Graphics Systems and Models

2주차, 2023

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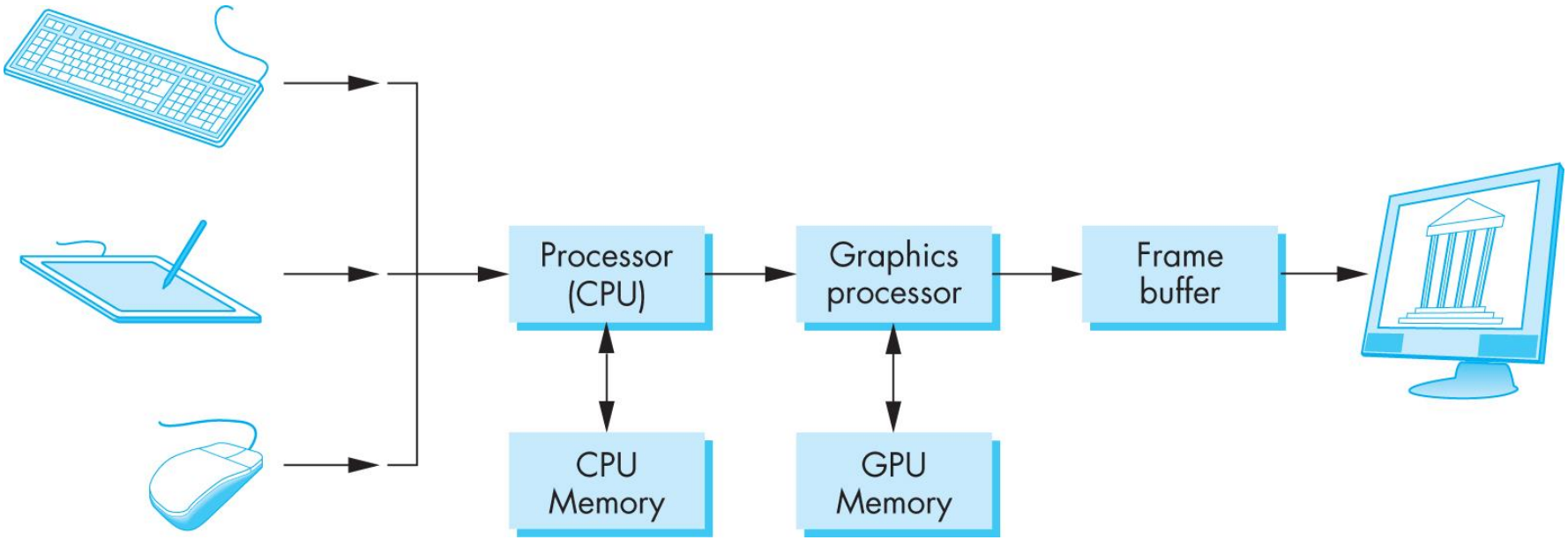
그래픽스 시스템

- 컴퓨터 그래픽스 시스템도 일종의 컴퓨터 시스템
- 6개의 구성 요소
  - 입력 장치, 중앙처리 장치, 그래픽 처리 장치
  - 메모리, 프레임 버퍼, 출력 장치



입력장치 (1)

- 다음과 같은 3차원 물체를 입력할 수 있는 방법은 무엇인가?

Michelangelo's David

입력장치 (2)

- 3차원 물체를 입력할 수 있는 방법은 무엇인가?

입력장치 (3)

- 3차원 물체를 입력할 수 있는 방법은 무엇인가?

모델러가 만드는 방법
혹시 다른 방법은 없을까?

입력장치 (4)

- 3차원 물체를 입력할 수 있는 방법은 무엇인가?

3D Scanner

The Digital Michelangelo Project: 3D Scanning of Large Statues
http://graphics.stanford.edu/papers/dmich-sig00/

입력장치 (5)

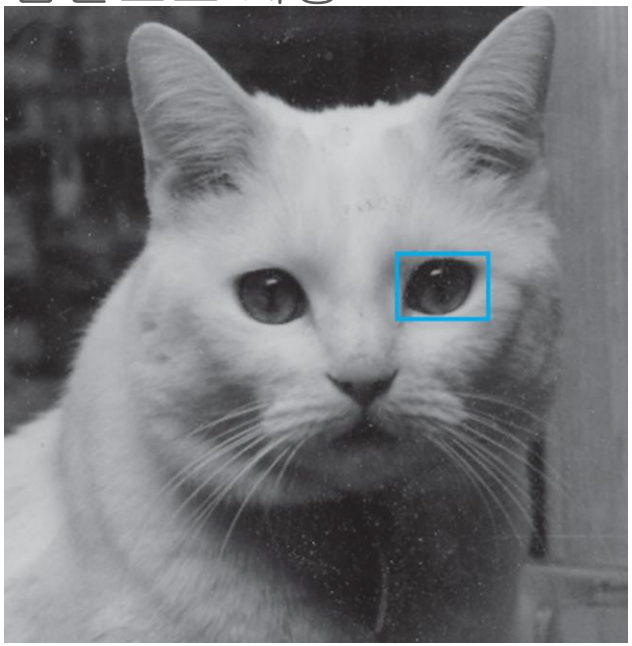
- 3차원 스캐너

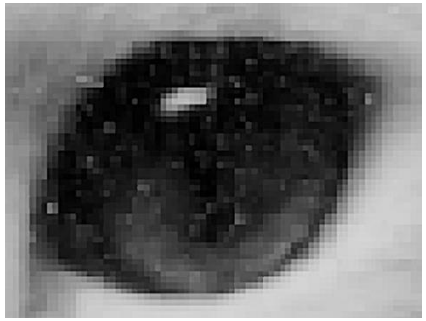
Full-Body 3D Scanner

3D Scanners

픽셀과 프레임 버퍼 (1)

- 래스터 방식 (Raster)
  - 그래픽스 시스템 안에서 픽셀의 배열, 즉 래스터로 생성됨
  - 각 픽셀은 영상의 한 위치나 작은 영역에 대응
  - 픽셀은 프레임 버퍼(frame buffer)라고 부르는 메모리의 한 부분에 집단으로 저장

