

Chap 1. Graphics Systems and Models

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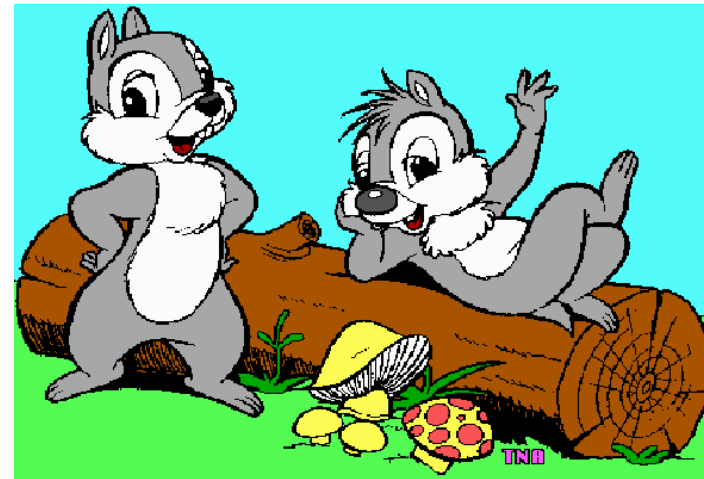
Hyoungseok B. Kim

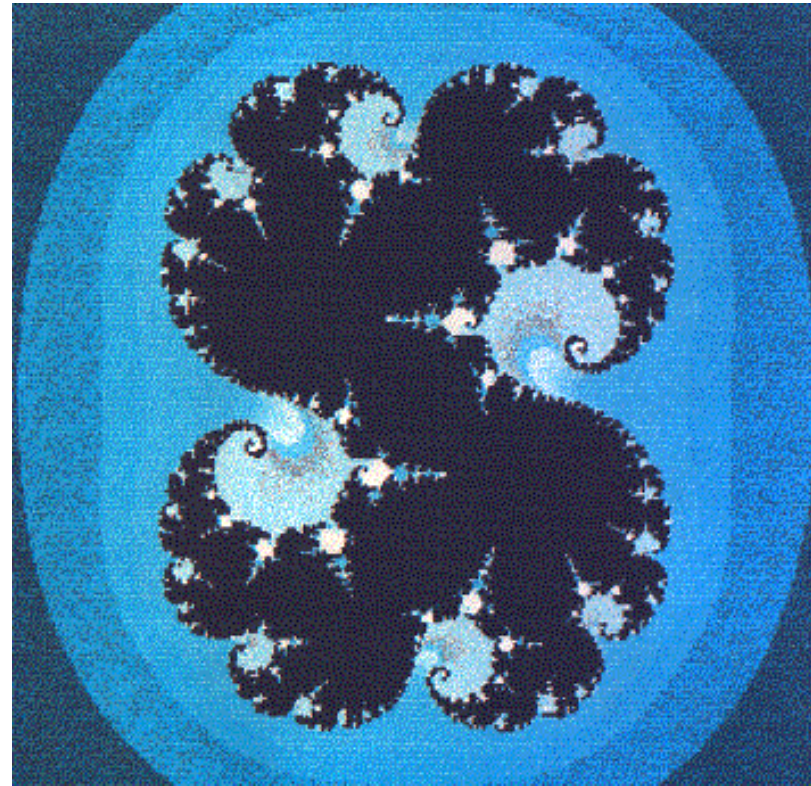
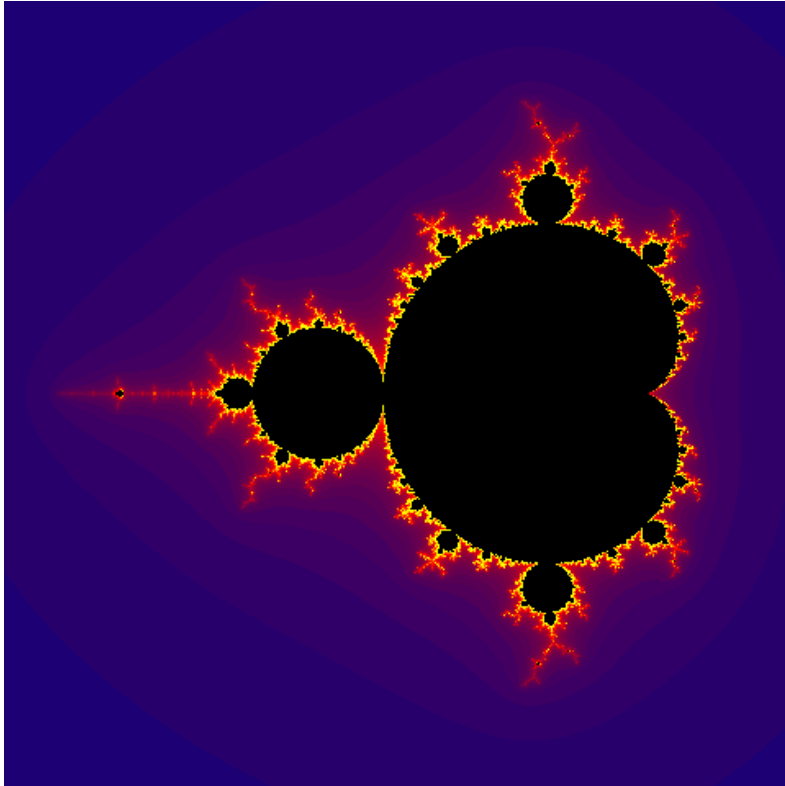
Computer Graphics

