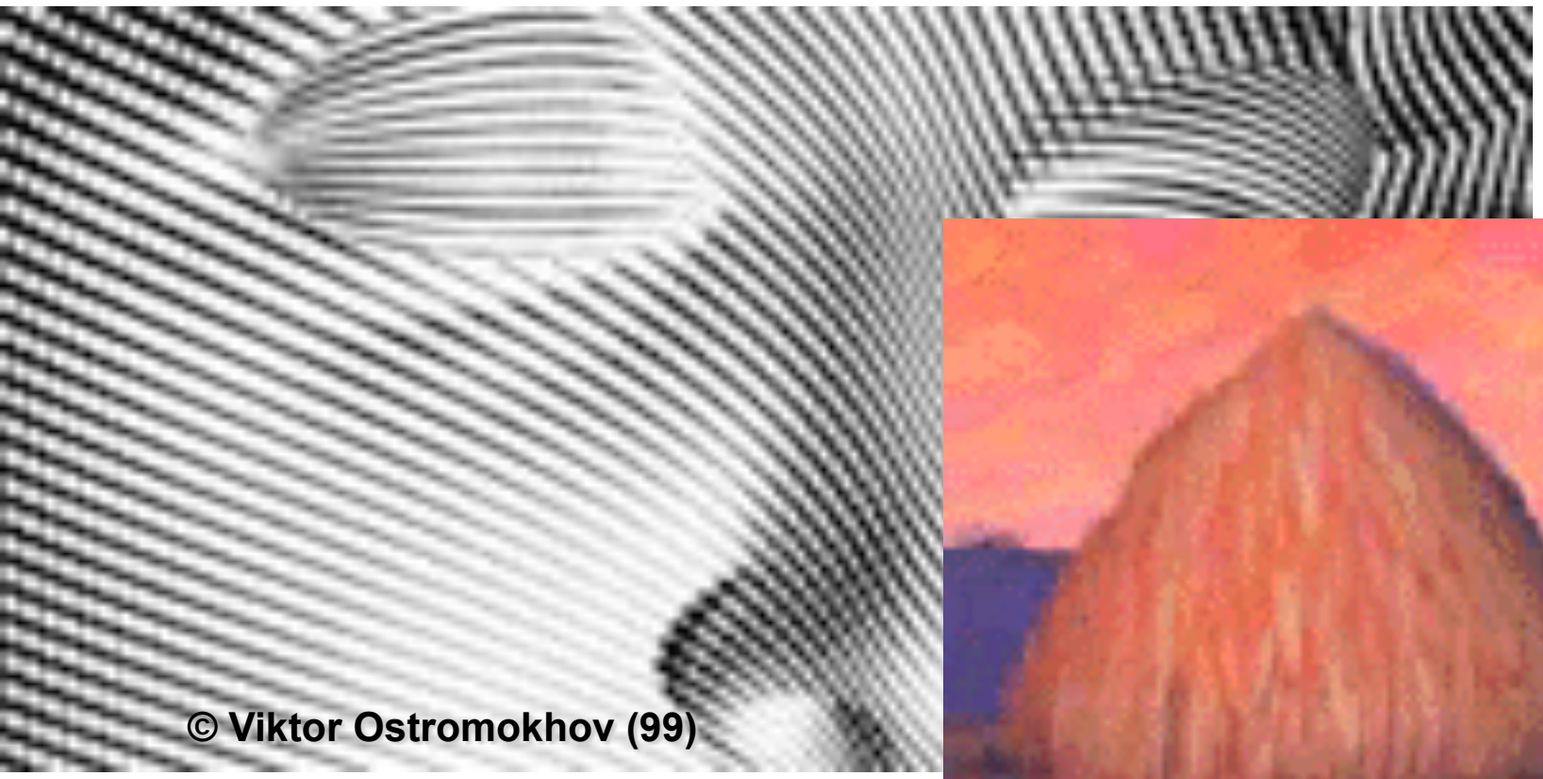






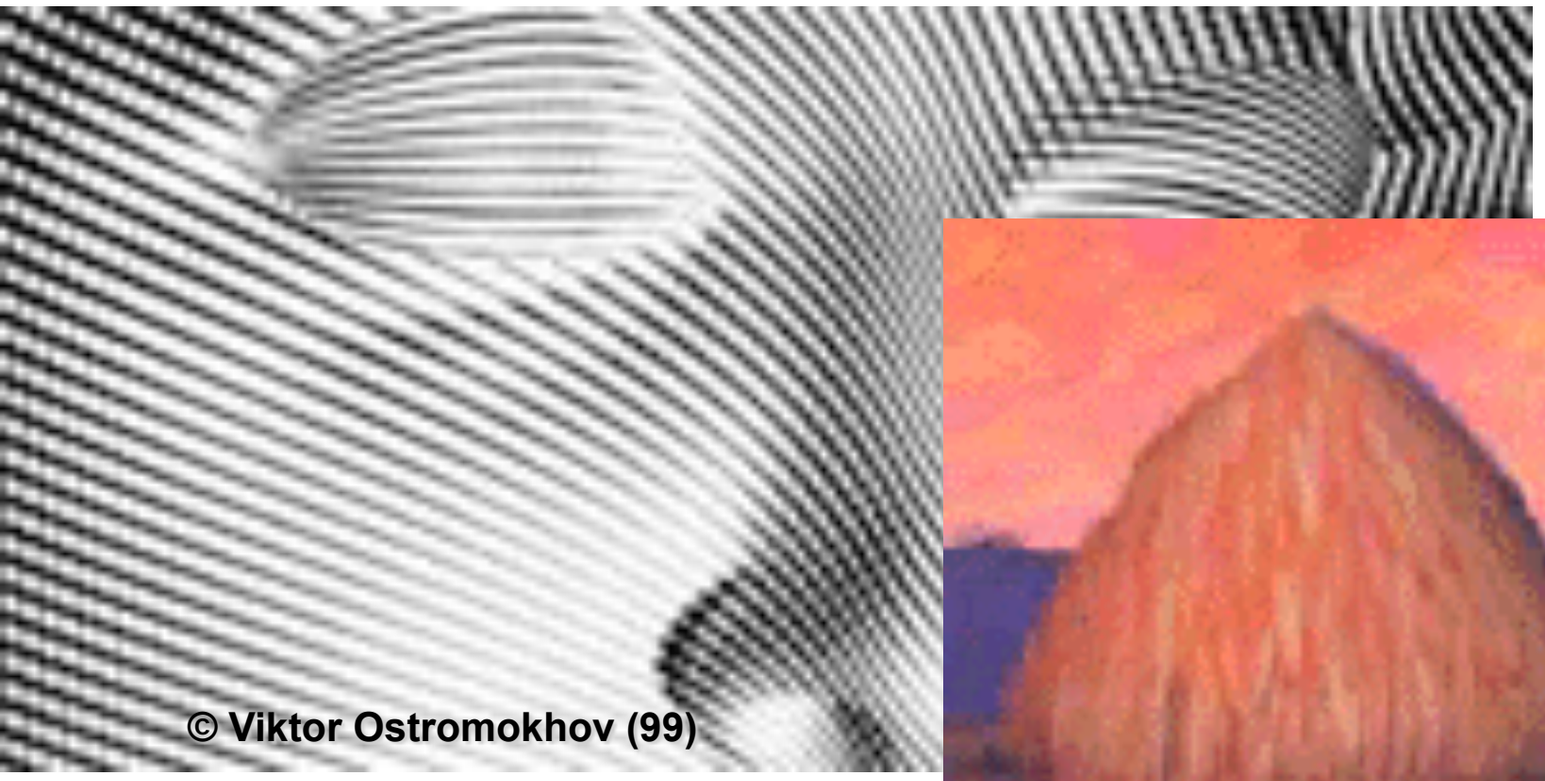



© Barbara J. Meier(96)


© Viktor Ostromokhov (99)


© Barbara J. Meier(96)

