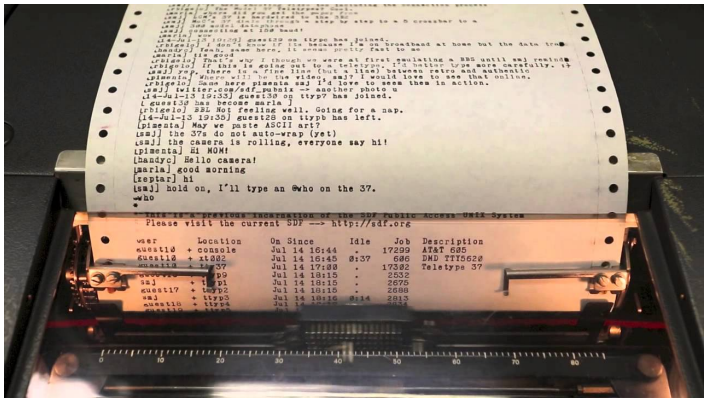
Computer Graphics

Contents

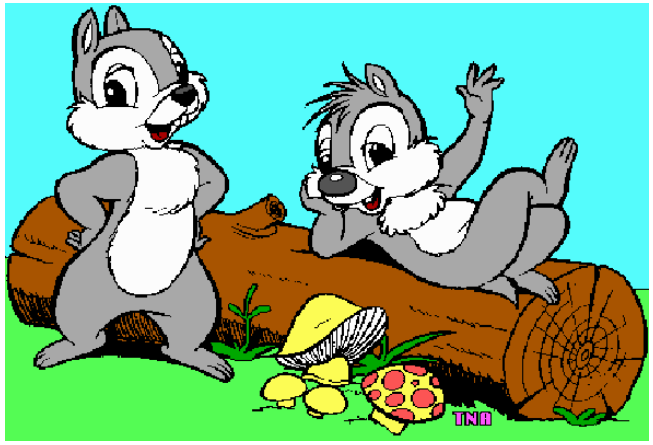
1. Motivation

- Examples
- Definition
- Objectives
  - Simulation
  - Realism
  - Interactivity
  - Presence