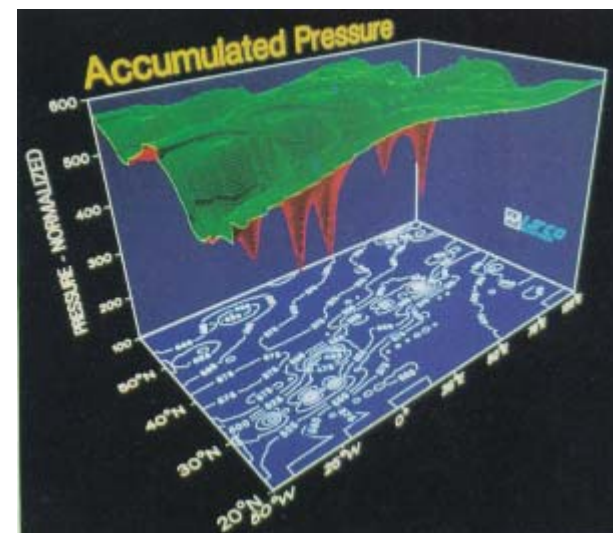
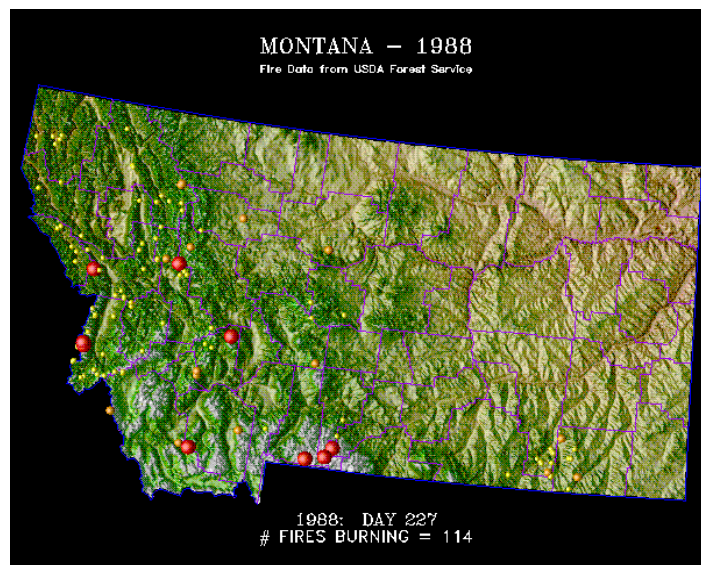
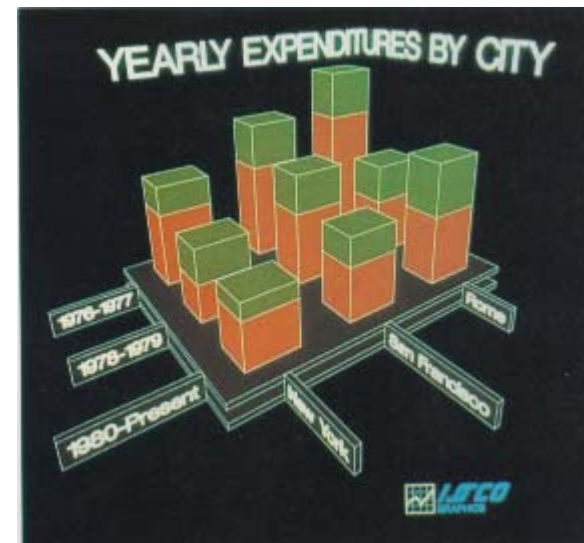
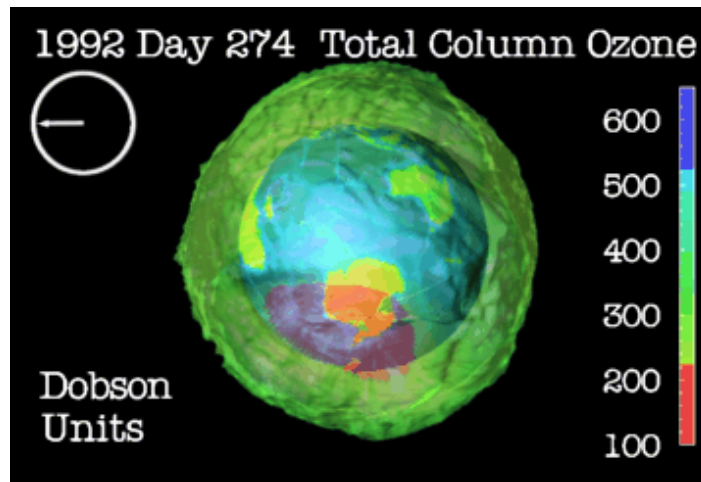
- definition
 - all technologies related to producing pictures or images using a computer
- 40년 정도의 역사
 - CRT characters
 - photo-realistic images