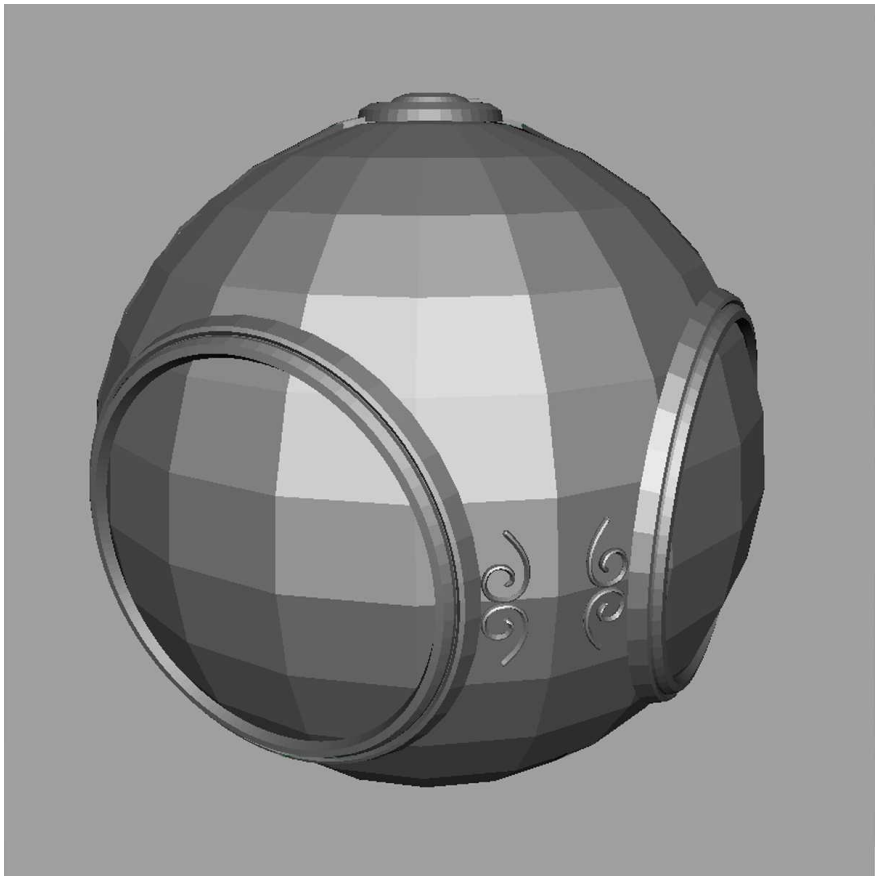




Pixels

픽셀과 프레임 버퍼 (2)

- 폴리곤에 라인과 와이어 프레임 이미지를 그려줌

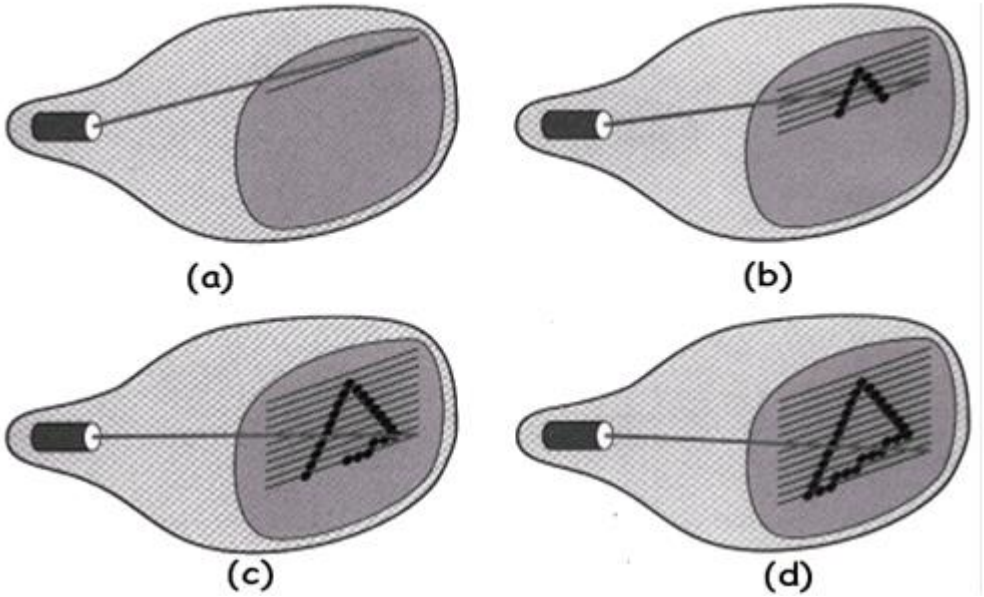


픽셀과 프레임 버퍼 (3)

- 해상도 (resolution)
  - 프레임 버퍼의 픽셀 수가 우리들이 볼 수 있는 영상의 상세함을 결정
  - 1비트 깊이의 프레임 버퍼
    - 두 색만들 표시
  - 8비트 깊이의 프레임 버퍼
    - 256가지 색을 표시 (2의 8승)
  - 각 픽셀의 비트 수로 정의되는 프레임 버퍼의 깊이(depth), 즉 정밀도(precision)가 주어진 시스템이 얼마나 많은 색을 표현할 수 있는지를 결정함

픽셀과 프레임 버퍼 (4)

- **래스터화(rasterization) 혹은 주사변화(scan conversion)**
  - 응용프로그램에 의하여 픽셀에 관한 정보를 처리하여 프레임 버퍼에 저장시키는 것