Examples - Pseudographics

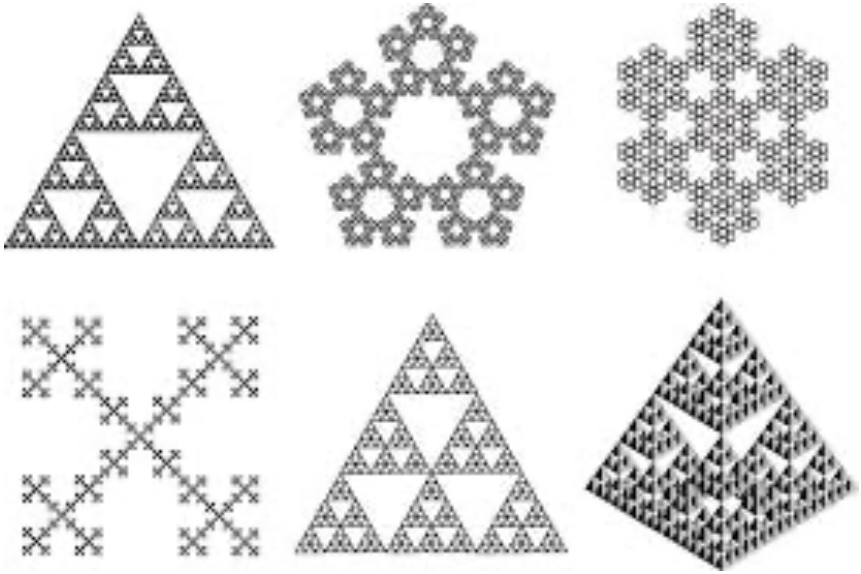


Examples - Art

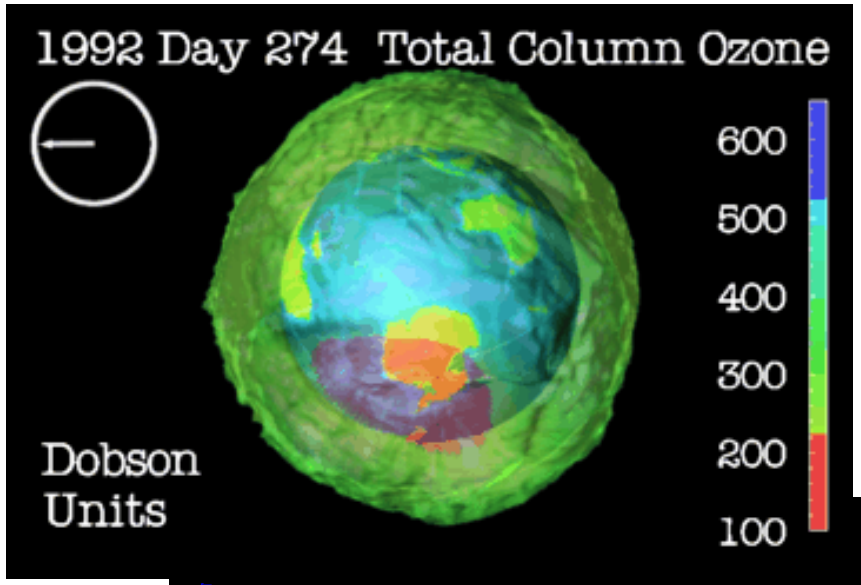


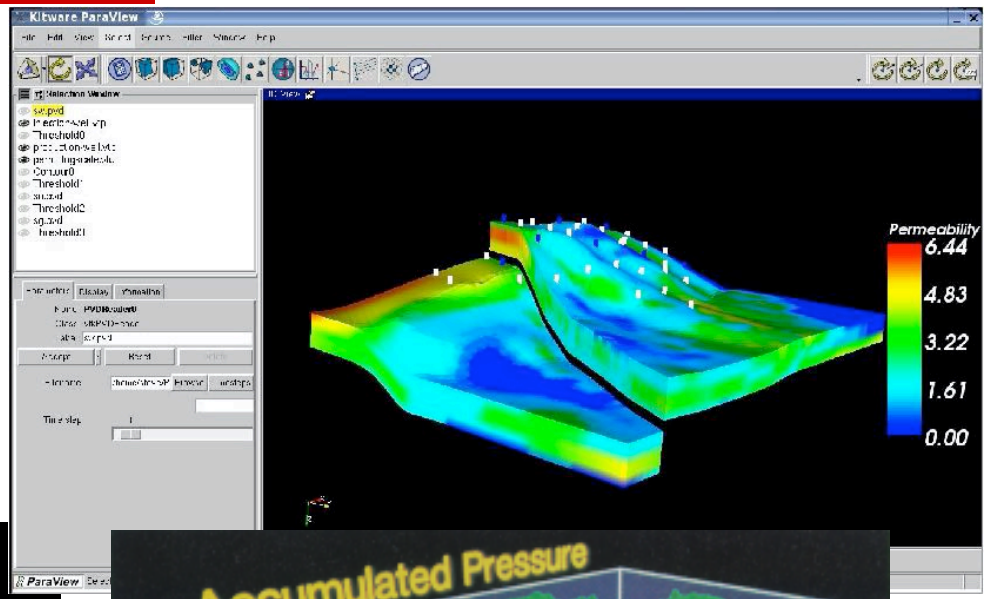
Examples - Entertainement

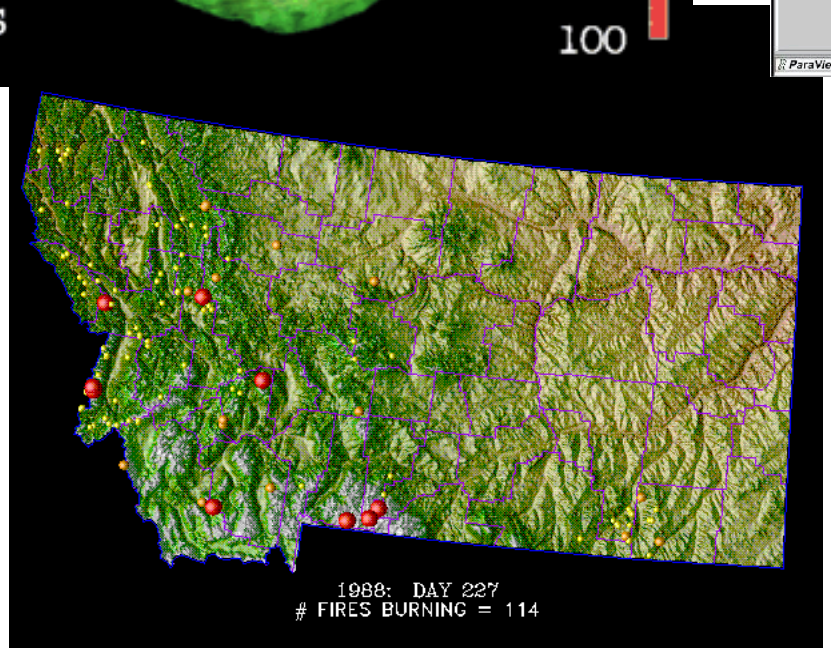
Examples - Fractals

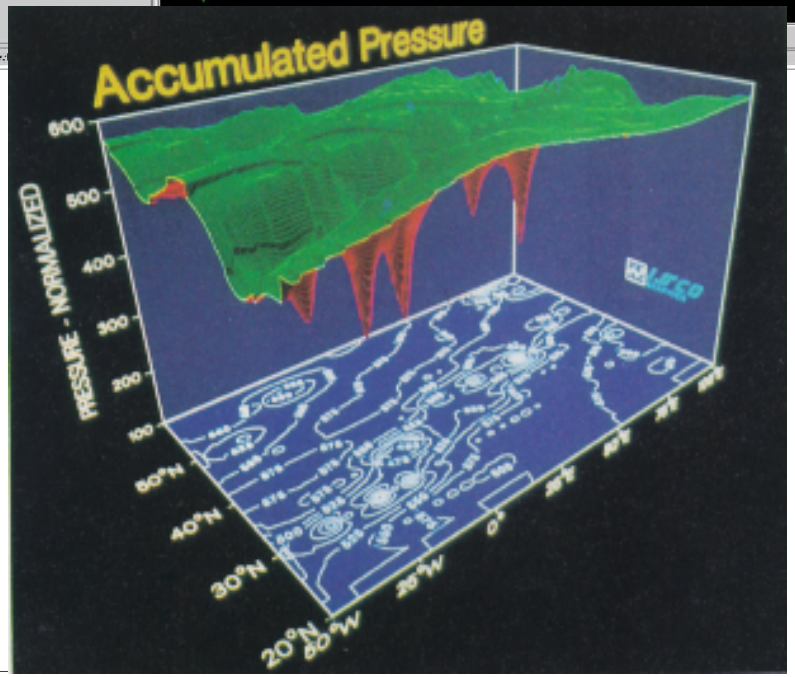


Examples – Scientific Visualization

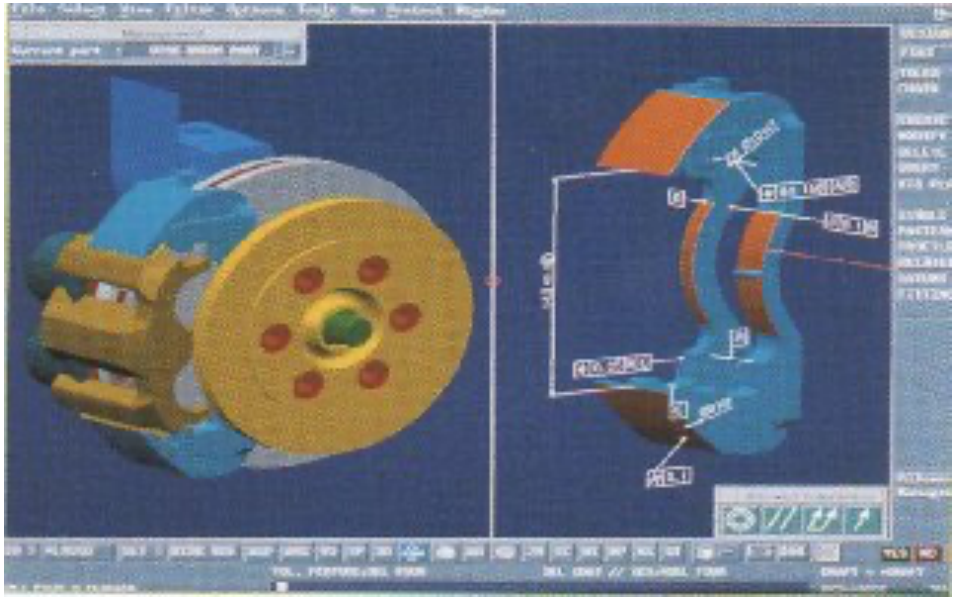


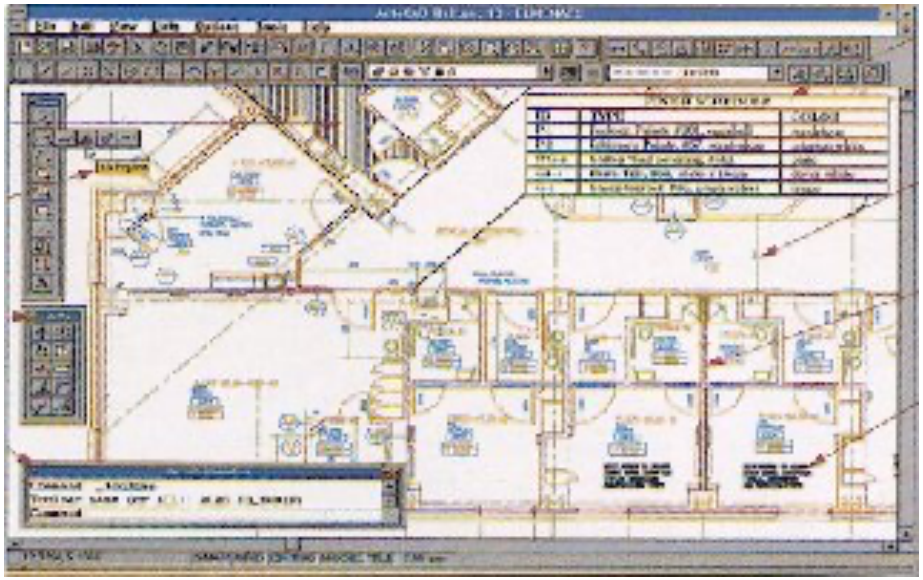


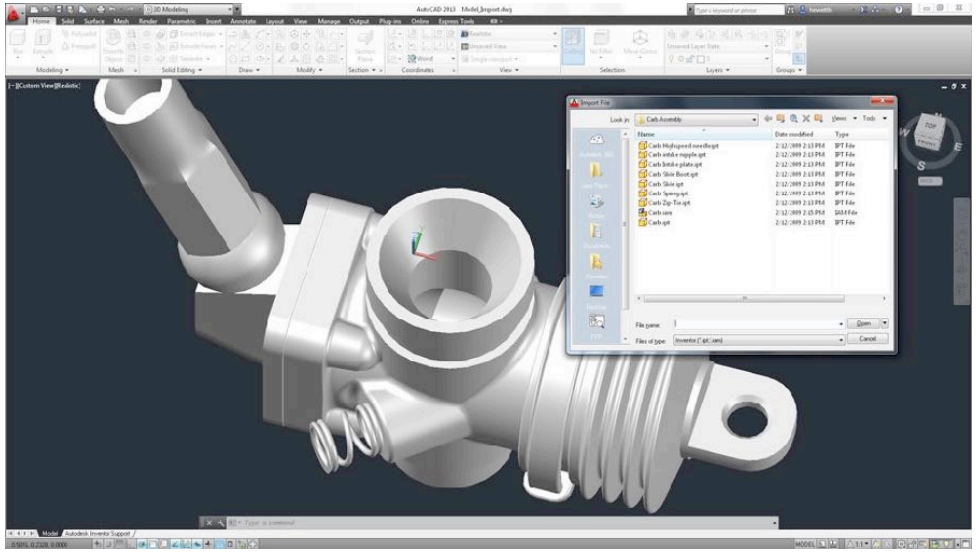


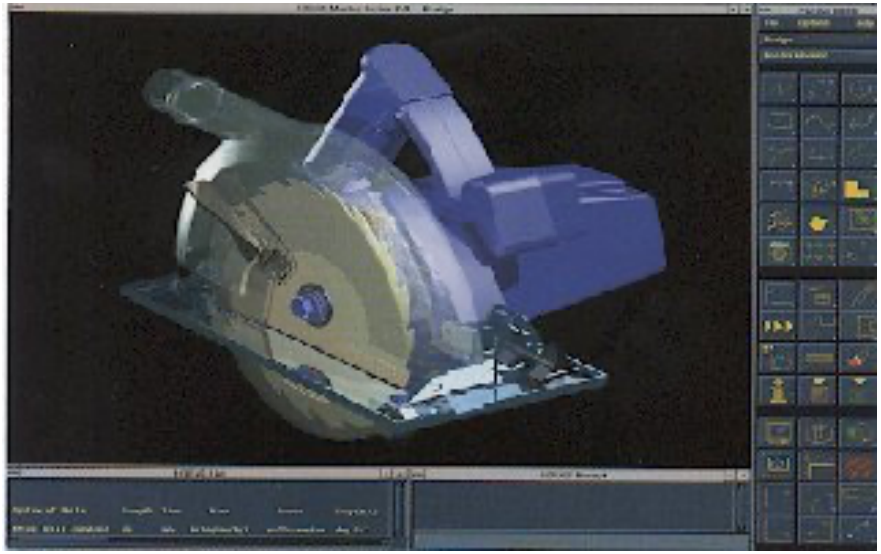


Examples – CAD, CAM

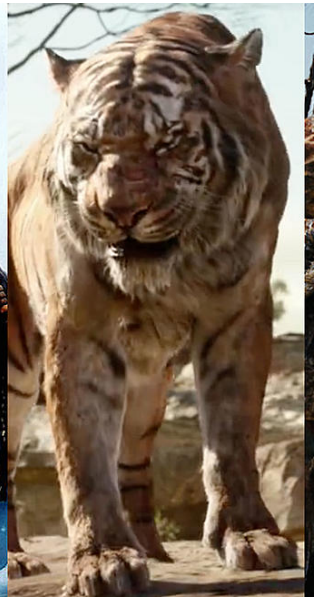




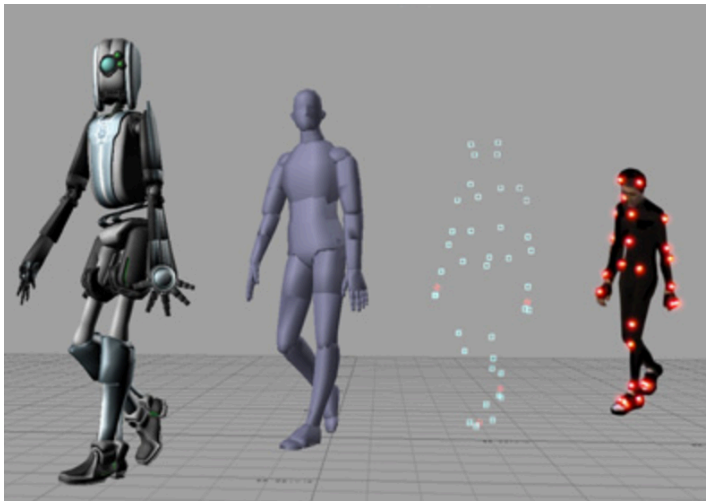


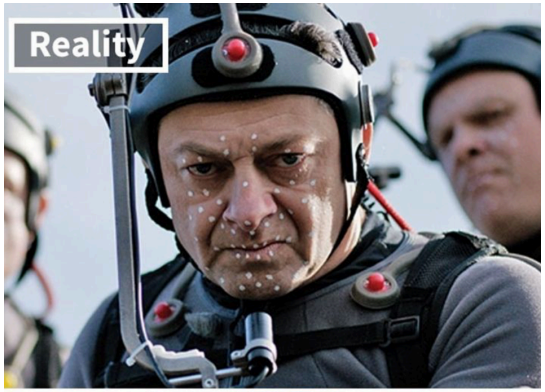


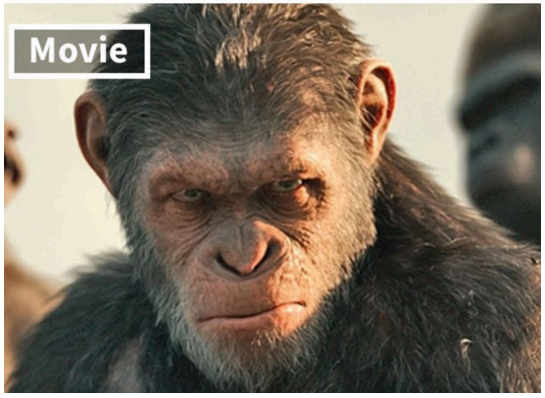
Examples - Movies



Examples - Animation







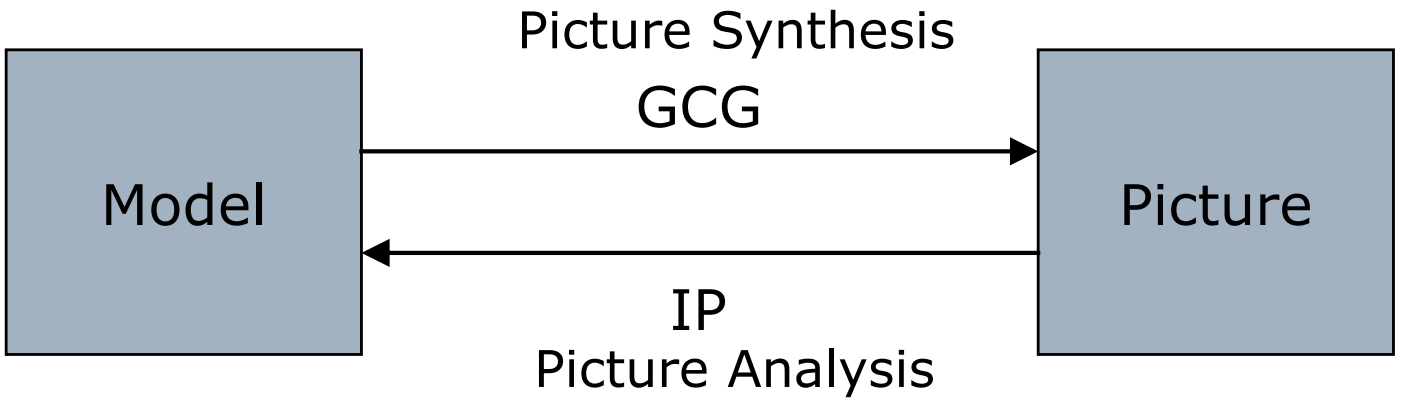
2. Computer Graphics

- Definition (ISO)
  - Method and Technologies for converting data to and from graphics devices via a computer
- The term of Graphics comes from the Greek word "*graphicos*", which means "something written". See autograph.
- Computer Graphics is the most versatile and powerful means of communication between a computer and a human being.
- A picture is worth than thousand words.

Computer Graphics

Generative Computer Graphics (GCG) → Computer Graphics

Picture Analysis
Picture Processing
→ Image Processing (IP)



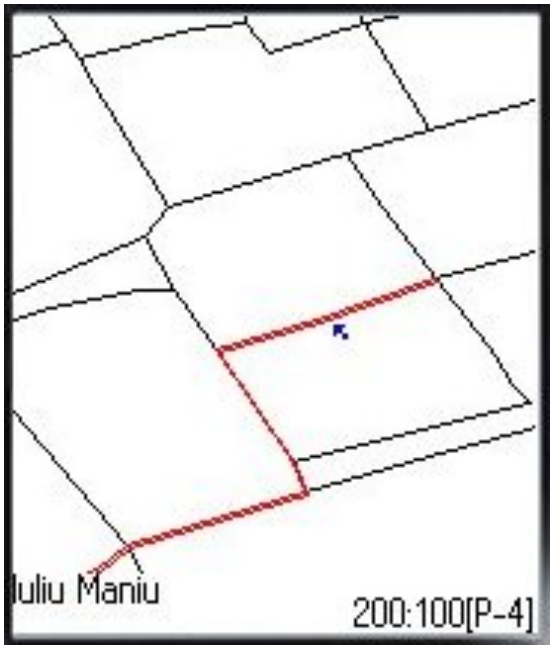
Subject of Computer Graphics

Domain:	***generative computer graphics***	***picture analysis***	***picture processing***
Input:	formal description	visual presentation	visual presentation
Output	visual presentation	formal description	visual presentation
Objects:	lines, pixels, area, texts, or set of objects	generated or scanned pictures	scanned picture
Purpose:	picture generation	pattern analysis, structure analysis, scene analysis	picture enhancement

History

- 1950 - simple pictures on CRT, Whirlwind Computer (MIT)
- Mid ‘50s – first light pen (SAGE System)
- 1963 -“Sketchpad”, Ivan E. Sutherland
- Mid ’60s - heavy research: MIT, General Motors, Bell Laboratories, Lockheed Aircraft
- Late ’60s - heavy research: University of Utah
- 1974 – technology threshold
- Late ’70s - economic raster graphics
- Early ’80s - microprocessor graphics, workstations
- Late ’80s - photorealism
- ’90s - graphics portability: Web formats, databases, GUI, Virtual space modeling
- 2000 – high performance graphics, GPU, graphics engine, physics engine, video animation, gaming

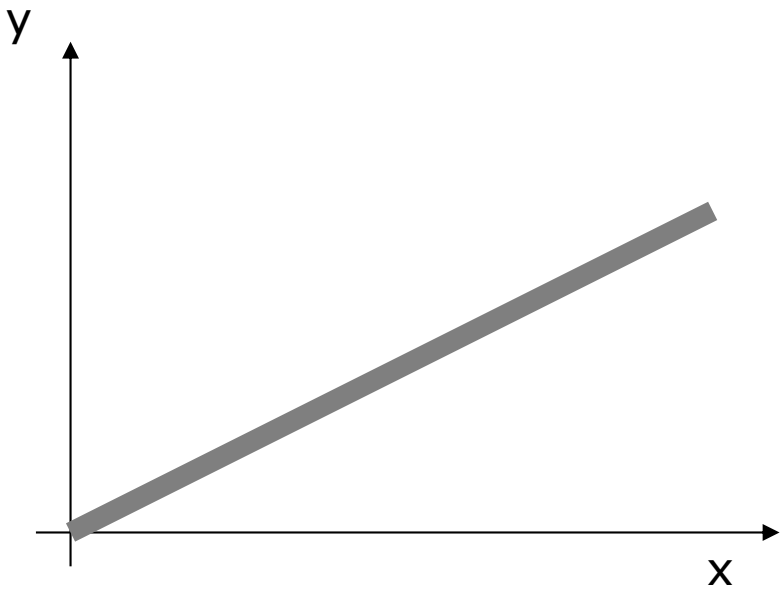
Vector vs Raster Graphics

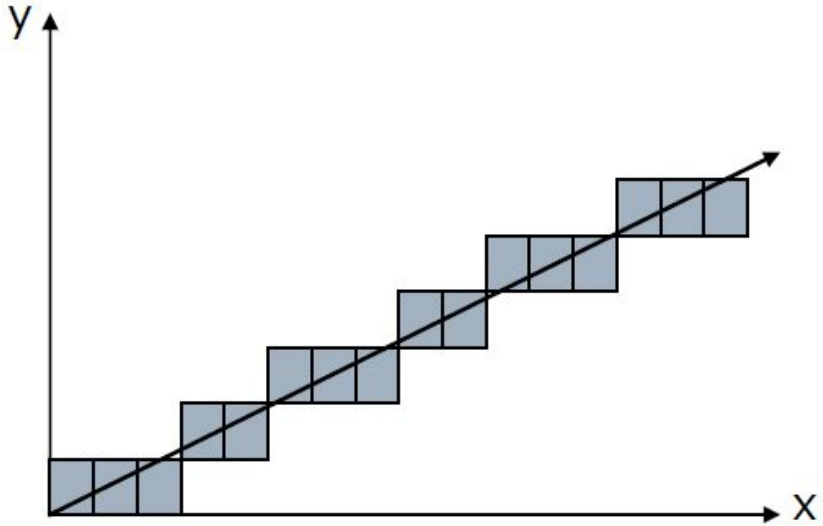


- Scene of objects in terms of vectors
- Processing time and model dimension depends on the object complexity
- Less visual information
- Object semantic information