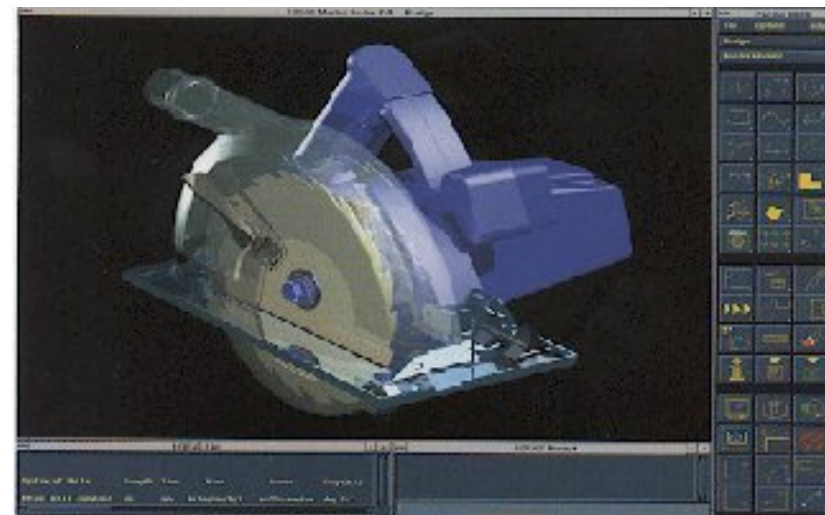
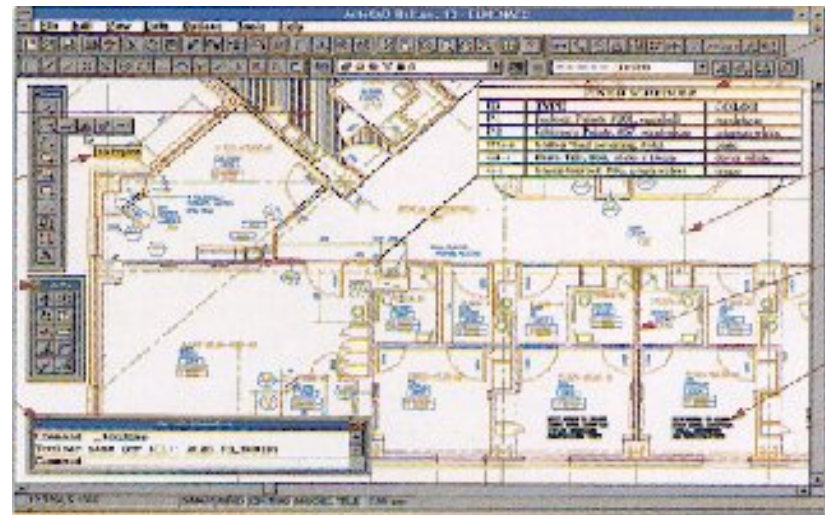
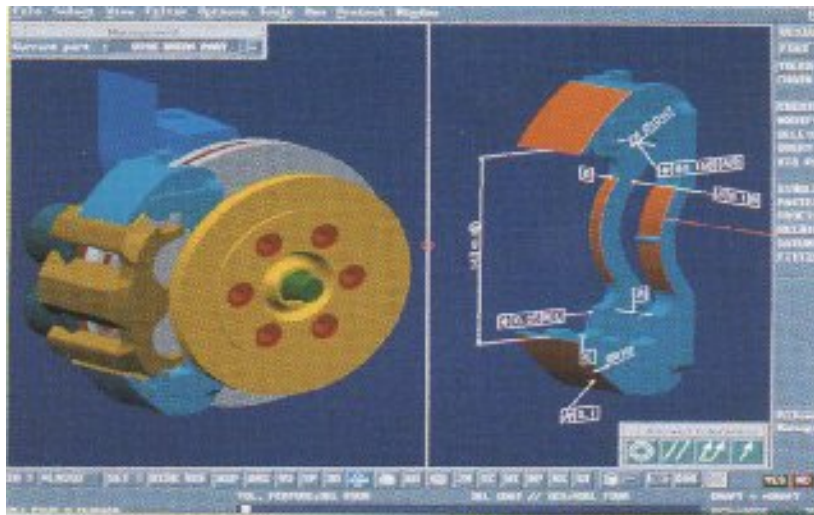


40 years !