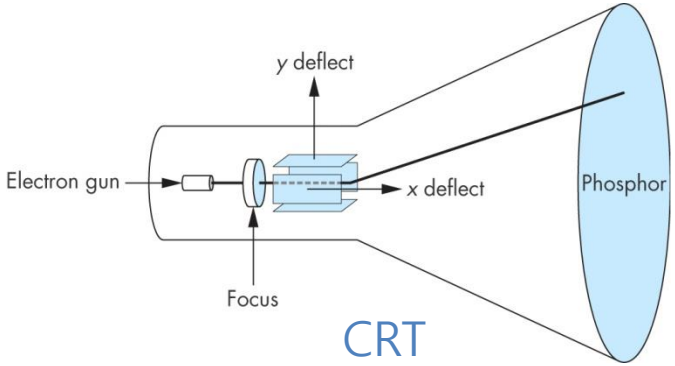


The CPU and GPU

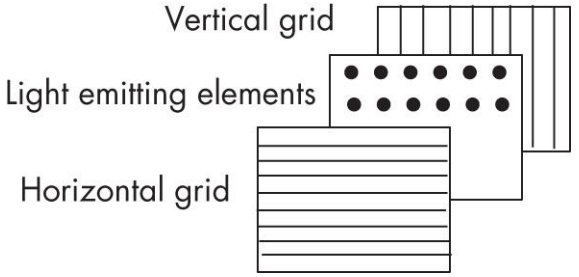
- **Central processing unit (*CPU*)**
  - Doing both the normal processing and the graphics processing
  - ***Rasterization*** or ***scan conversion***
    - 응용프로그램에 의하여 픽셀에 관한 정보를 처리하여 프레임 버퍼에 저장시키는 것
- **Graphics processing units (*GPUs*)**
  - Custom-tailored to carry out specific graphics functions
  - High degree of parallelism

출력장치

- **Cathode-ray tube (CRT)**



CRT



Generic Flat-Panel Display

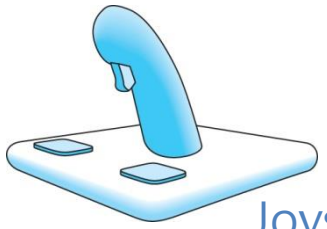
- **Flat-panel monitors**
  - Light-emitting diodes (LEDs), liquid-crystal displays (LCDs), and plasma panels
- **Projection systems**
  - Digital light projection (DLP)
- **Hard-copy devices**

Input Devices

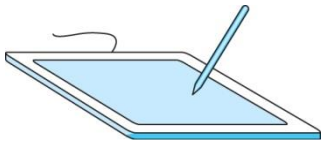
- **Most graphics systems provide a keyboard and at least one other input device**
  - Pointing devices

Mouse

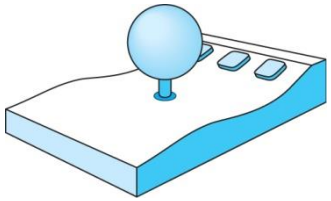
Trackball



Joystick



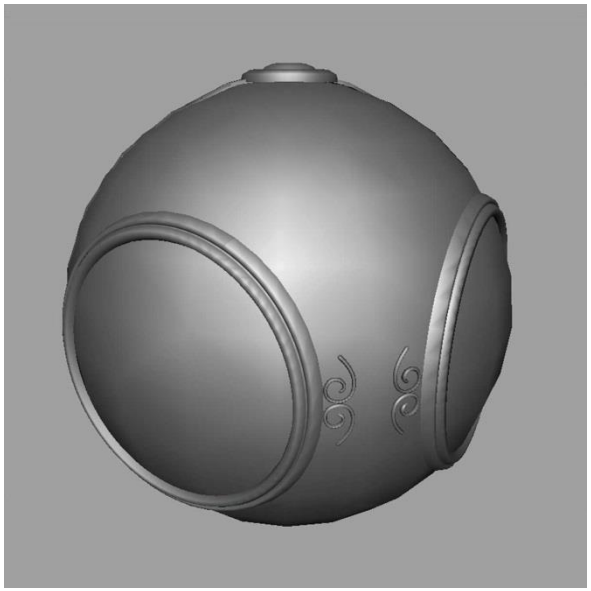
Data Tablet



Spaceball

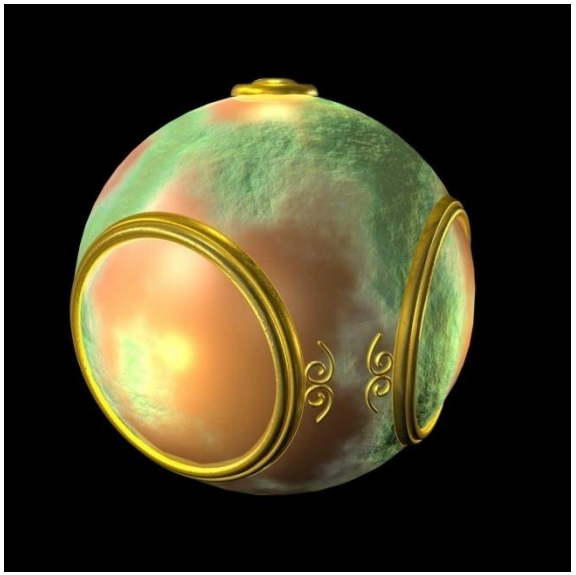
Computer Graphics: 1980-1990

Realism comes to computer graphics



smooth shading

environment mapping



bump mapping

Computer Graphics: 1980-1990

- **Special purpose hardware**
  - Silicon Graphics geometry engine
    - VLSI implementation of graphics pipeline
- **Industry-based standards**
  - PHIGS
  - RenderMan
- **Networked graphics: X Window System**
- **Human-Computer Interface (HCI)**