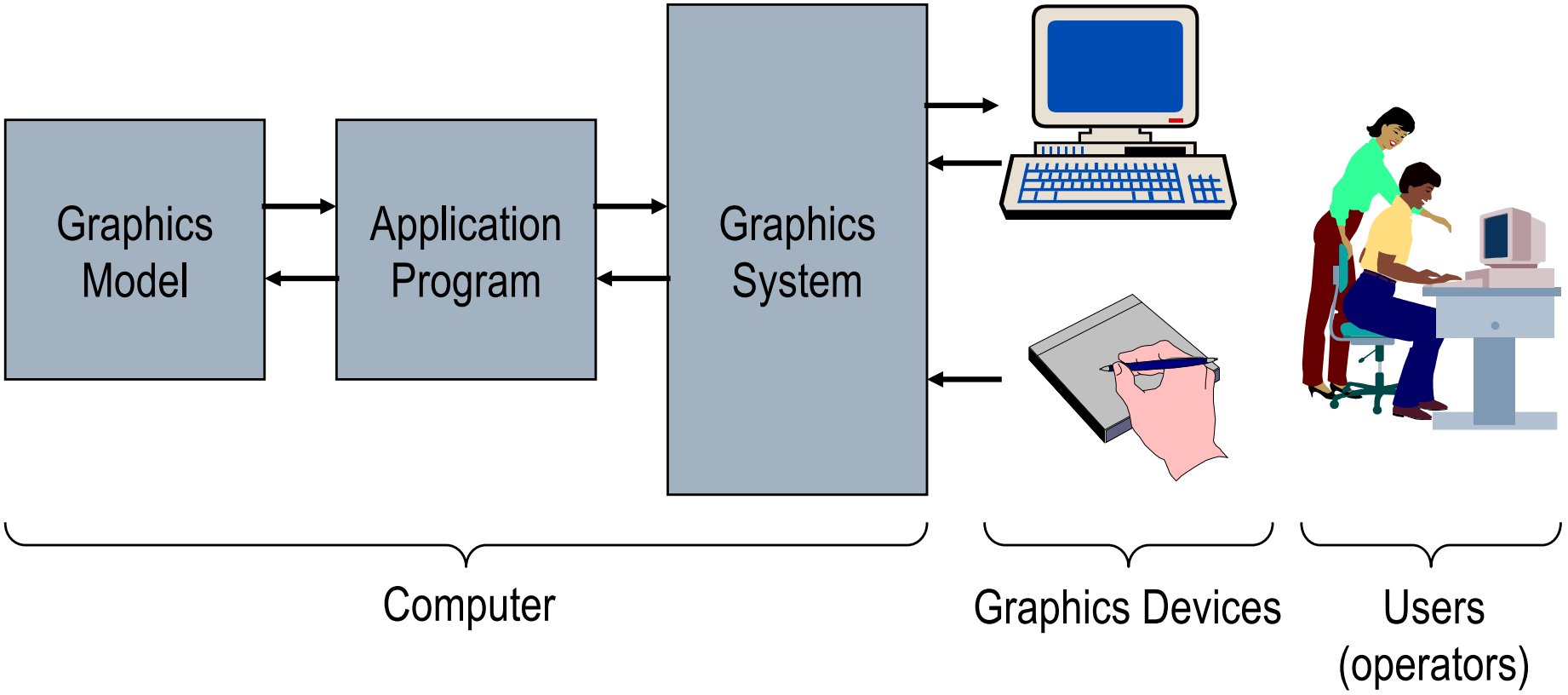
- Scene of objects in terms of pixels
- Processing time and model dimension depends on the image resolution
- More visual information
- No semantic information

Vector and Raster Graphics





Programmer's Model of Interactive CG

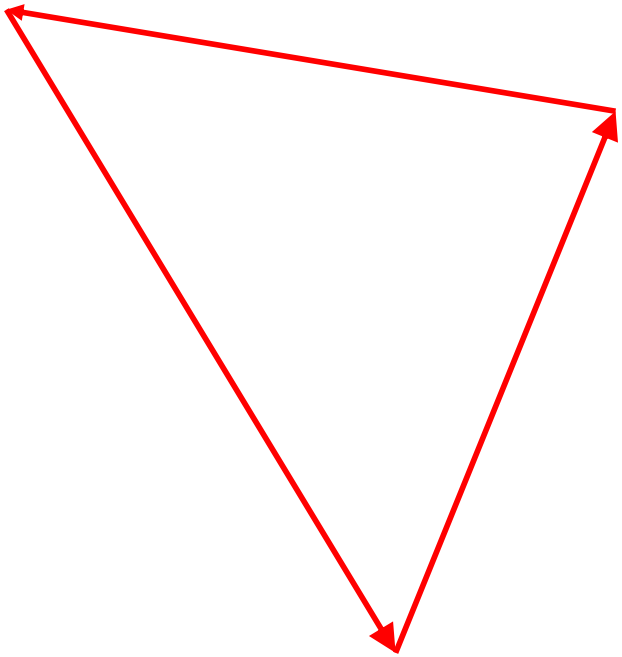


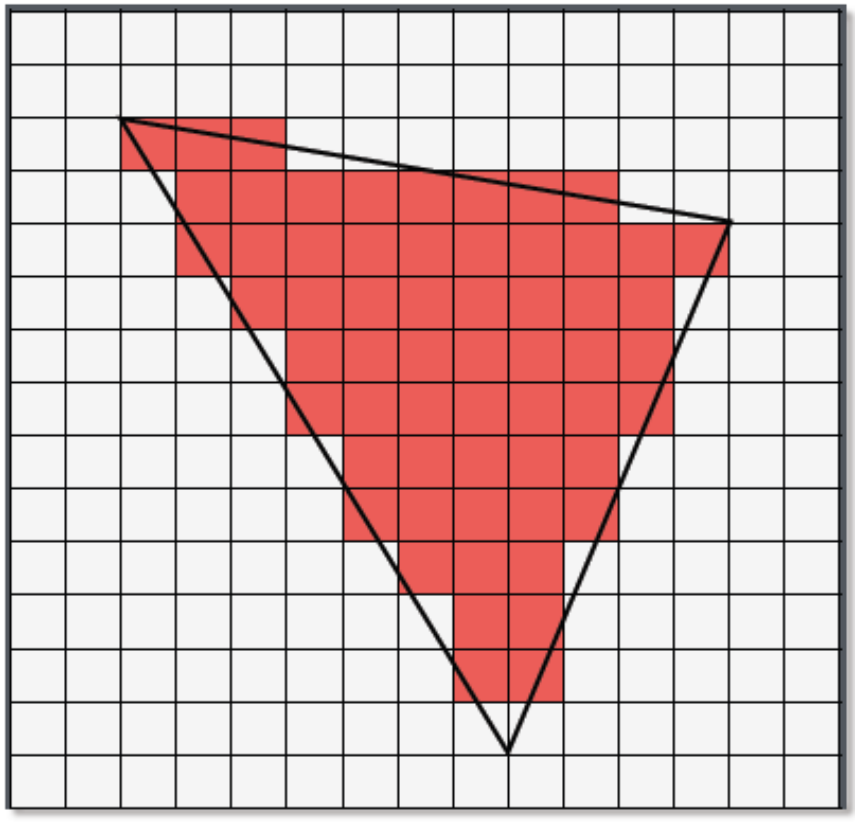
- Graphics Models - Application Data Structures
- Application Programs
- Graphics Systems
- Graphics Devices

3. Graphics Devices

- Output device
  - Graphics diplay, printer, plotter,etc.
- Input device
  - Mouse, lighth pen, track ball, etc.
- Interactive device
  - Graphics console, graphics tablet, head mounted display, etc.