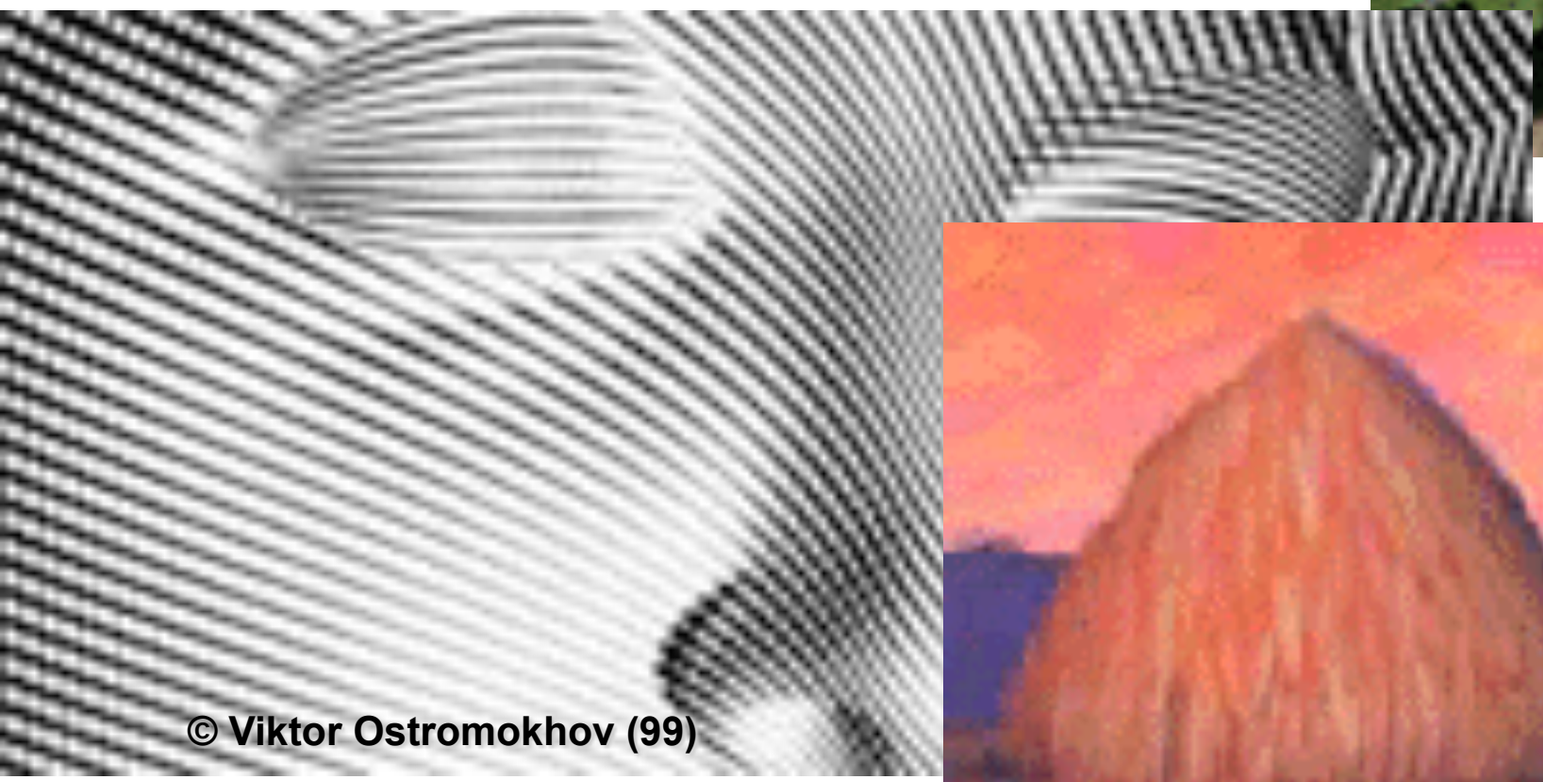

© Aaron Hertzman (98)


© Viktor Ostromokhov (99)


© Barbara J. Meier(96)


© Aaron Hertzman (98)


© RE:Vision Effects(99)


© Viktor Ostromokhov (99)


© Barbara J. Meier(96)

新浪微博

@浙大张宏鑫