Computer Graphics: 1990-2000

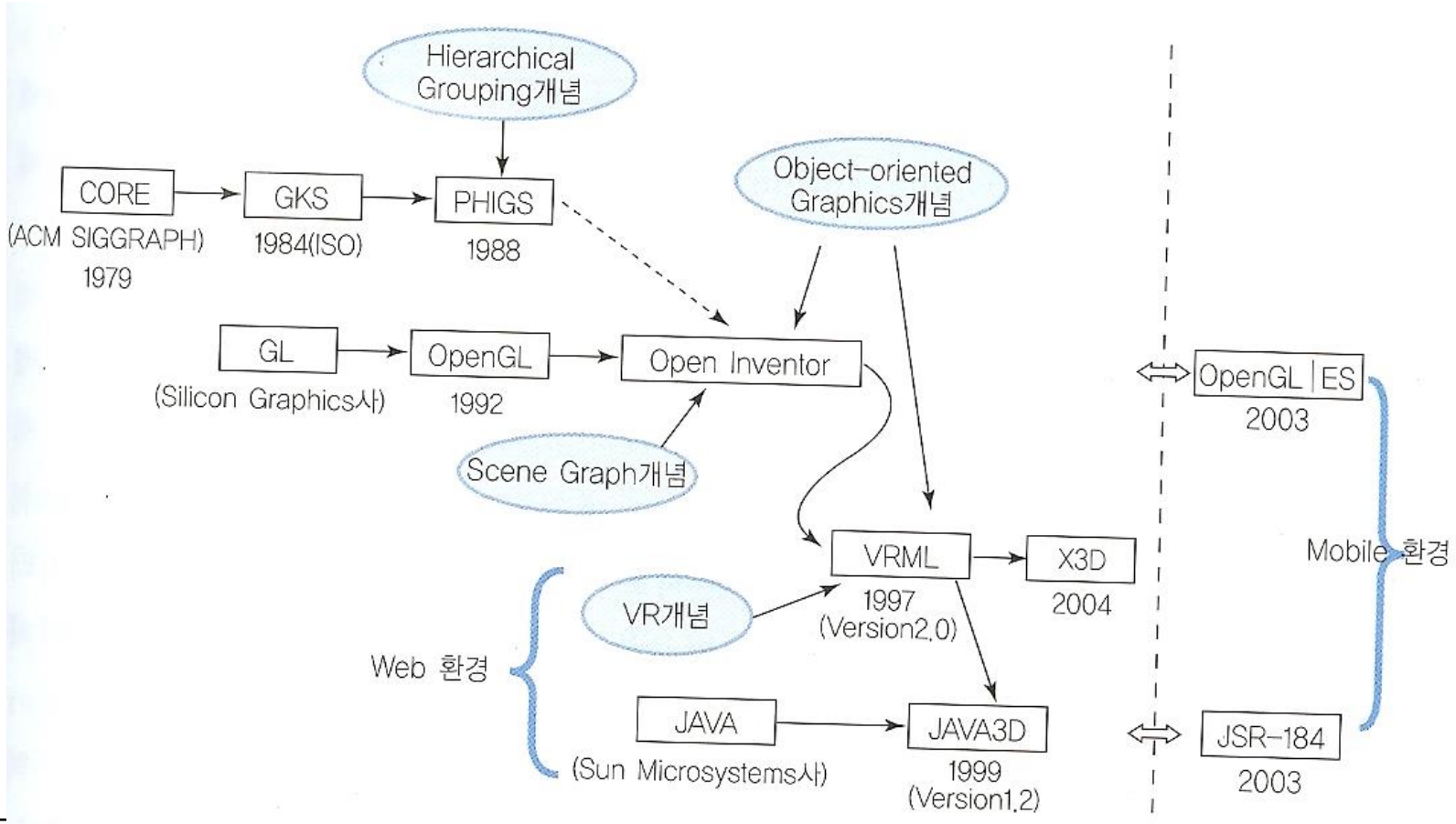
- OpenGL API
- Completely computer-generated feature-length movies (Toy Story) are successful
- New hardware capabilities
  - Texture mapping
  - Blending
  - Stencil buffers

Computer Graphics: 2000-

- Photorealism
- Graphics cards for PCs dominate market
  - Nvidia, ATI
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry: Maya, Lightwave
- Programmable pipelines