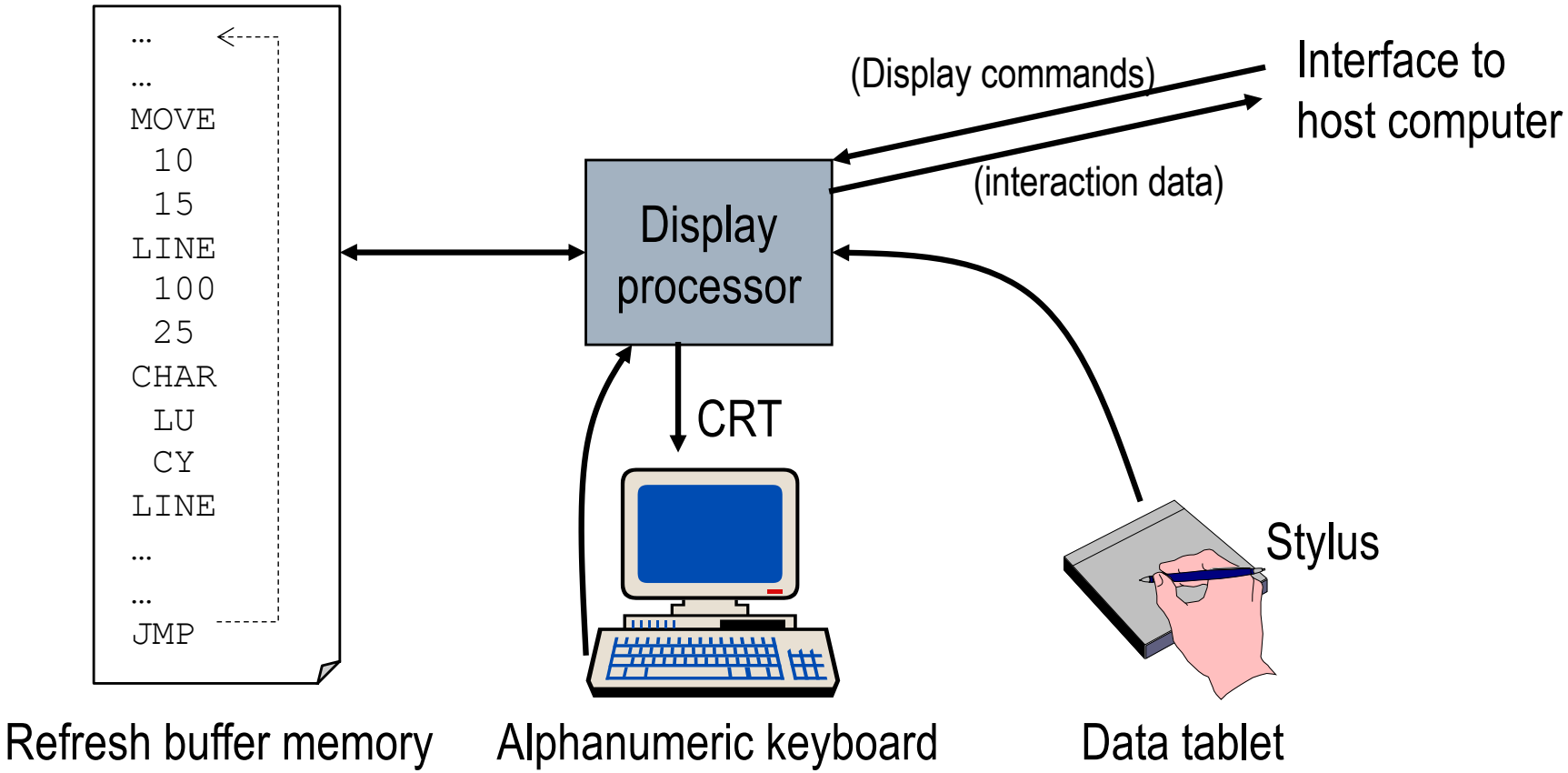
Vector and Raster Devices



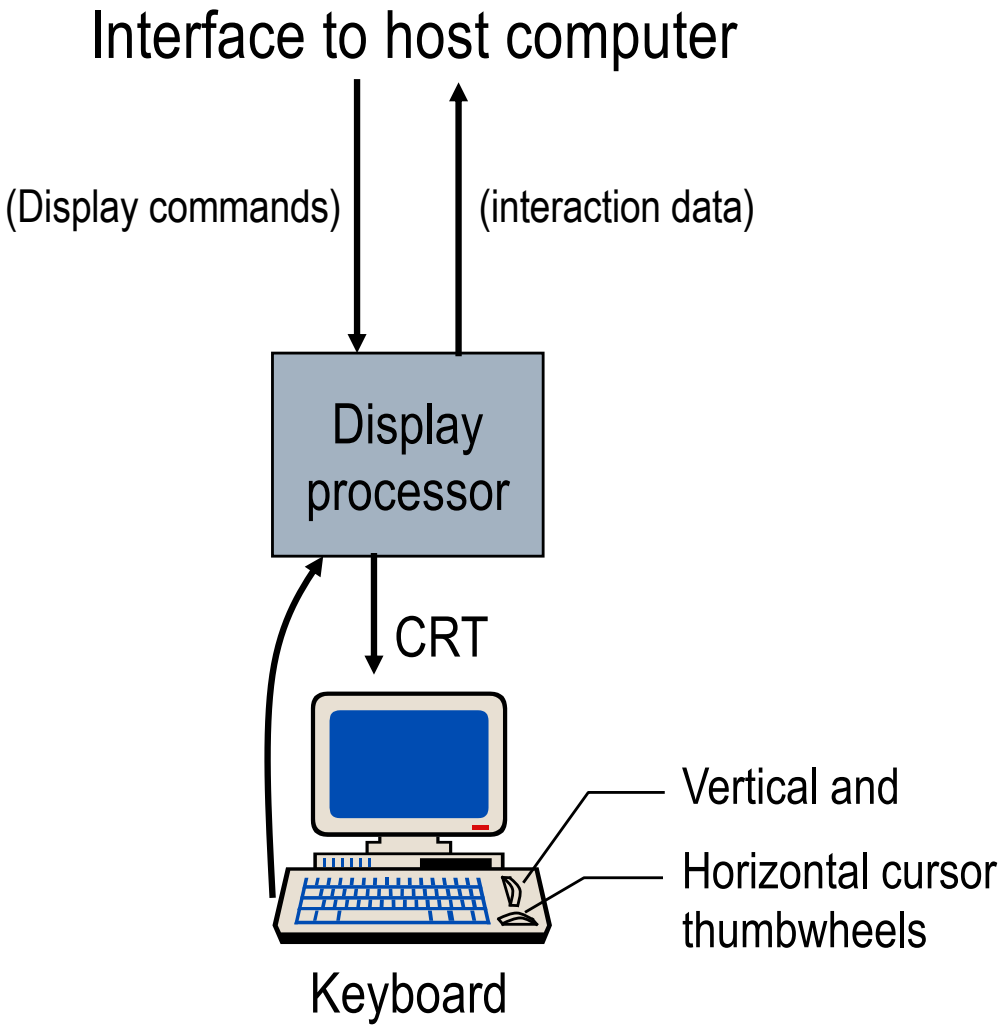


3.1 Graphics Display

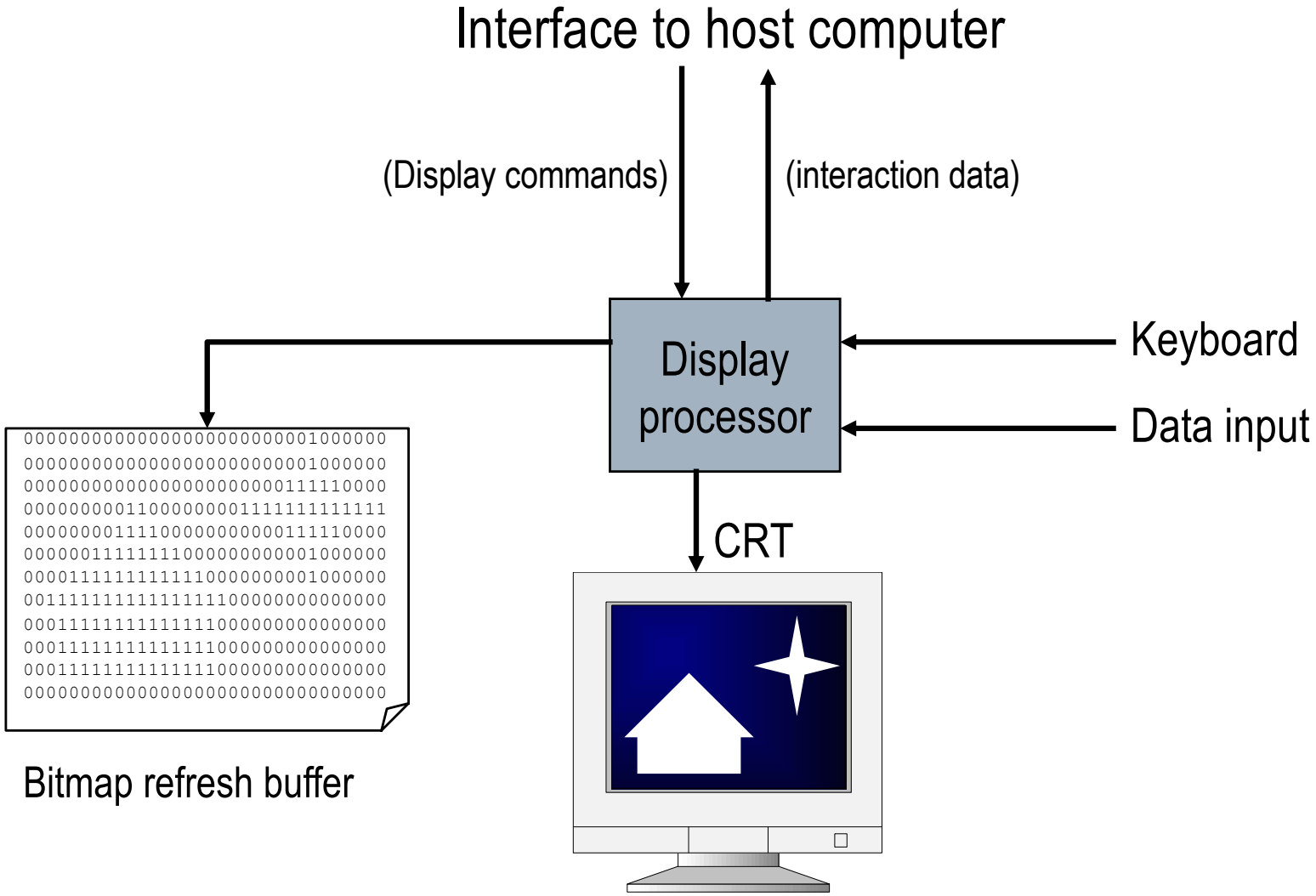
Vector display device



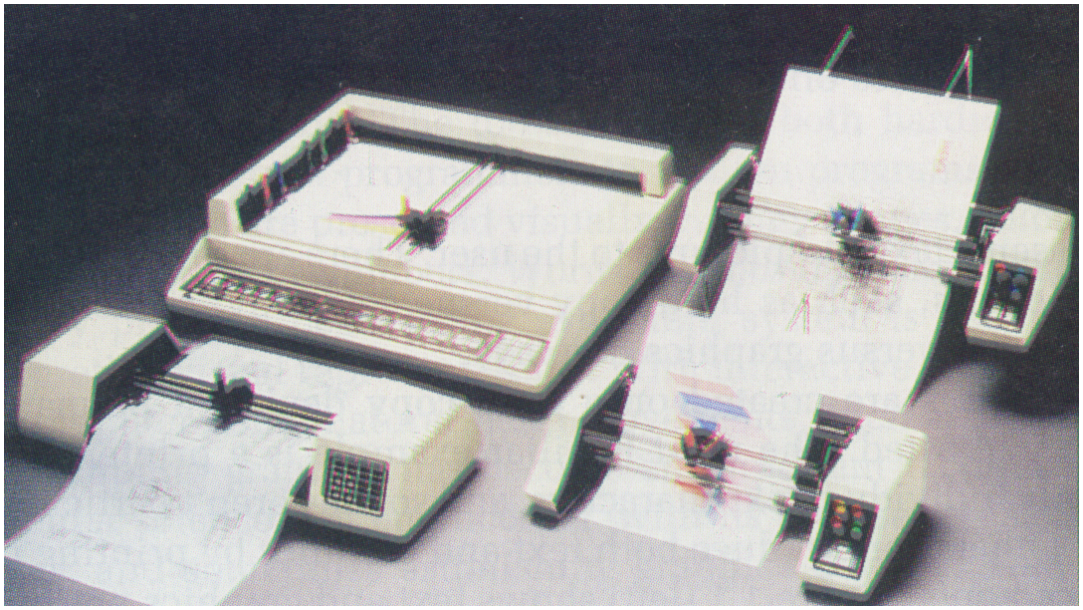
Typical vector storage tube device



Raster graphics display



3.2 Plotter



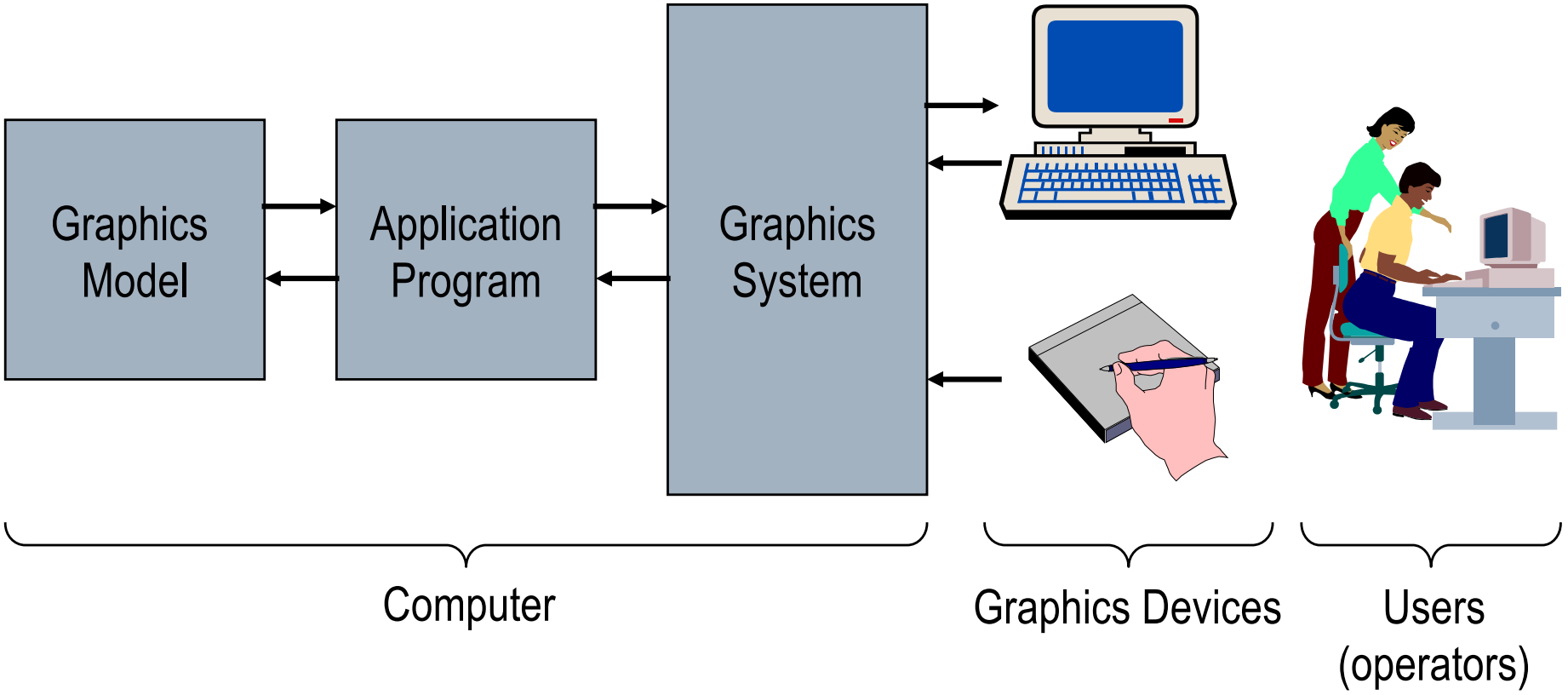
3.3 Logical Input Devices

- Input Graphics Device
  - Logical

    locator, stroke, string, valuator, choice, pick
  - Physical

    mouse, trackball, joystick, scanner, keyboard, etc
- Logical Input Devices:
  - LOCATOR: specifies a coordinate position (x, y)
  - STROKE: specifies a series of coordinate position
  - STRING: specifies text input
  - VALUATOR: specifies scalar values
  - CHOICE: selects menu options
  - PICK: selects picture components

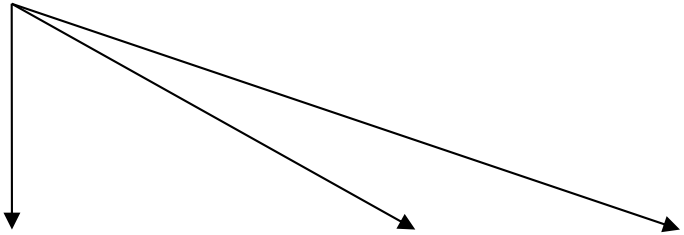
Programmer's Model of Interactive CG



- Graphics Models - Application Data Structures
- Application Programs
- Graphics Systems
- Graphics Devices

4. Application Data Model

Application model (conceptual description + data) = **graphics model** (geometry + graphics attributes, parameters, ...) + **behavior data** (simulation, animation parameters, ...) + **application data** (price, producer, ...)



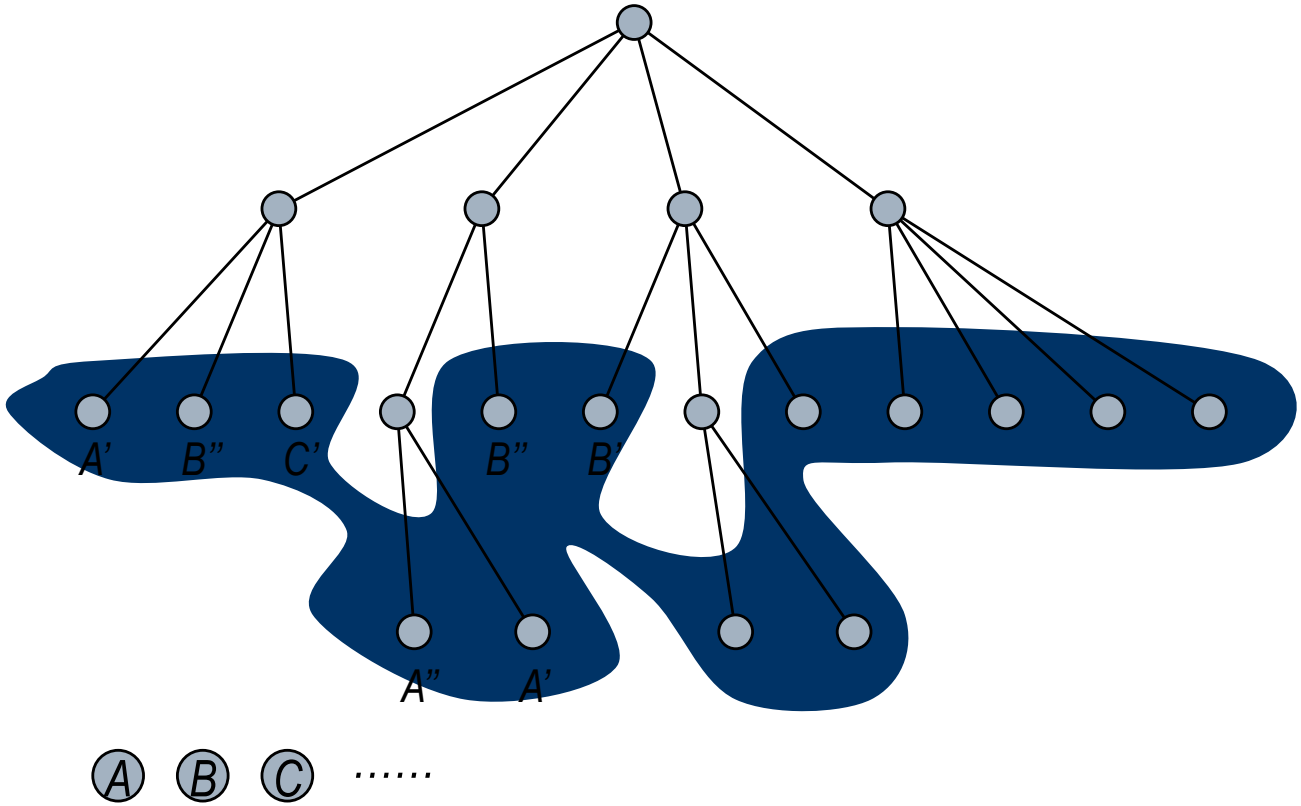
Memory (Data structures)