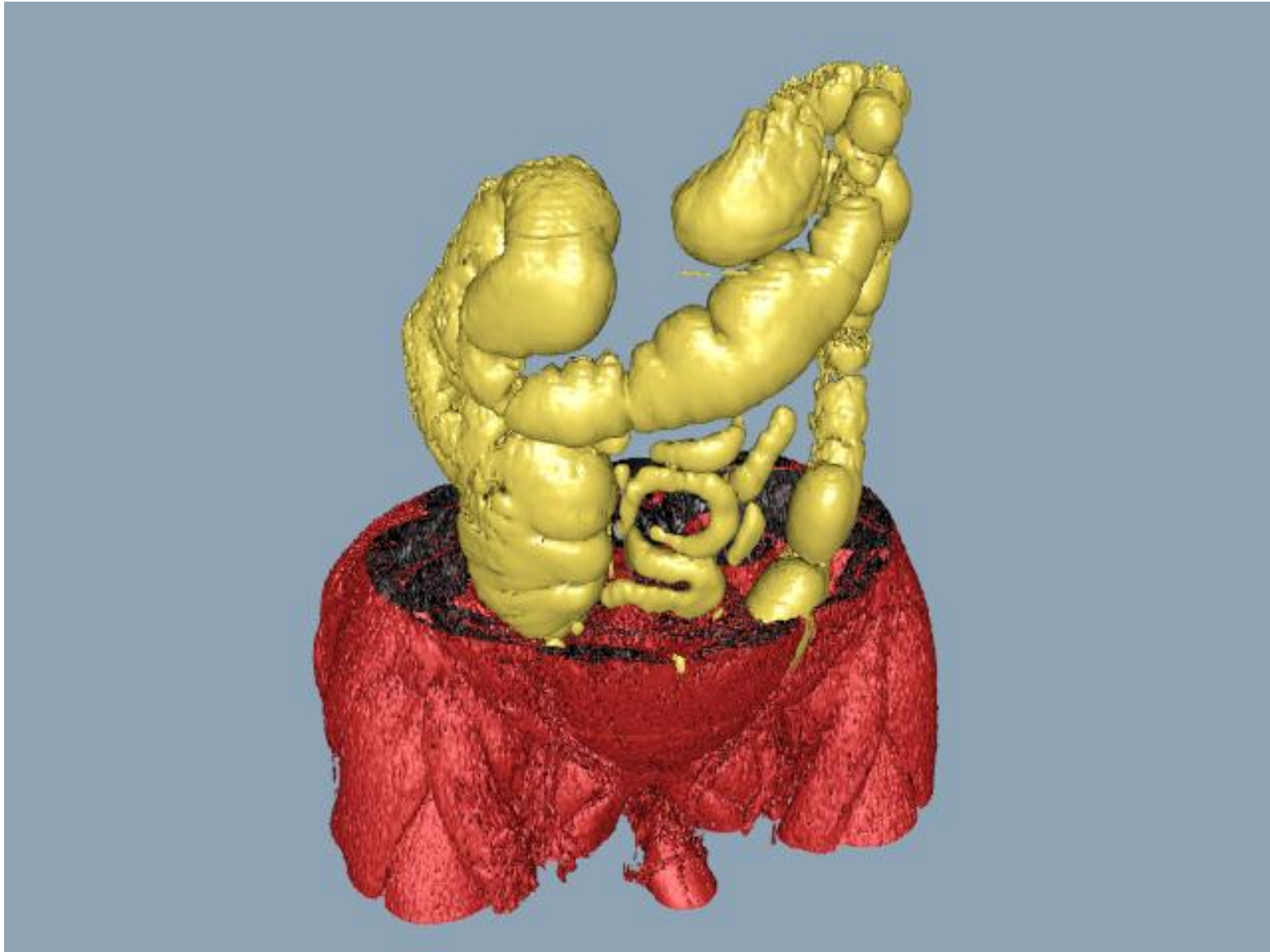


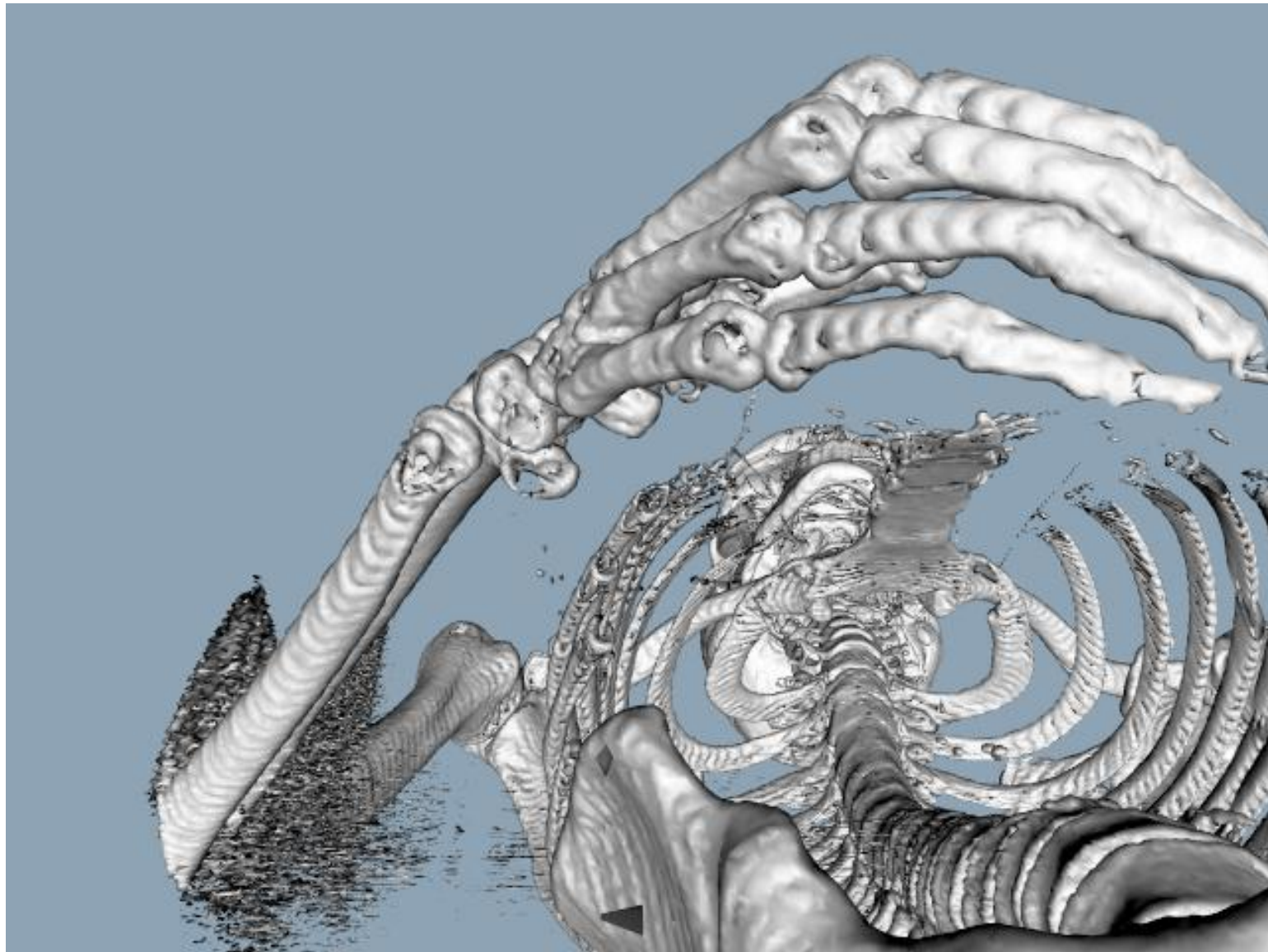