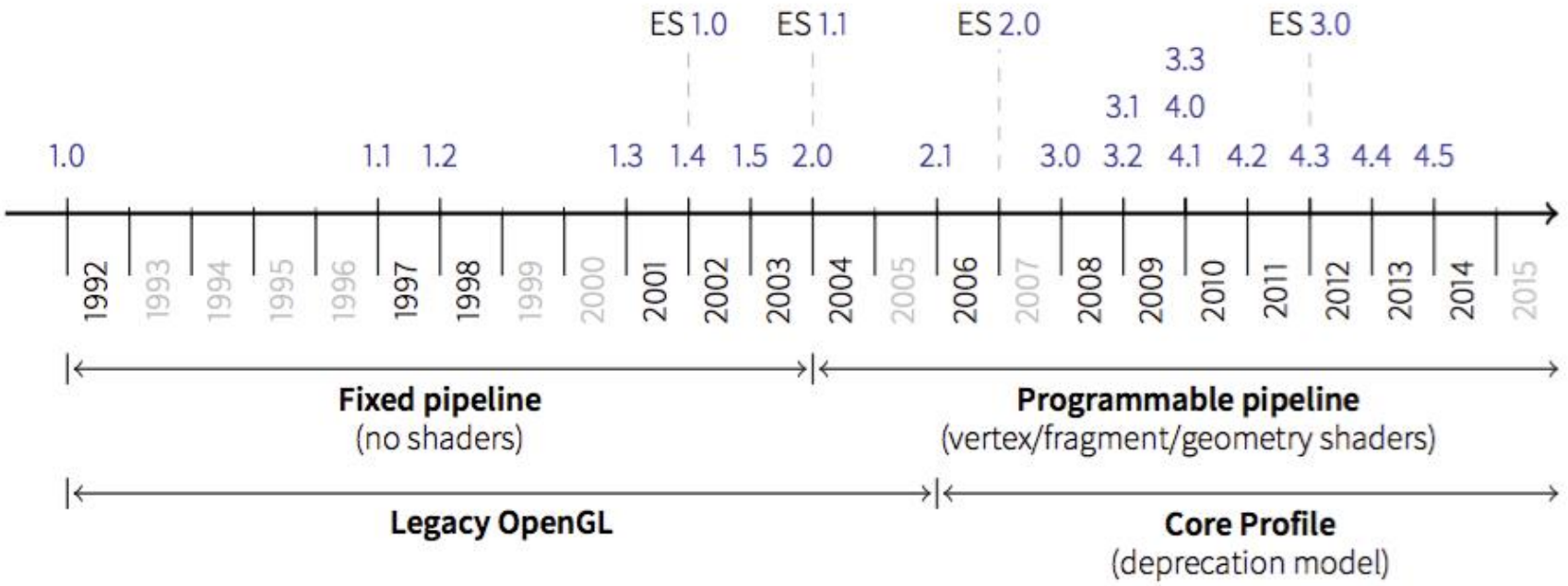
컴퓨터 그래픽스의 표준 1

- **OpenGL**
  - http://www.opengl.org



컴퓨터 그래픽스의 표준 2

- OpenGL
  - http://www.opengl.org



컴퓨터 그래픽스의 표준 3

- OpenGL
  - http://www.opengl.org

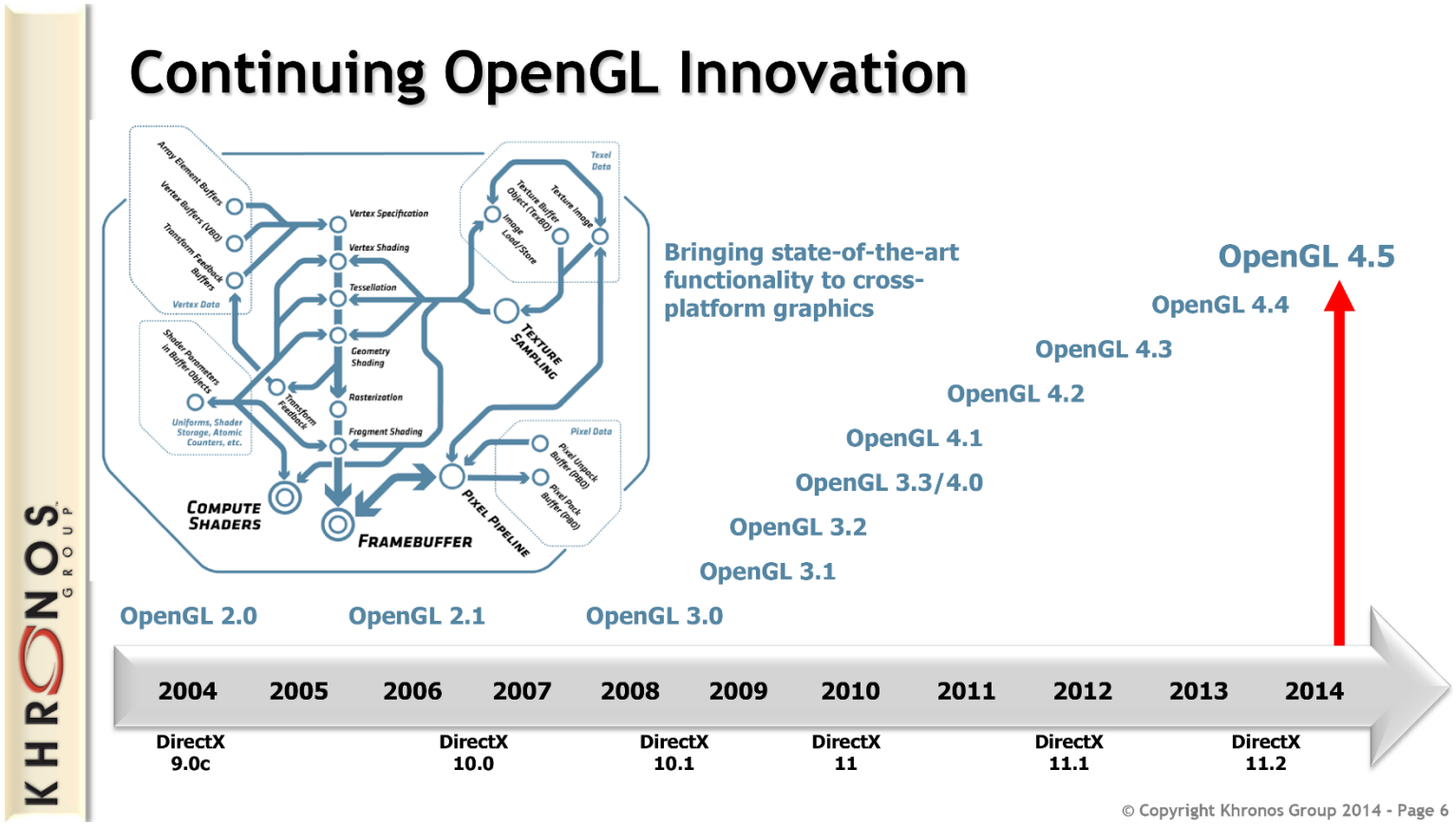
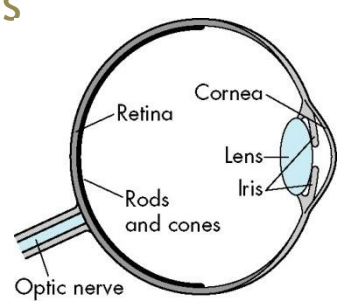


Image Formation (1)

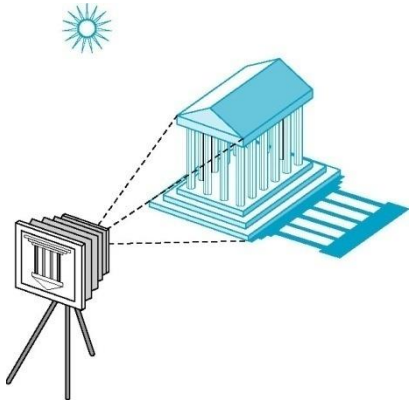
- **There always has been analogous process how image are formed by physical imaging systems**
  - Cameras
  - Microscopes
  - Telescopes
  - Human visual system
    - Rods(간상체) and cones(원추체) are light sensors
    - Rods – monochromatic, night vision
    - Cones – color sensitive
      - Three types of cones
      - Only three values (the tristimulus values) are sent to the brain



The Human Visual System

Image Formation (2)

- **Elements of image formation**
  - Objects
    - Independent of any viewer and of any image-formation process
  - Viewer (camera)
    - To form the image of objects
  - Light sources