Database (entities, relationships)

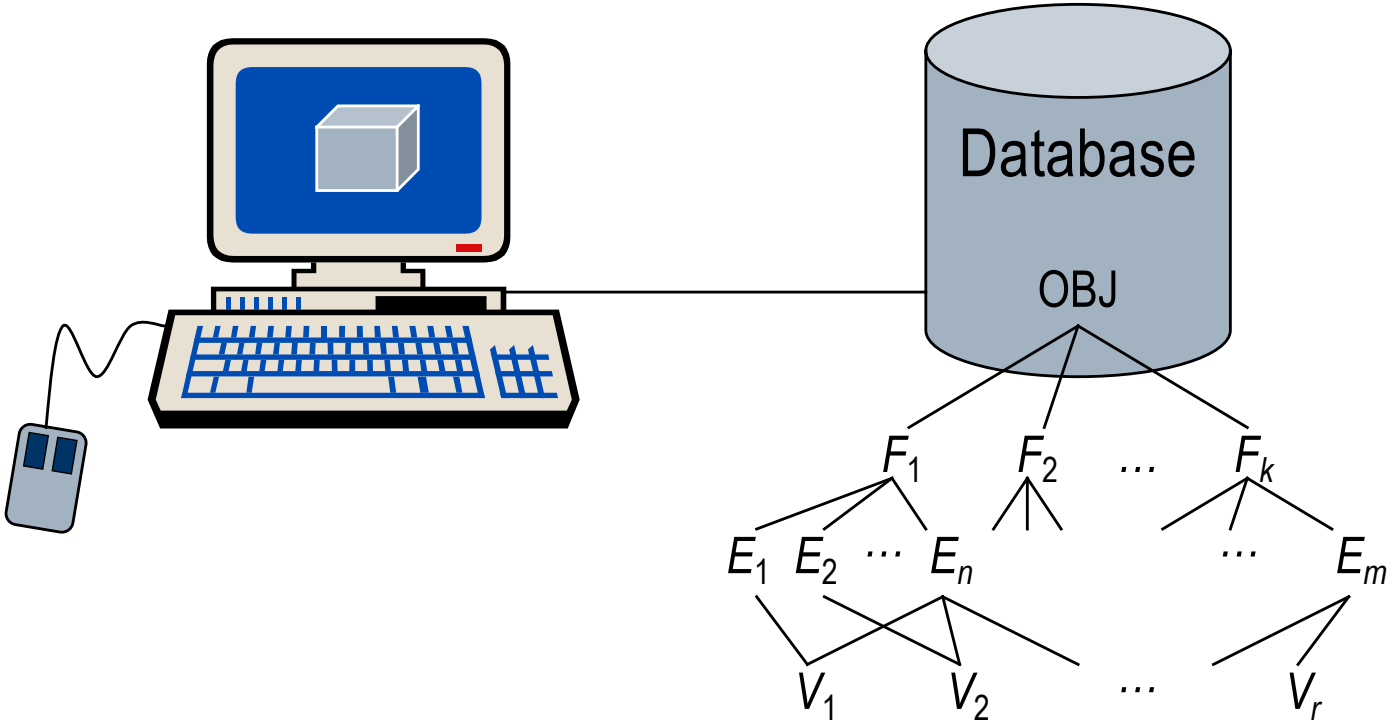
Graphics files (format, shape, topology, dynamics)

Object Hierarchy

- geometric data
- non-geometric data (application data)



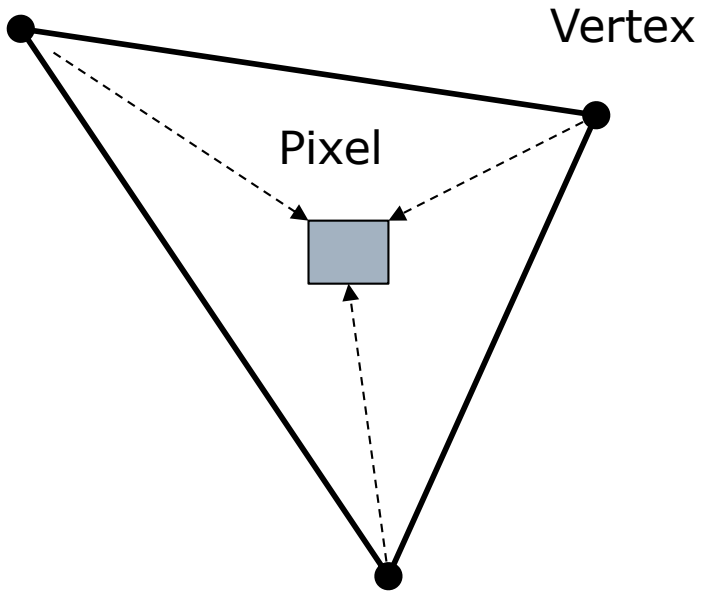
Database Description



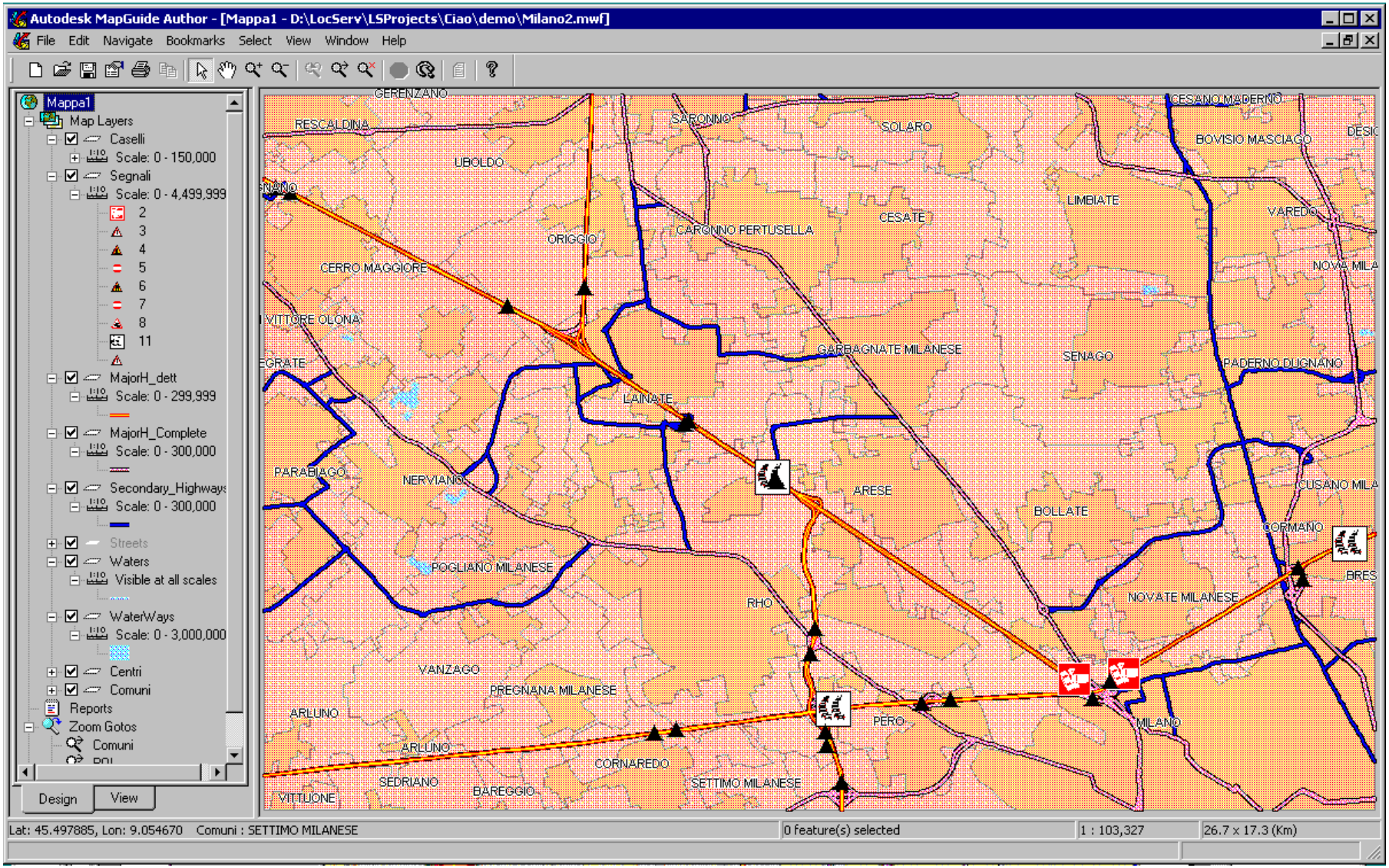
Graphics Model

Graphics model = Geometry + graphics attributes

Vertex attributes
- Color
- Normal vector
- Light intensity
- Texture
- . . .



GIS - Mapping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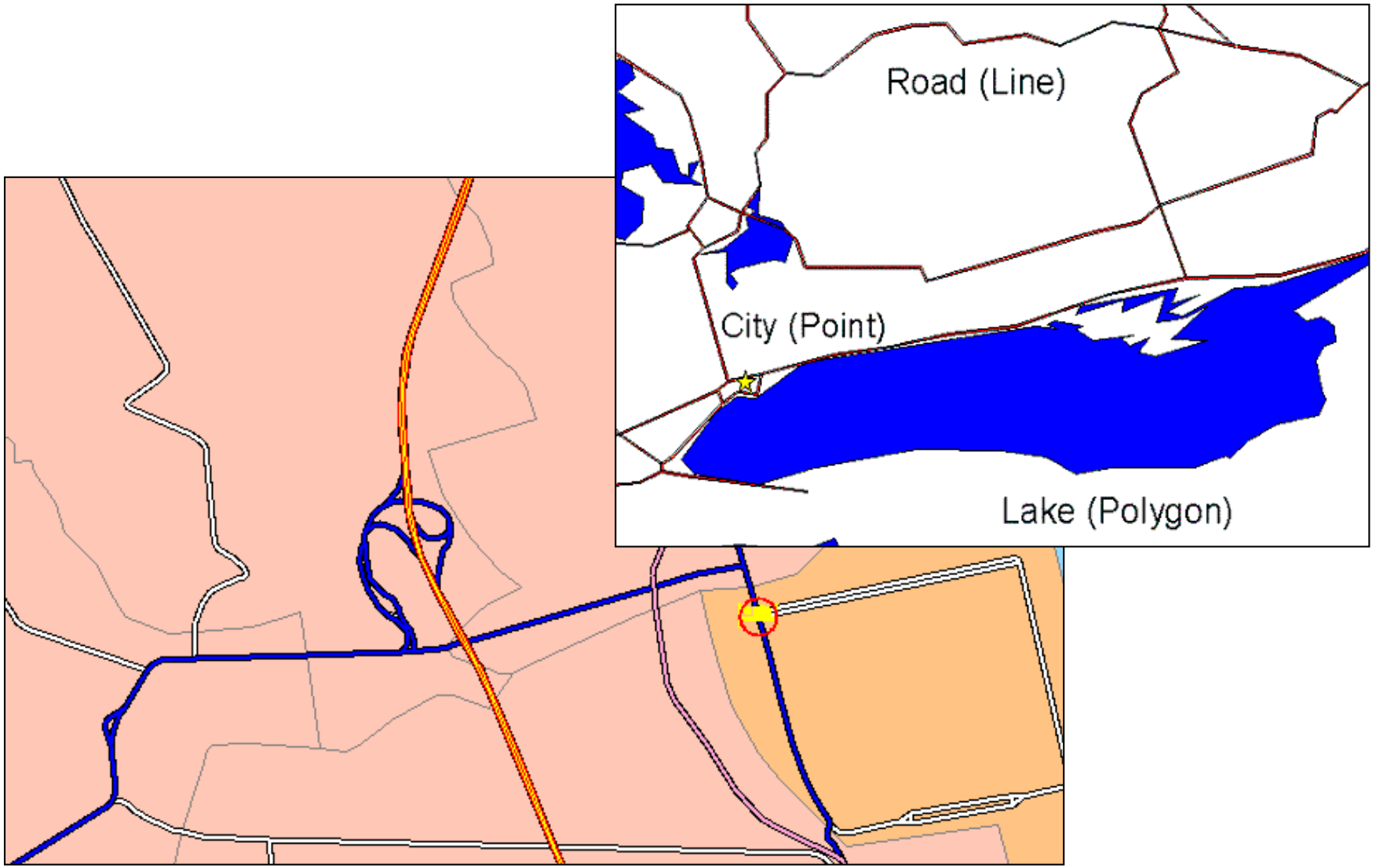
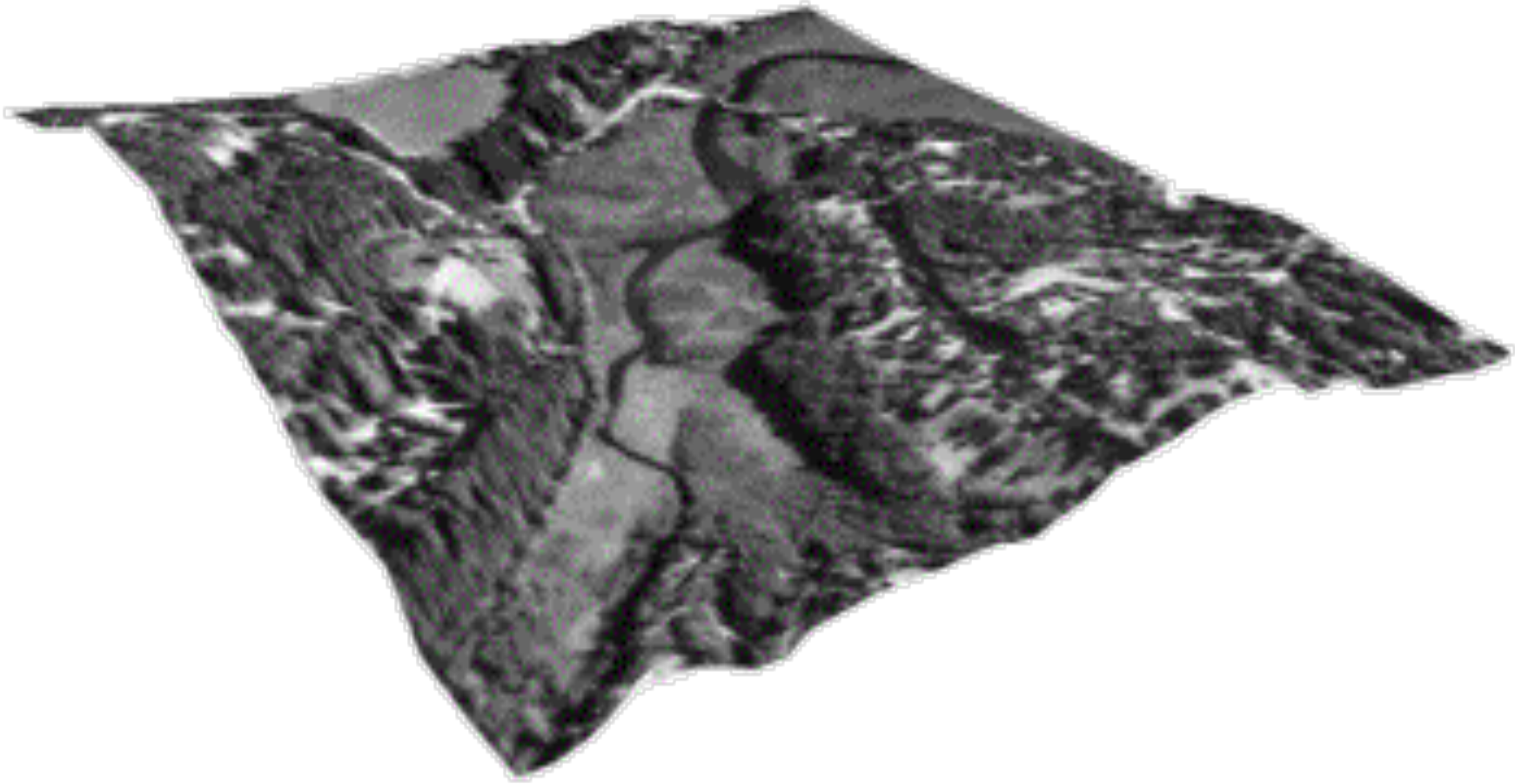
File Edit Navigate Bookmarks Select View Window Help
Mappa1
Map Layers
Caselli
Scale: 0 - 150,000
Segnali
Scale: 0 - 4,499,999
2
3
4
5
6
7
8
11
MajorH_dett
Scale: 0 - 299,999
MajorH_Complete
Scale: 0 - 300,000
Secondary_Highways
Scale: 0 - 300,000
Streets
Waters
Visible at all scales
WaterWays
Scale: 0 - 3,000,000
Centri
Comuni
Reports
Zoom Gotos
Comuni
Design
View
GERENZANO
RESCALDINA
SARONNO
SOLARO
CESANO MADERNO
BOVISIO MASCIAGO
UBOLDO
LIMBIATE
CESATE
CARONNO PERTUSELLA
VAREDO
ORIGGIO
CERRO MAGGIORE
VITTORE OLONA
GARBAGNATE MILANESE
SENAGO
PADERNO DUGNANO
LAINATE
PARABIAGO
NERVIANO
ARESE
BOLLATE
CUSANO MILA
CORMANO
POGLIANO MILANESE
RHO
NOVATE MILANESE
VANZAGO
PREGNANA MILANESE
ARLUNO
PERO
MILANO
CORNAREDO
SEDRIANO
BAREGGIO
SETTIMO MILANESE
VITTUONE
Lat: 45.497885, Lon: 9.054670 Comuni : SETTIMO MILANESE
0 feature(s) selected
1 : 103,327
26.7 x 17.3 (Km)