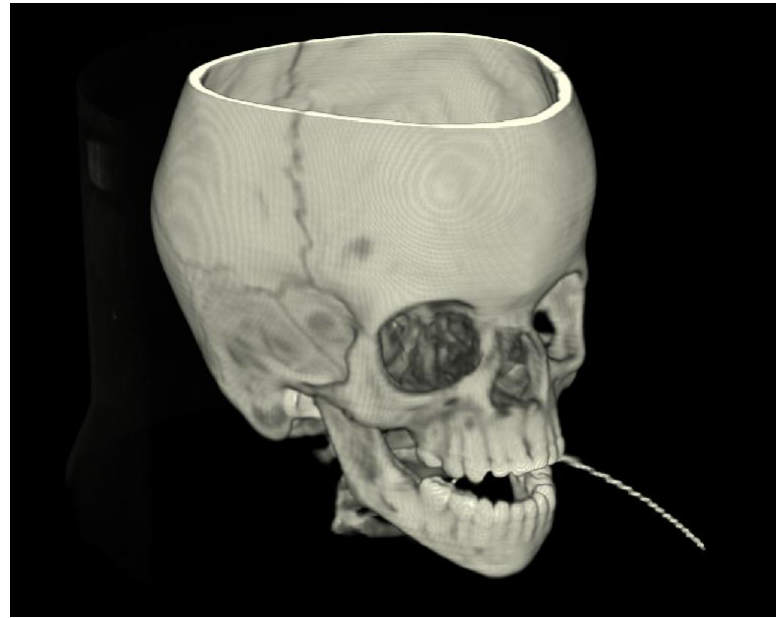
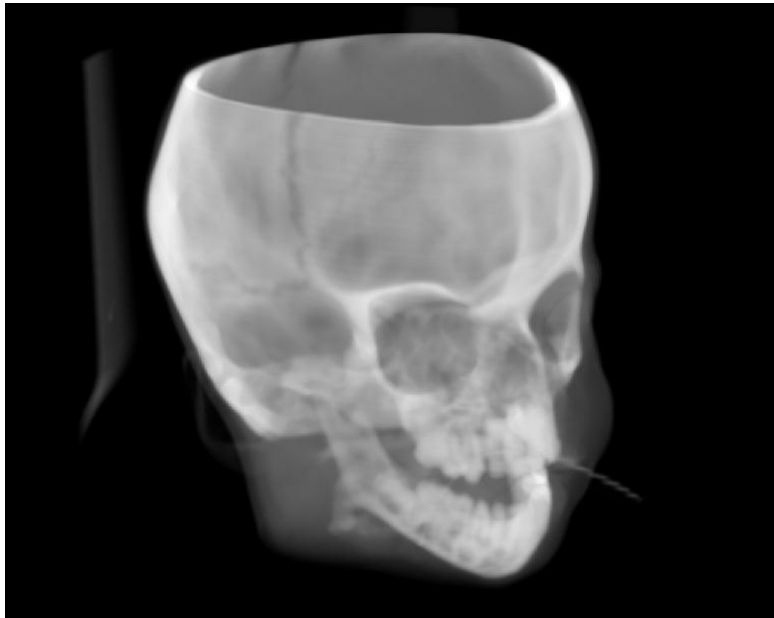