Camera System

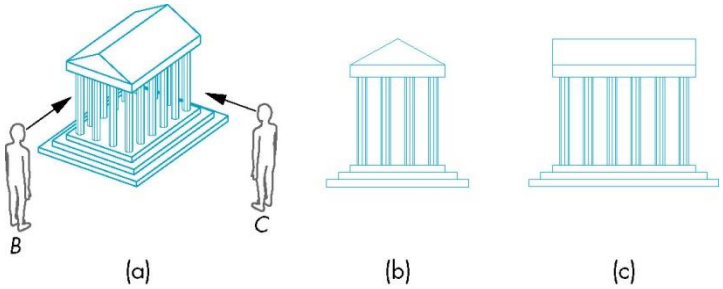
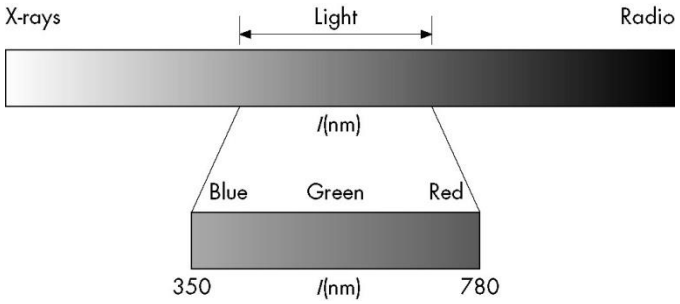


Image Seen by Three Different Viewers

Light and Images

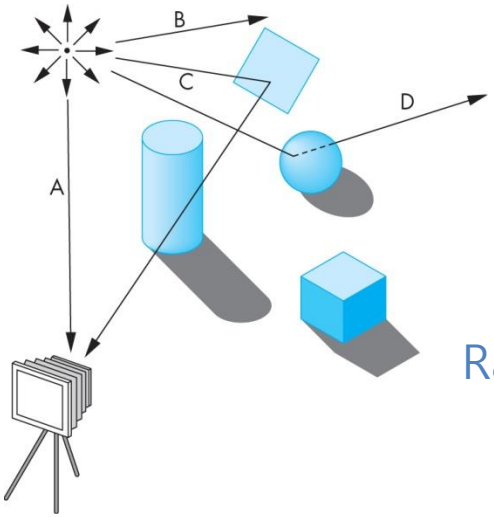
- Interaction between light and the surfaces of the object ➔ How much light enters the camera
- Light = ***visible spectrum***
  - Wavelengths in the range 350~780 nm
    - Long wavelengths: reds
    - Short wavelengths: blues



The Electromagnetic Spectrum

Imaging Models

- ***Ray tracing***
  - Image formation techniques
  - Following rays of light from a point source finding which rays enter the lens of the camera