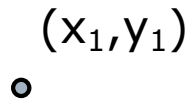
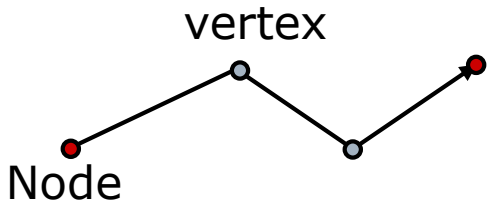
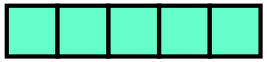
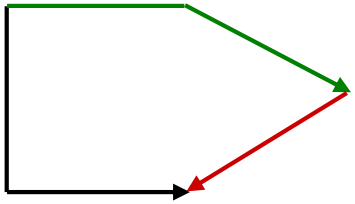
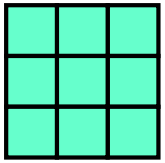
GIS – Vector Data



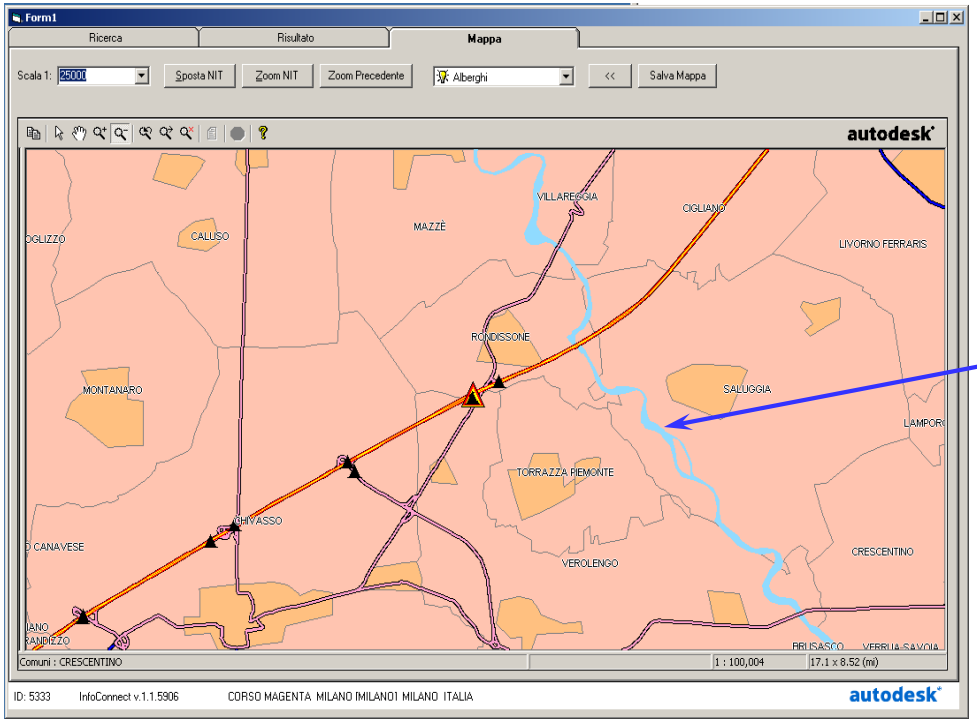
GIS – Raster Data



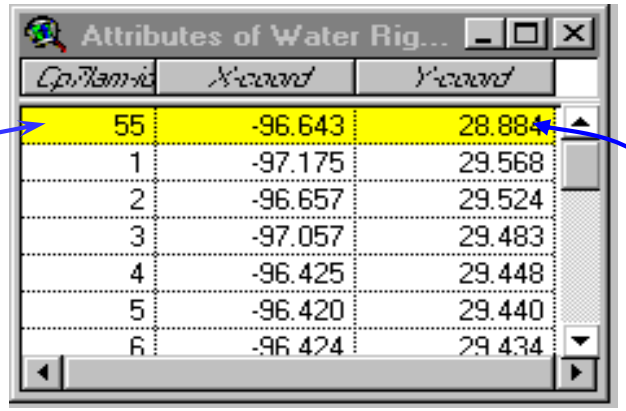
GIS – Data Primitives

Graphics entity:	**Vector** data:	**Raster** data:
Point - a pair of x and y coordinates		
Line - a sequence of points		
Polygon - a closed set of lines		

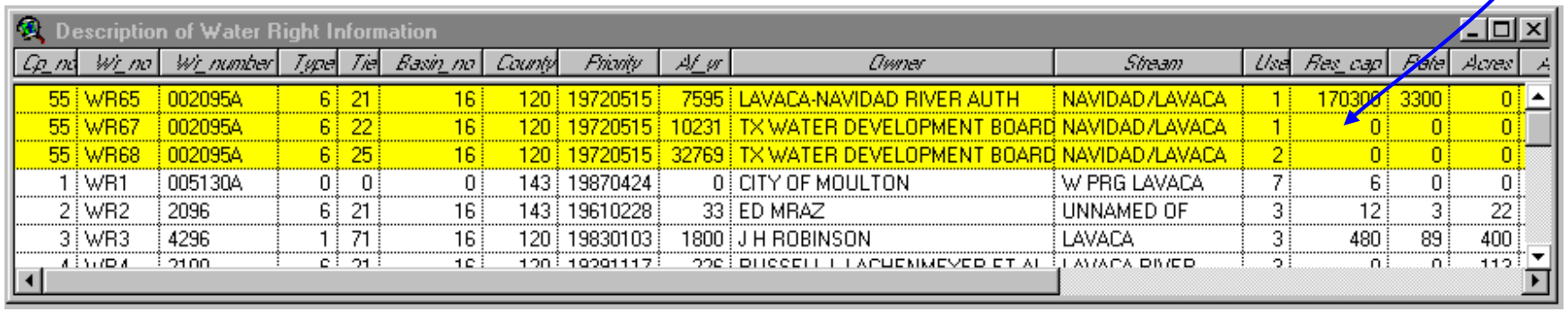
GIS – Relational database



Spatial Attributes



Descriptive Attributes



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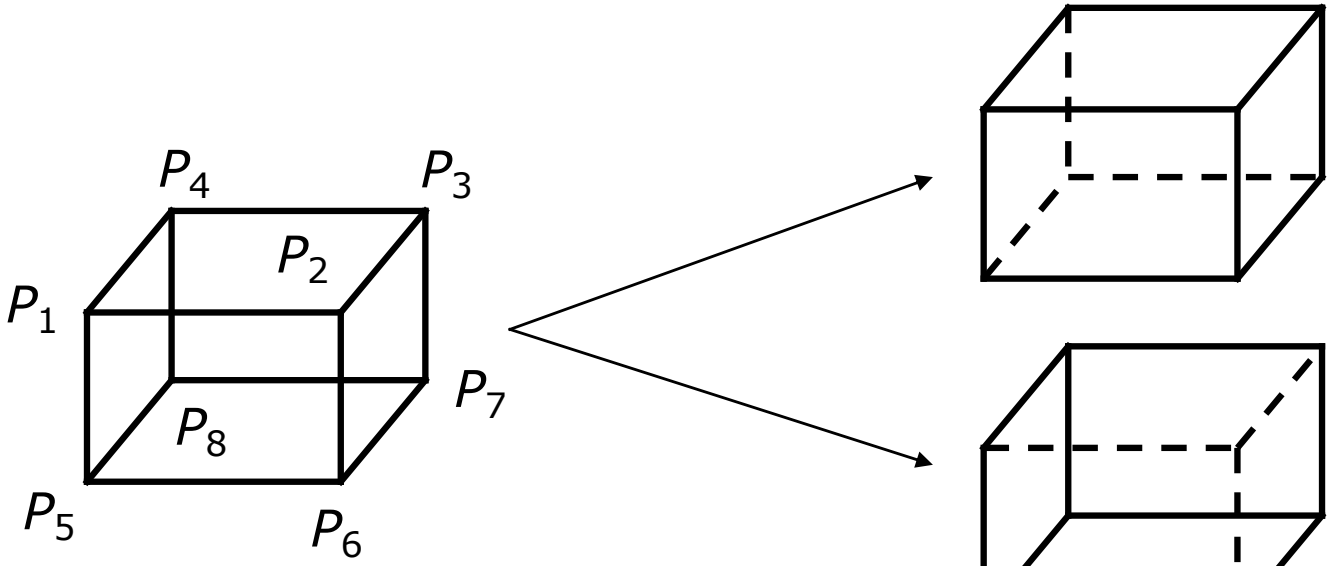
55	WR67	002095A	6	22	16	120	19720515	10231	TX WATER DEVELOPMENT BOARD	NAVIDAD/LAVACA	1	0	0	0
55	WR68	002095A	6	25	16	120	19720515	32769	TX WATER DEVELOPMENT BOARD	NAVIDAD/LAVACA	2	0	0	0
1	WR1	005130A	0	0	0	143	19870424	0	CITY OF MOULTON	W PRG LAVACA	7	6	0	0
2	WR2	2096	6	21	16	143	19610228	33	ED MRAZ	UNNAMED OF	3	12	3	22
3	WR3	4296	1	71	16	120	19830103	1800	J H ROBINSON	LAVACA	3	480	89	400

Geometric Models

- Definition
  - A collection of methods to define geometric and topological characteristics of an object
- Usual geometric models
  - wireframe model
  - surface model
  - solid model

Wireframe Model

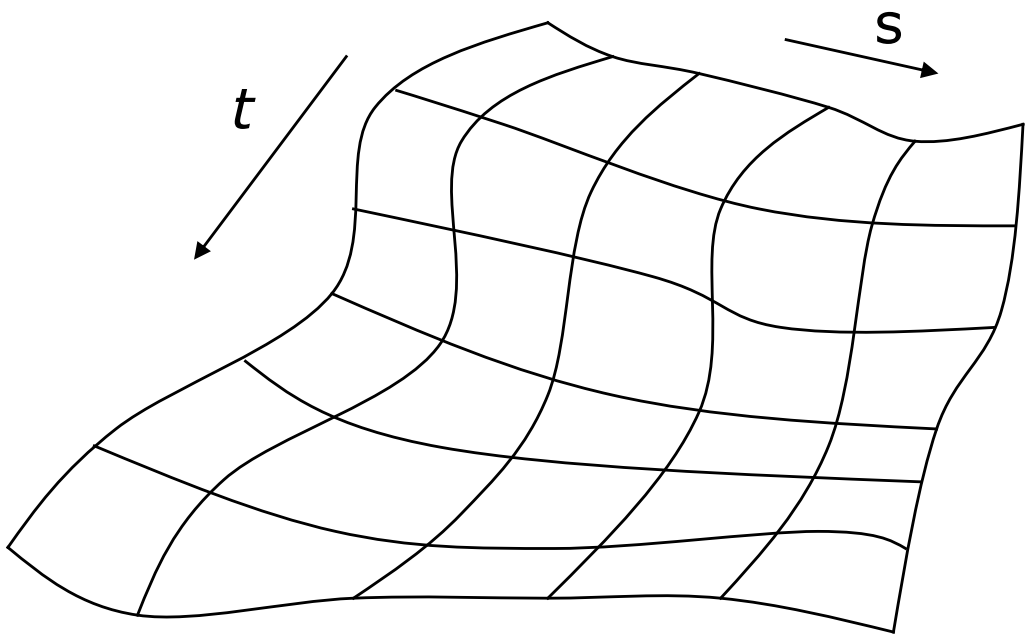
- Primitives: points and lines
- Applications: 2D CAD/CAM, Drafting