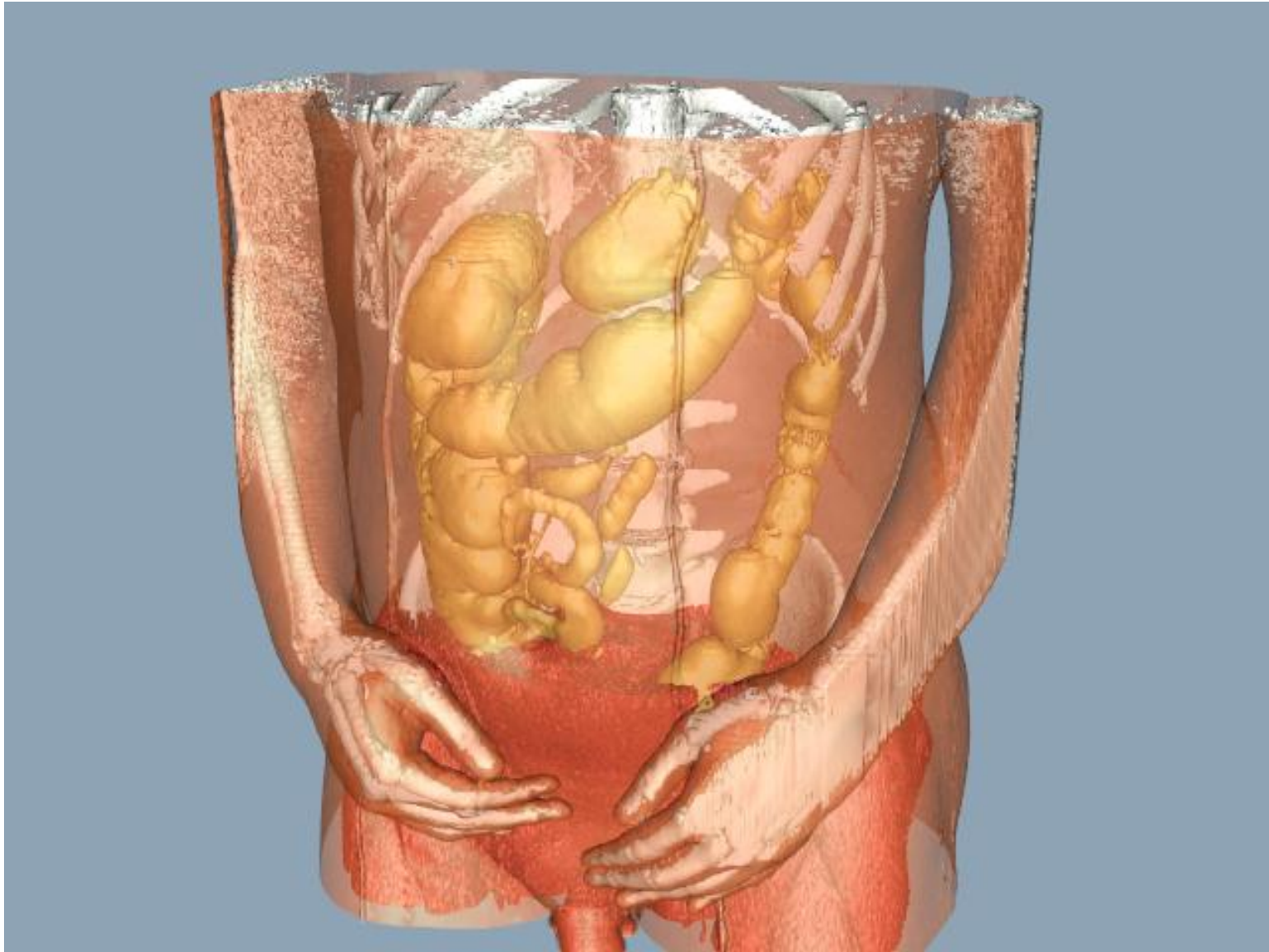


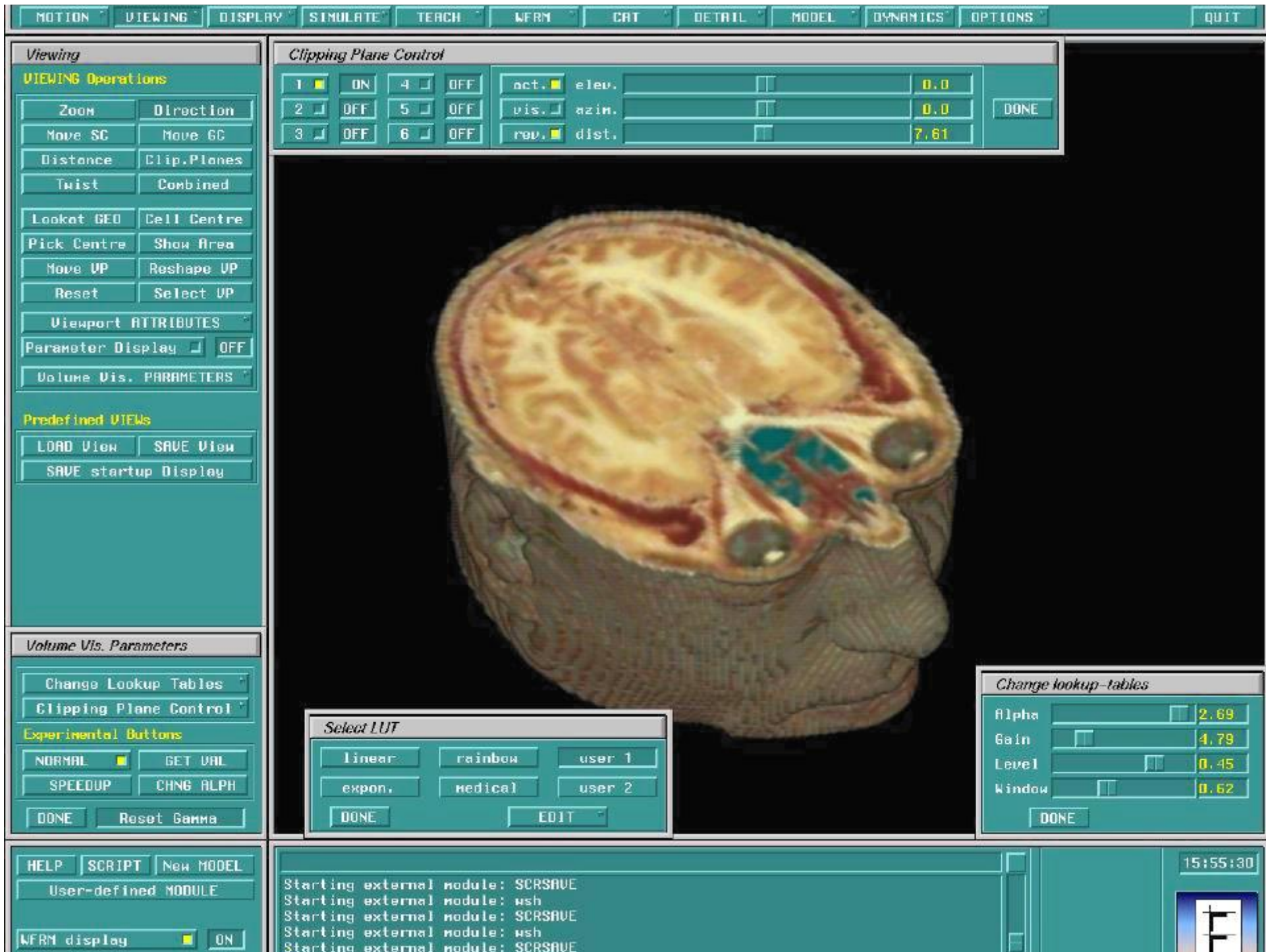












2개의 접근 방법

- 디자인 관점에서
 - 미술 도구로서 사용
 - 얼마나 미학적인가?
- 공학/전산학적 접근
 - 프로그램의 개발
 - 얼마나 효율적인가?



이 course 의 접근 방법

- 공학/전산학적으로
 - programmer의 입장에서
graphics program 개발 방법 ?
- OpenGL – the graphics library
 - graphics application 개발용
 - de facto standard
 - 이 course에서 중점적으로 사용

1.1 Applications of Computer Graphics

Computer Graphics 응용 분야들

- computer graphics 의 발달
 - 사용자 요구 : 고기능, 더 편리
 - ↑ ↓ 서로 상승 작용
 - h/w, s/w의 발달
- 대표적인 응용 분야들
 - display of information
 - design
 - simulation
 - user interface

Display of Information

- architectural drawings
 - CAD (computer-aided design)
- geographical information
 - GIS (geographic information system)
- mathematical graphs
 - computer plotting packages
- X-ray
 - CT, MRI, PET
- super computer + graphics
 - scientific visualization

Design, User Interface

- design → CAD
 - iterative process 에 대한 획기적인 해결책
 - computer graphics 를 제안한 최초의 이유
- user interfaces
 - window, icon, menu, pointing device
 - GUI (graphical user interface)
 - Xerox → Macintosh
 - X windows → Microsoft windows