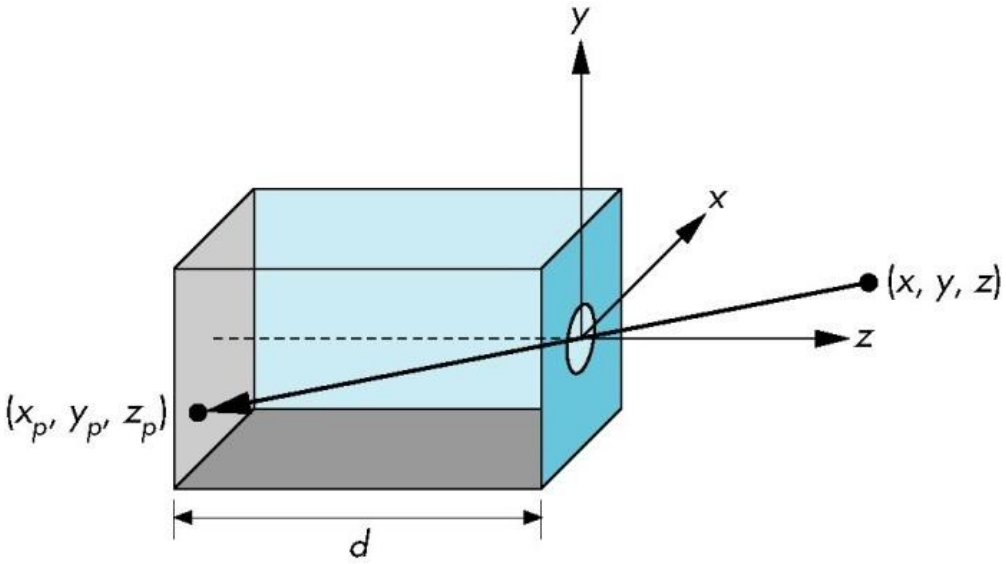


Ray Interactions

- ***Radiosity***
  - Based on conservation of energy

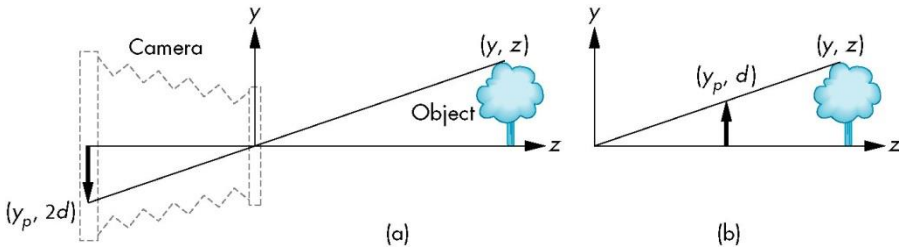
Imaging Models

- Pinhole camera



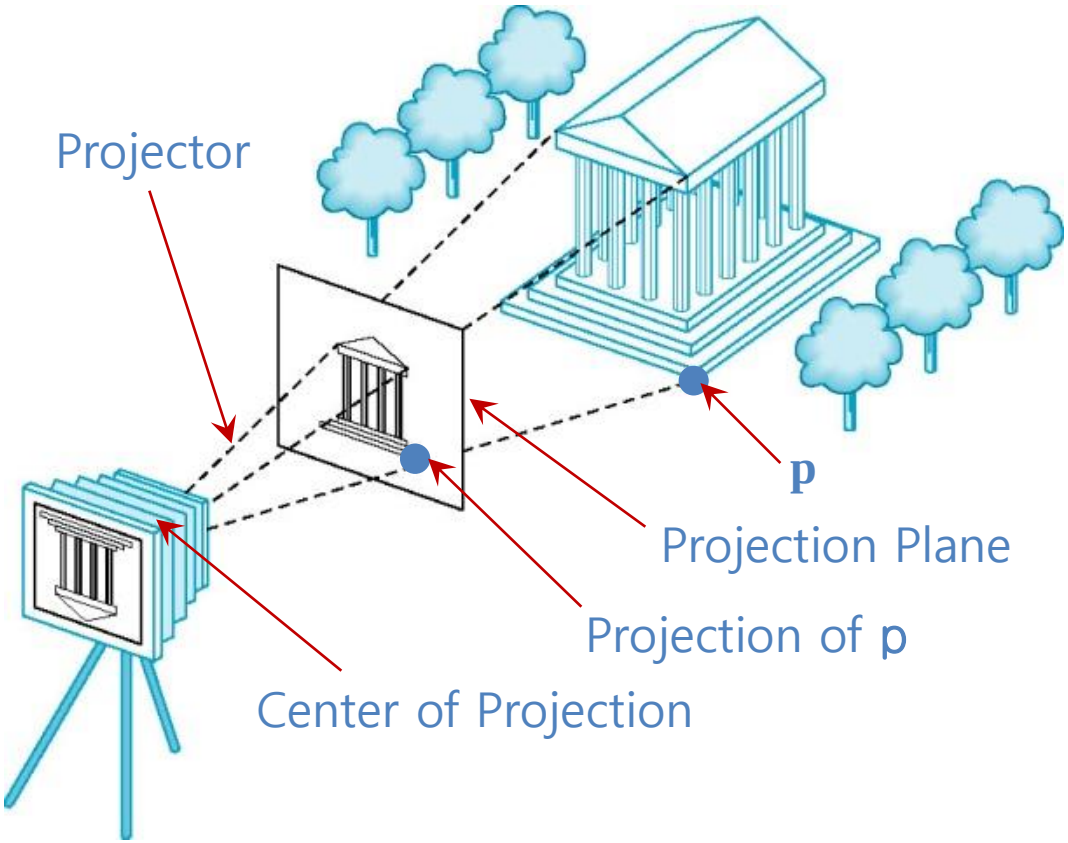
Synthetic-Camera Model (1)

- Conceptual foundation for three-dimensional computer graphics
  - ***Projector***
    - Line from the center of lens to a point on the object
  - ***COP*** (***center of projection***)
    - The center of the lens
  - ***Projection plane***
    - Virtual image plane that are moved in front of the lens



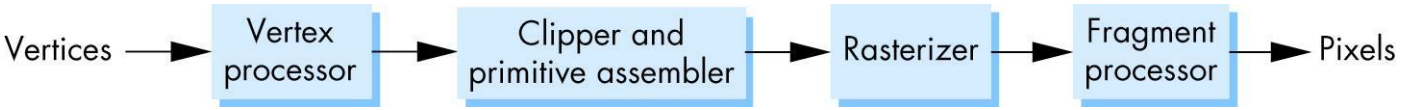
Equivalent views of image formation

Synthetic-Camera Model (2)



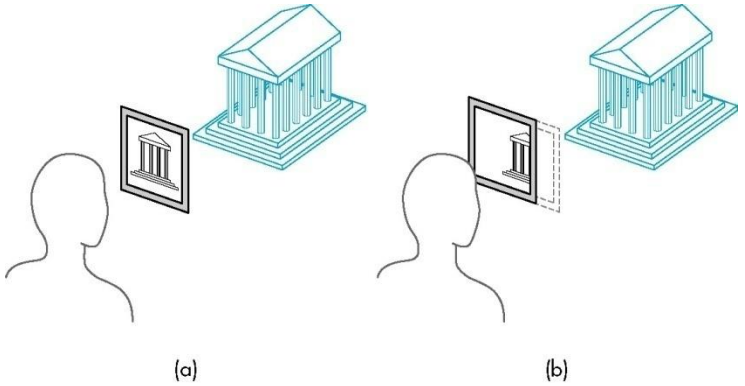
Graphics Architectures

- **Graphics pipeline**
  - ***Geometry*** – collection of primitive types and vertices



Geometric pipeline

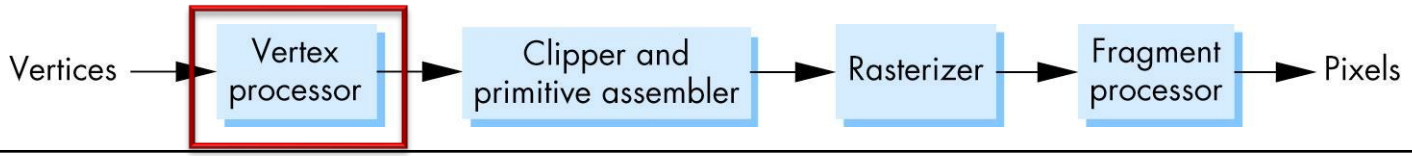
  - Vertex processing
    - World and view transformations
    - Projection
    - Lighting
  - Clipping and primitive assembly
  - Rasterization
  - Fragment processing



Clipping

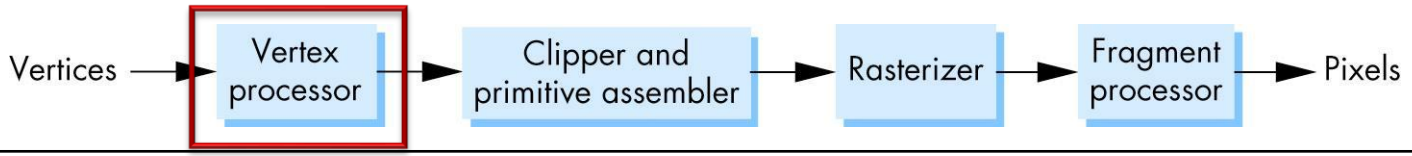
Vertex Processing (1)

- Much of the work in the pipeline is in converting object representations from one coordinate system to another
  - Object coordinates
  - Camera (eye) coordinates
  - Screen coordinates
- Every change of coordinates is equivalent to a matrix transformation
- Vertex processor also computes vertex colors