Simple and efficient,
but ambiguous

Surface Model

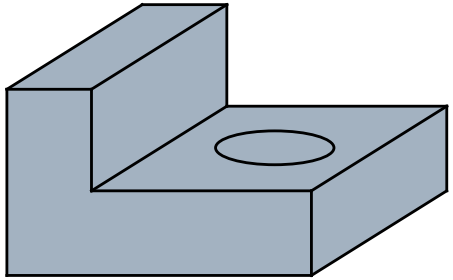
- Primitives: points and lines (sometimes patches)
- Applications: Representation of sculptured surfaces



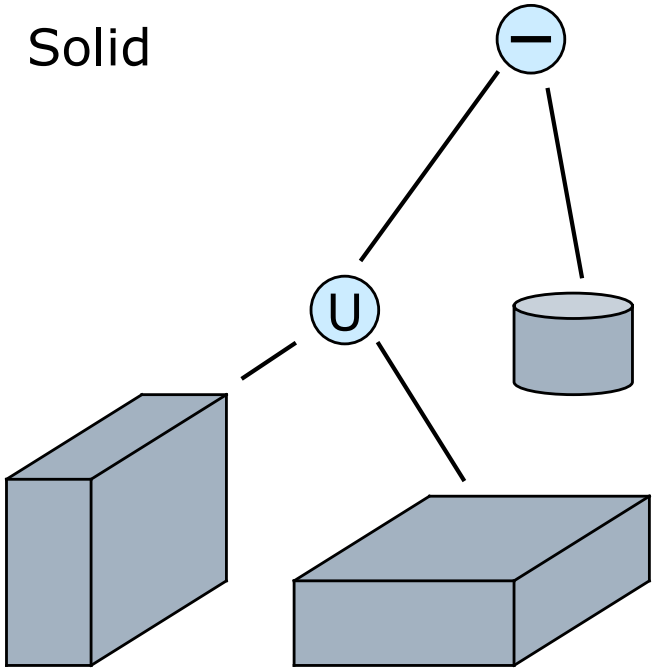
Accurate representation of surface,
but cannot represent a true solid object (inside/outside)

Solid Object Modeling

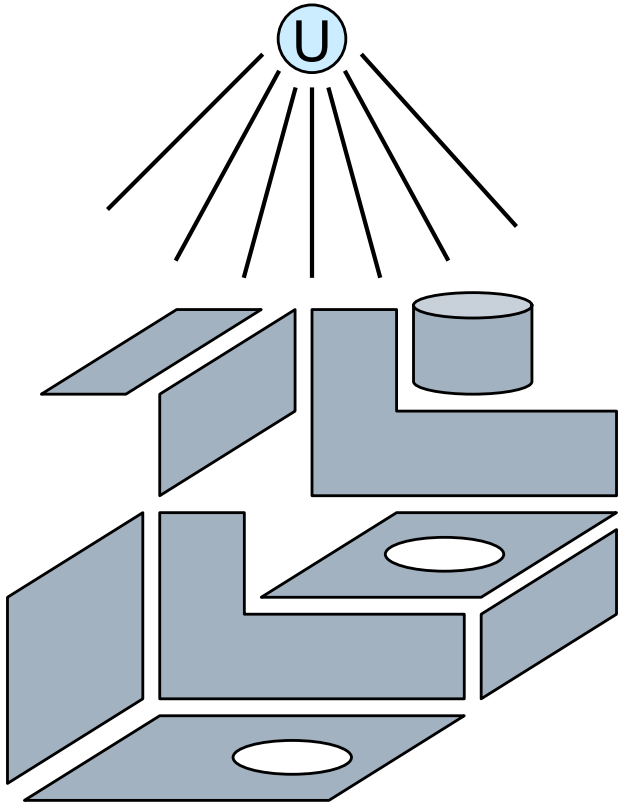
- Shading and hidden line removal
- Mass properties calculation
- Interference test



Solid

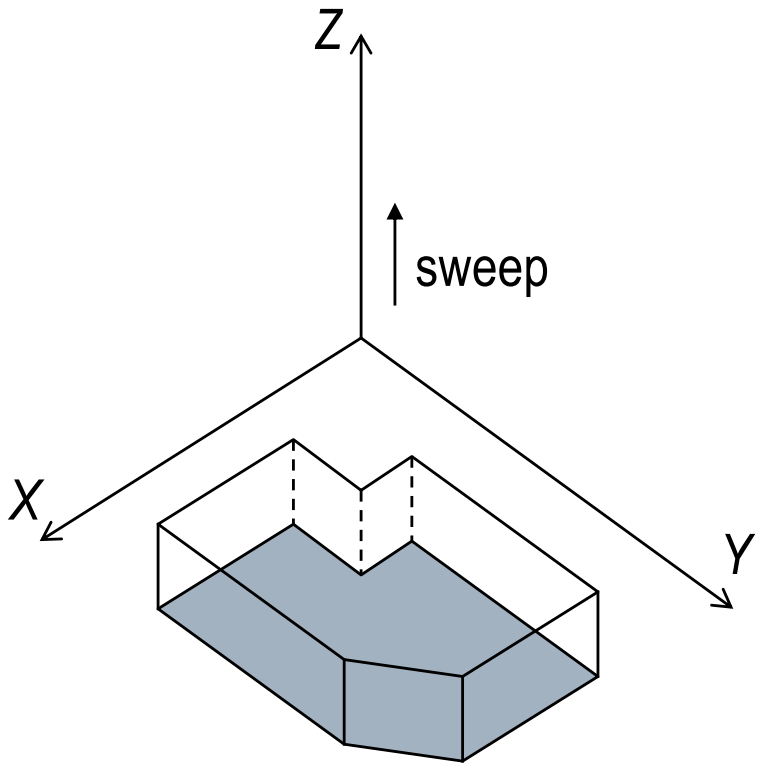


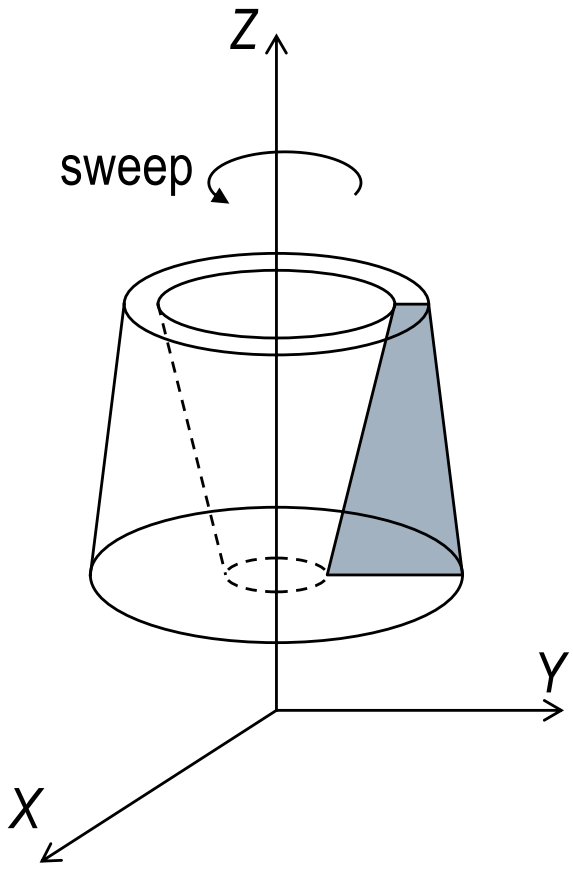
Constructive Solid Geometry (CSG)



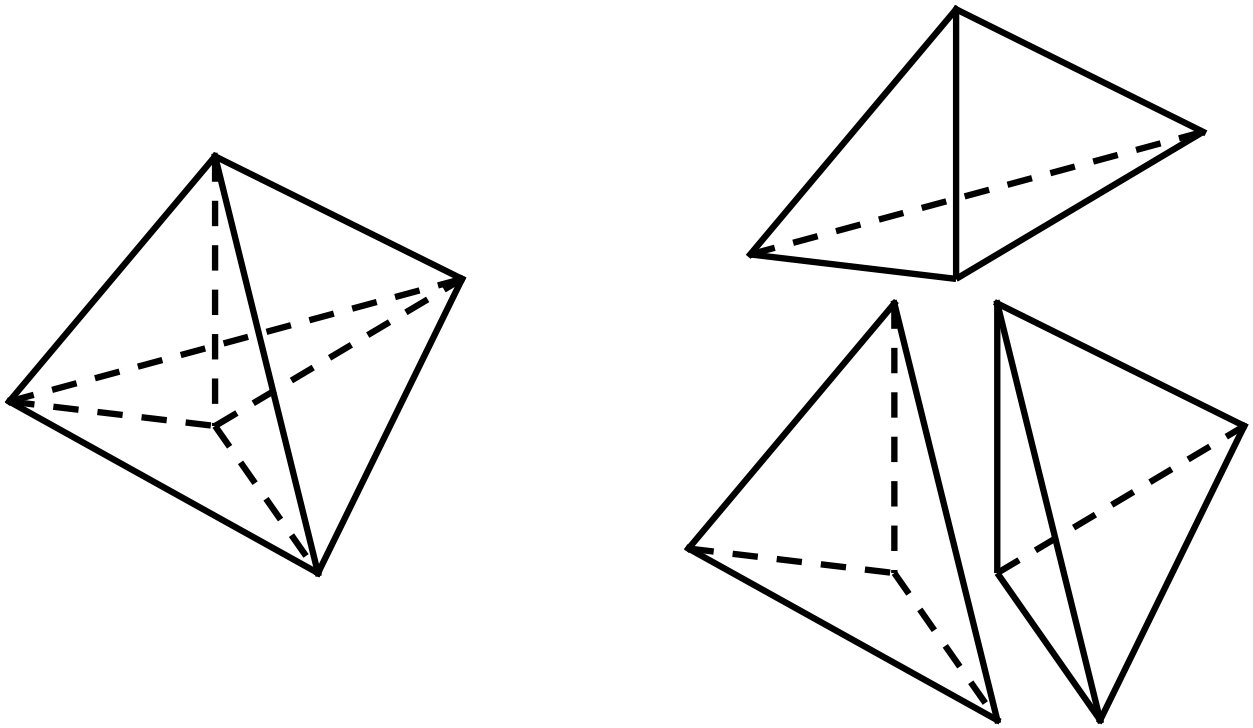
Boundary Representation (BRep)