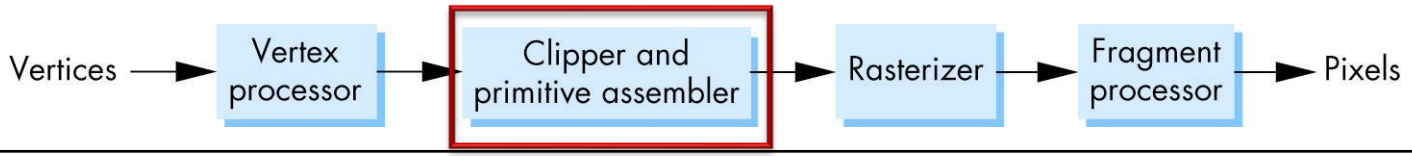
Vertex Processing (2)

- ***Projection*** **is the process that combines the 3D viewer with the 3D objects to produce the 2D image**
  - Perspective projection: all projectors meet at the center of projection
  - Parallel projection: projectors are parallel, center of projection is replaced by a direction of projection



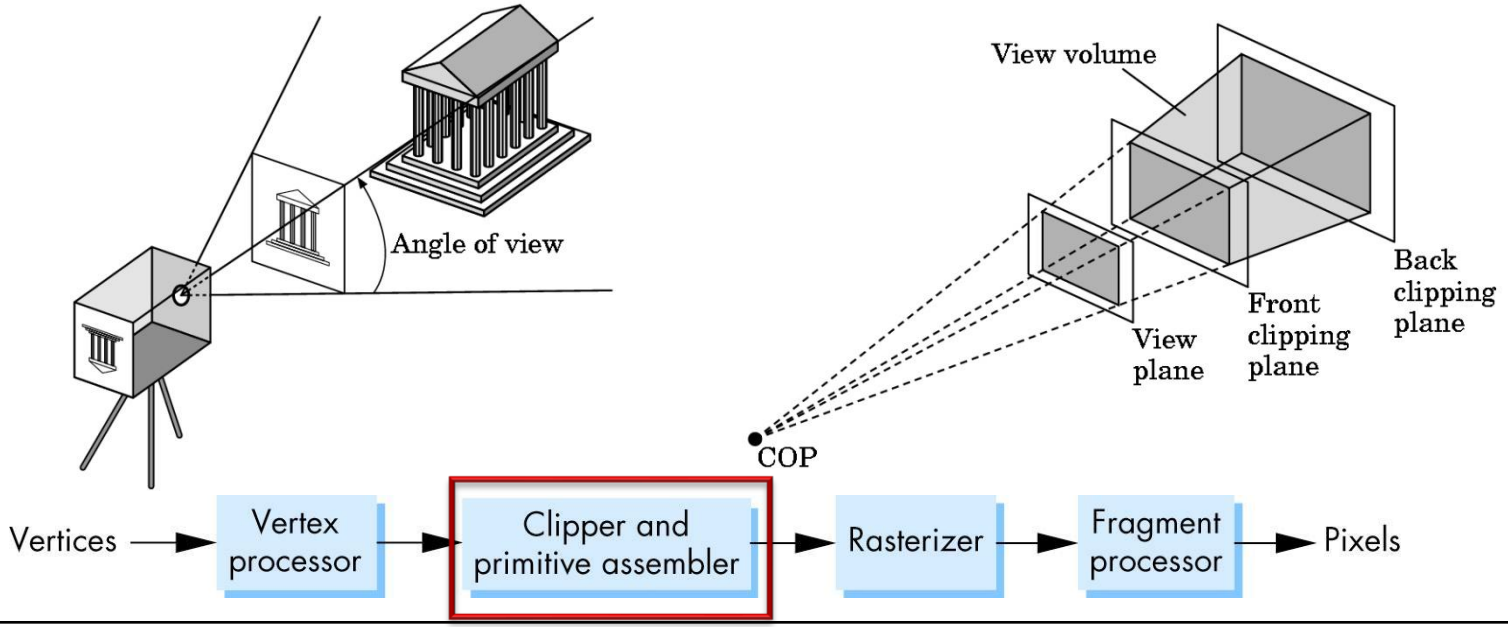
Primitive Assembly

- **Vertices must be collected into geometric objects before clipping and rasterization can take place**
  - Line segments
  - Polygons
  - Curves and surfaces



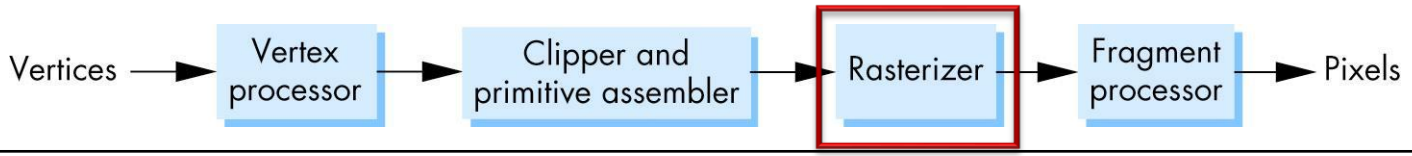
Clipping

- **Just as a real camera cannot "see" the whole world, the virtual camera can only see part of the world or object space**
  - Objects that are not within this volume are said to be clipped out of the scene



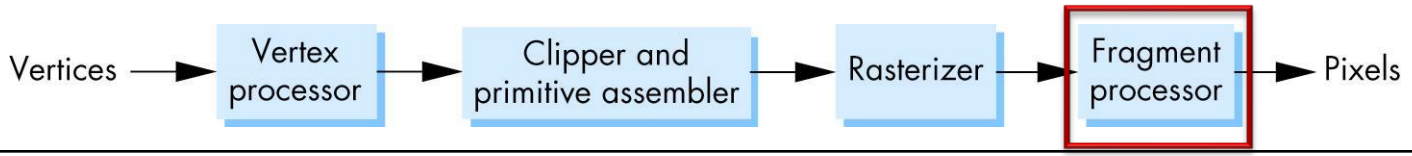
Rasterization

- If an object is not clipped out, the appropriate pixels in the frame buffer must be assigned colors
- Rasterizer produces a set of fragments for each object
- Fragments are "potential pixels"
  - Have a location in frame buffer
  - Color and depth attributes
- Vertex attributes are interpolated over objects by the rasterizer



Fragment Processing

- Fragments are processed to determine the color of the corresponding pixel in the frame buffer
- Colors can be determined by texture mapping or interpolation of vertex colors
- Fragments may be blocked by other fragments closer to the camera
  - Hidden-surface removal



The End