Swept Volume Generation

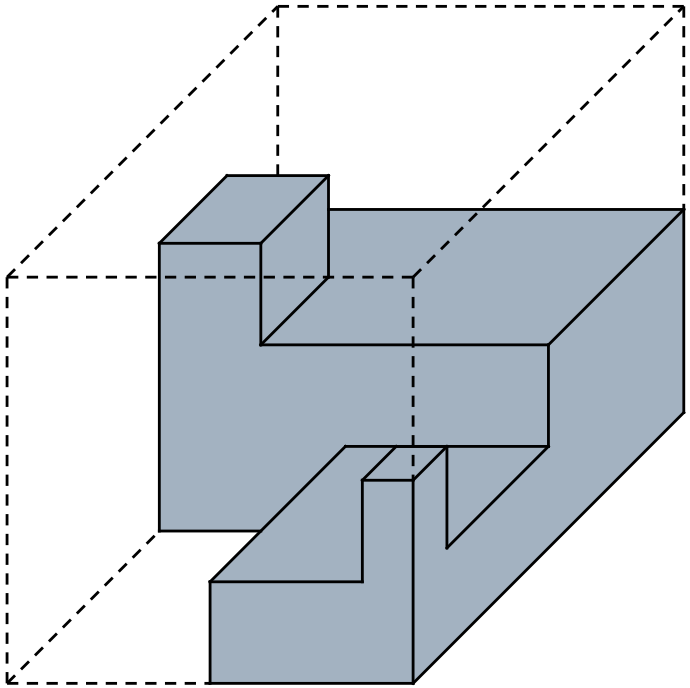


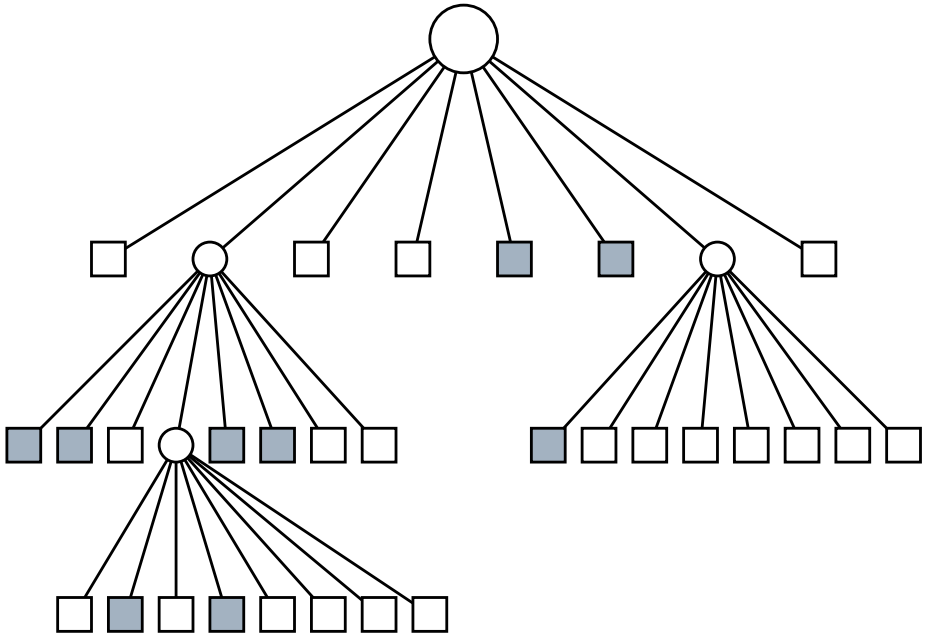


Object Decomposition

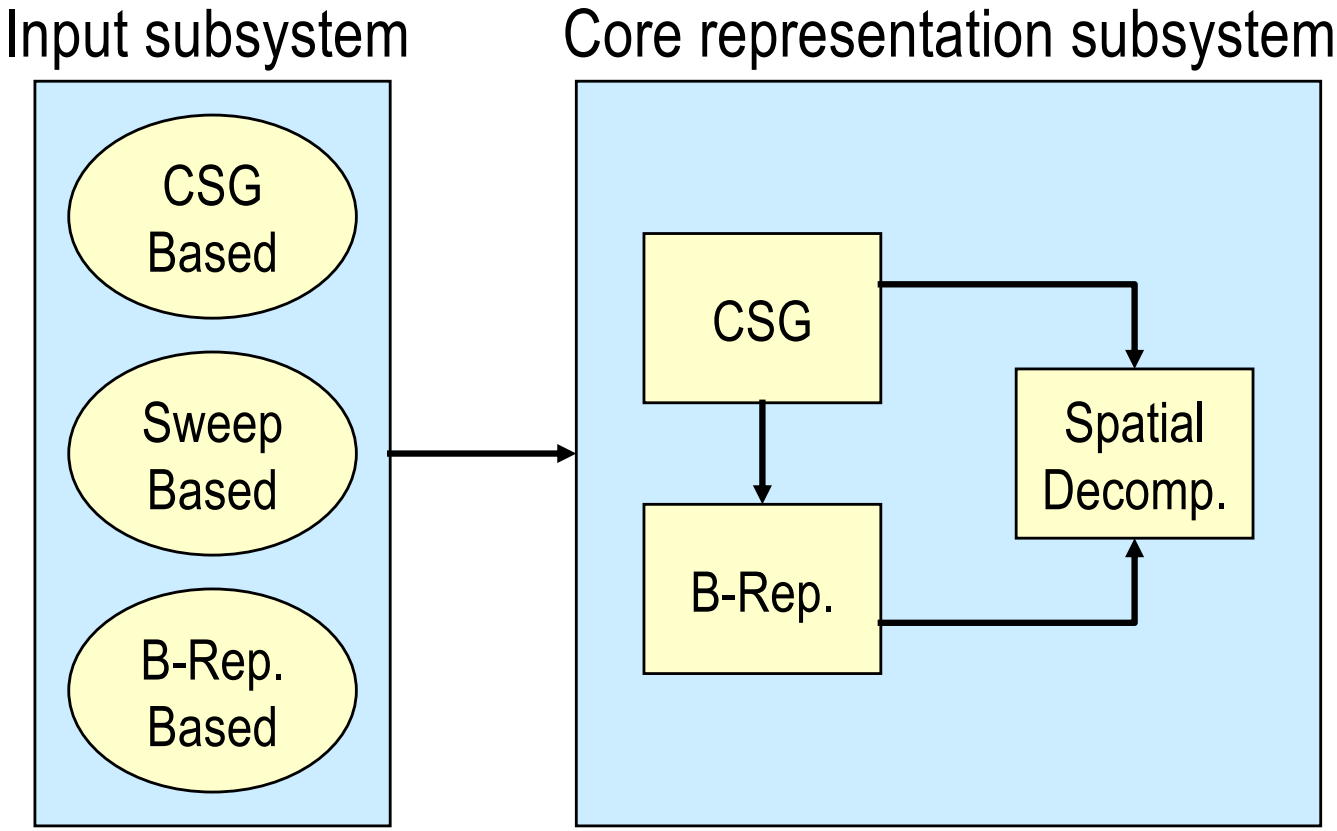


Octree Representation

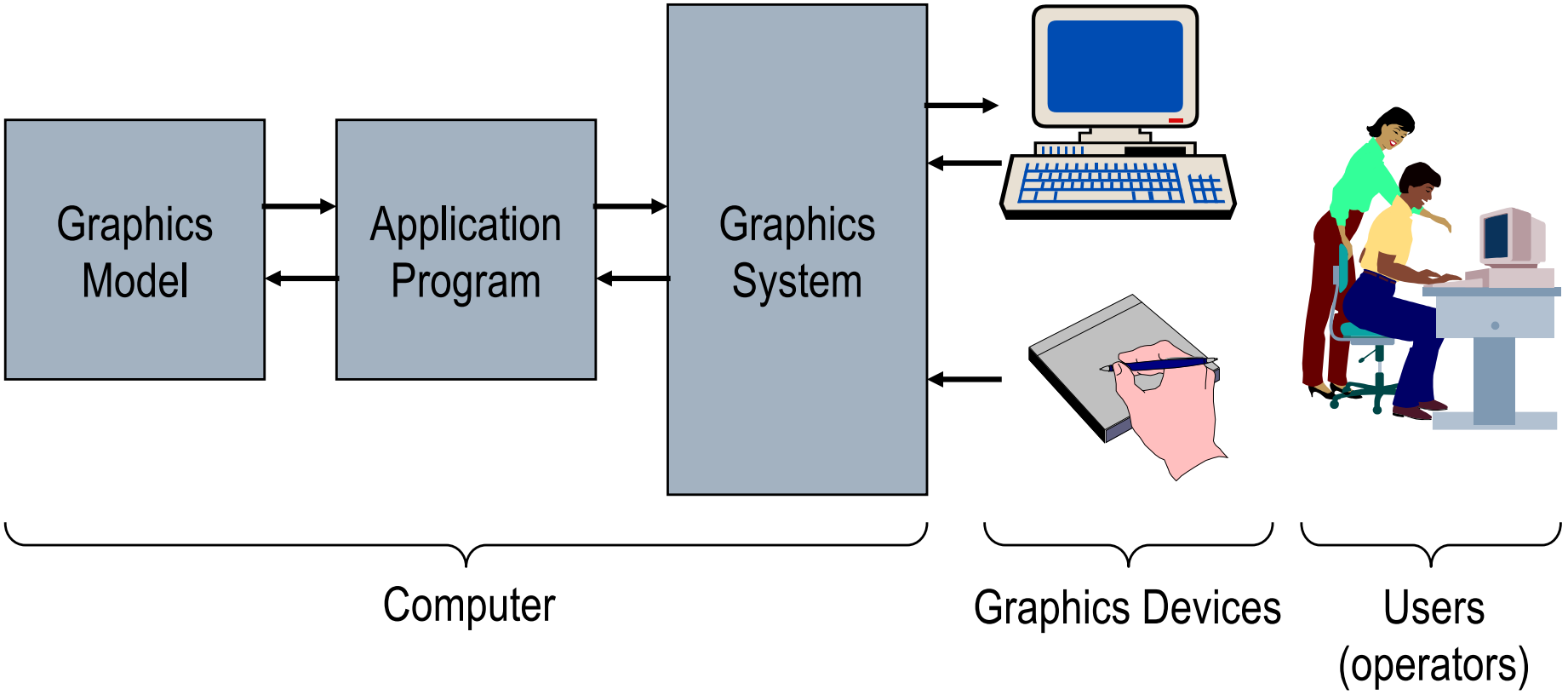




Geometric Modeling System



Programmer's Model of Interactive CG



- Graphics Models - Application Data Structures
- Application Programs
- Graphics Systems
- Graphics Devices

5. Graphics Systems

- Definition:
  - Interface between application software and graphics hardware system

- Fundamentals
  - Output primitives
  - Primitive aspects
  - Primitive attributes
  - Output model
  - Coordinate systems and clipping
  - Input primitives
  - Input model
  - Storage

Graphics Systems - Requirements

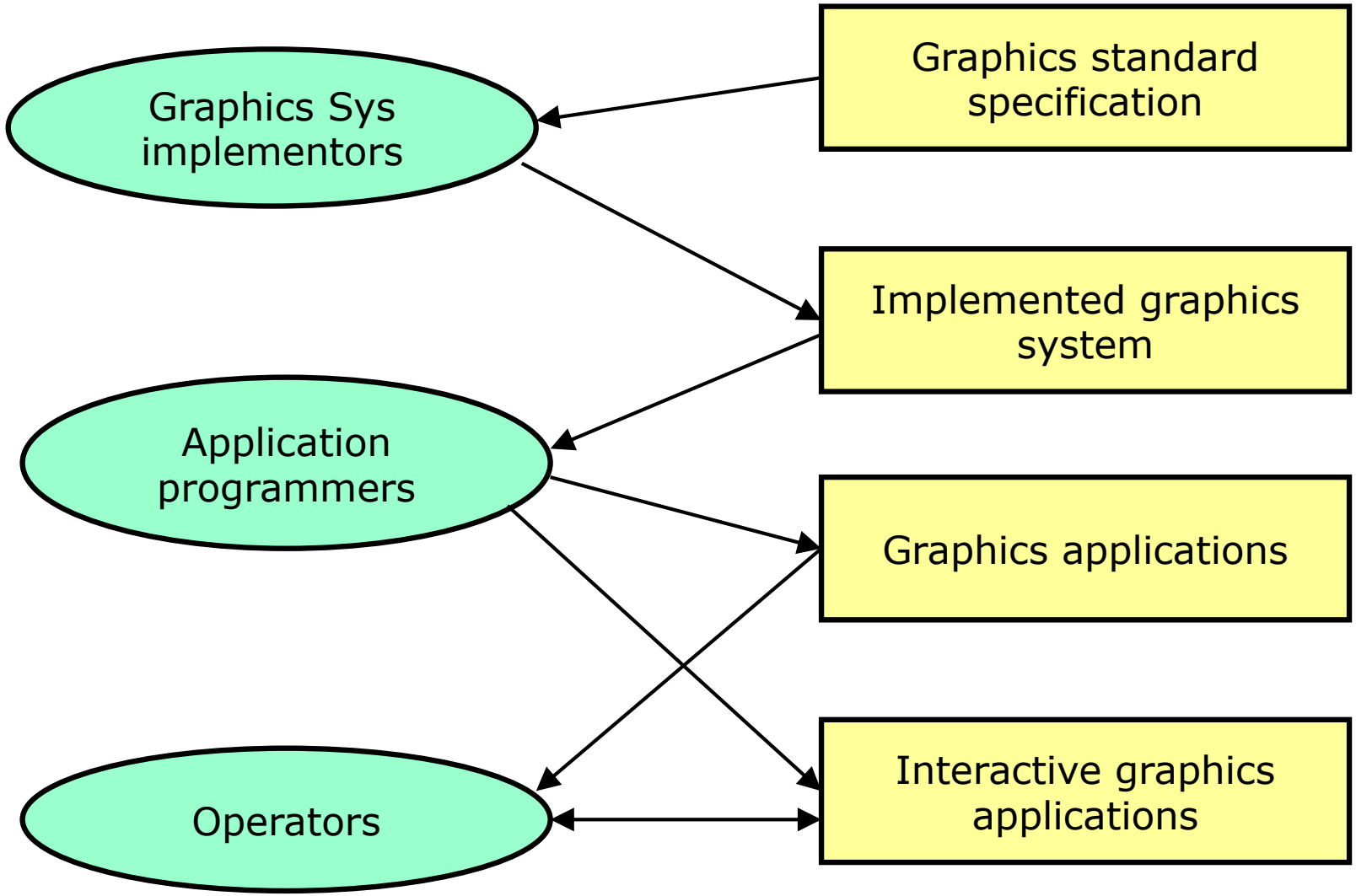
- Consist of input subroutines and output subroutines
- Accept input data and commands from user
- Convert internal representations into external pictures
- Graphics kernel assures
  - Application portability
    - Device independence
    - Language independence
    - Computer independence
    - Programmer independence
  - Application flexibility

Graphics Systems - Examples

- Core - 1977
- GKS (Graphical Kernel System) - 1985
- X-Window - 1986
- GKS-3D - 1988
- PHIGS (Programmers Hierarchical Interface Graphics System) - 1989
- CGI (device interface)
- CGM (metafile)
- CGRM (Computer Graphics Reference Model) - 1992
- IGES (Initial Graphics Exchange Specification) - 1980
- OpenGL (Open Graphics Library) - 1992
- DirectX

See CGI Historical Timeline, http://accad.osu.edu/~waynec/history/timeline.html

Roles in Graphics



6. Future Research Directions

- Graphics accelerators
  - parallel processing
- Geometric modeling
  - physically-based modeling
  - level of detail
- Motion control / synthesis
  - kinematics / dynamics
  - motion capture / modification
- Rendering
  - photo-realism
  - real-time
  - image-based rendering
  - non-photorealistic rendering
- Scientific visualization
- Geometric algorithms
- User interface

Questions and proposed problems

1. What are the main components of the Programmer's Model for the Interactive Computer Graphics?
2. What is the main role of the display processor? Is it a computer? Does it execute a graphics application?
3. What is the difference between a logical and a physical input graphics device?
4. Explain the status of graphics objects as graphics model, application model, data structure, graphics file, and graphics database. What is the relationship and the flow between these states.
5. What graphics operations can be supported by the wireframe model? Does it support the computation of areas and volumes? What about light intensity computation, and texture mapping? Explain your answer.
6. What graphics operations can be supported by the surface model? Does it support the computation of areas and volumes? What about light intensity computation, and texture mapping? Explain your answer.

Questions and proposed problems

7. What graphics operations can be supported by the CSG model? Does it support the computation of areas and volumes? What about light intensity computation, and texture mapping? What other operations are supported? Explain your answer.
8. What graphics operations can be supported by the BREP model? Does it support the computation of areas and volumes? What about light intensity computation, and texture mapping? What other operations are supported? Explain your answer.
9. Exemplify the CSG model on the 3D object of a table and a glass.
10. Exemplify the BREP model on the 3D object of a table.
11. Exemplify and explain the Octree model on the 3D object of a sphere.
12. Explain the concept of the graphics application portability. Give some examples.
13. Explain the concept of graphics application flexibility.