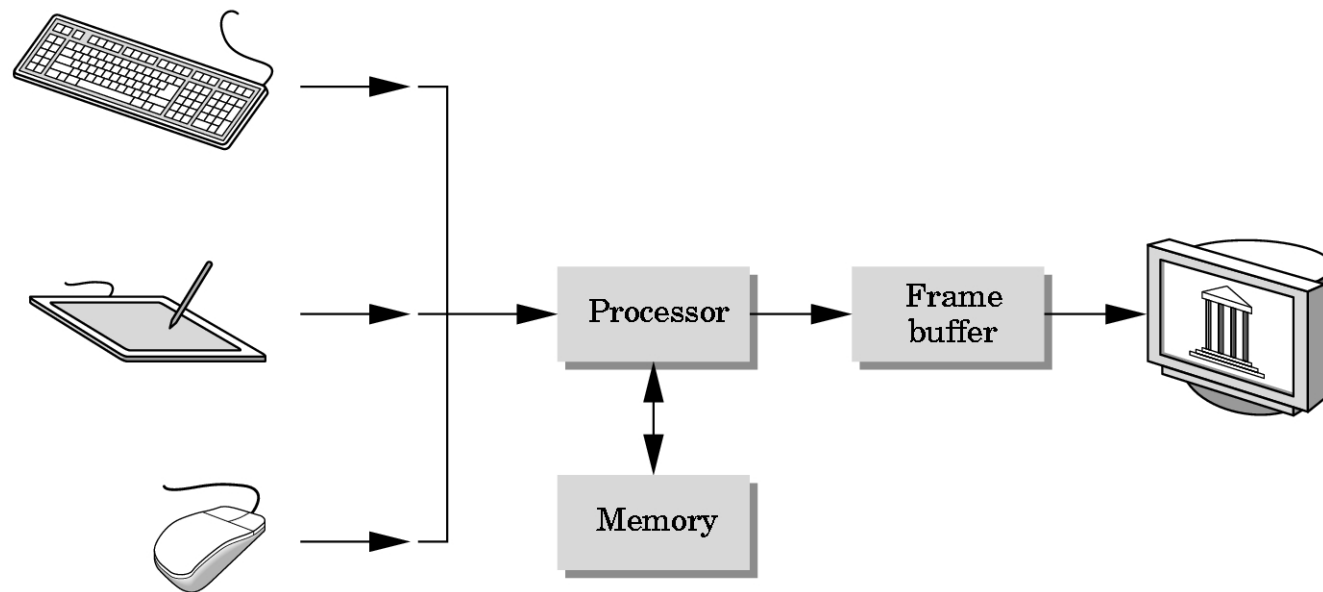
Simulation

- simulation
 - graphics system에서
real-time image 생성이 가능해 지면서
 - simulation 가능 : flight simulator
 - 또 다른 응용 분야 : computer games
- computer animation
 - photo-realistic image 생성이 가능해 지면서
- VR : virtual reality
 - graphics + interface 기술

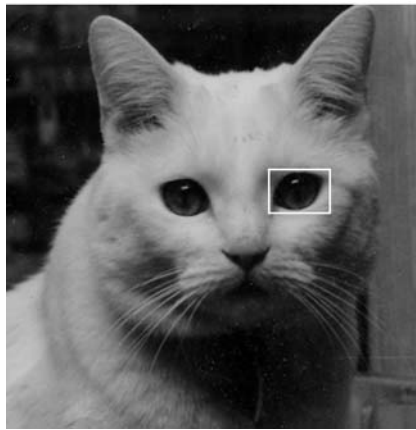
1.2 A Graphics System

Computer Graphics System

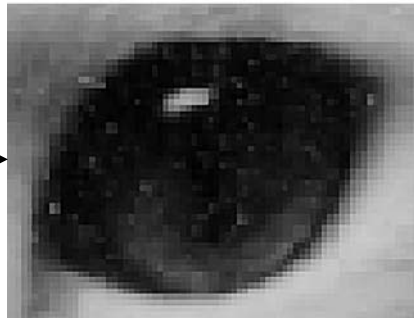
- 근본적으로, computer system
 - processor, memory
 - frame buffer : graphics system의 특징
 - output devices, input devices



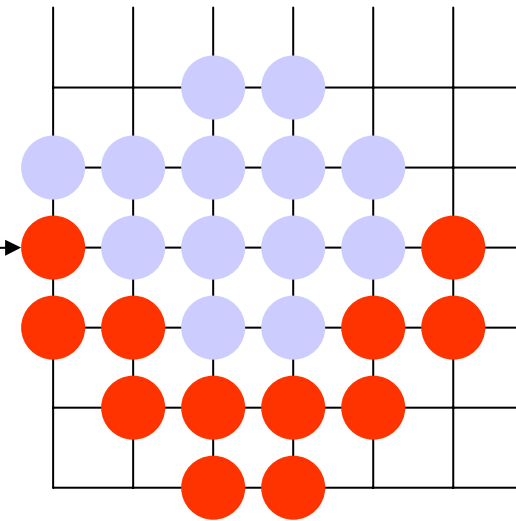
Raster system 용어 정의



image



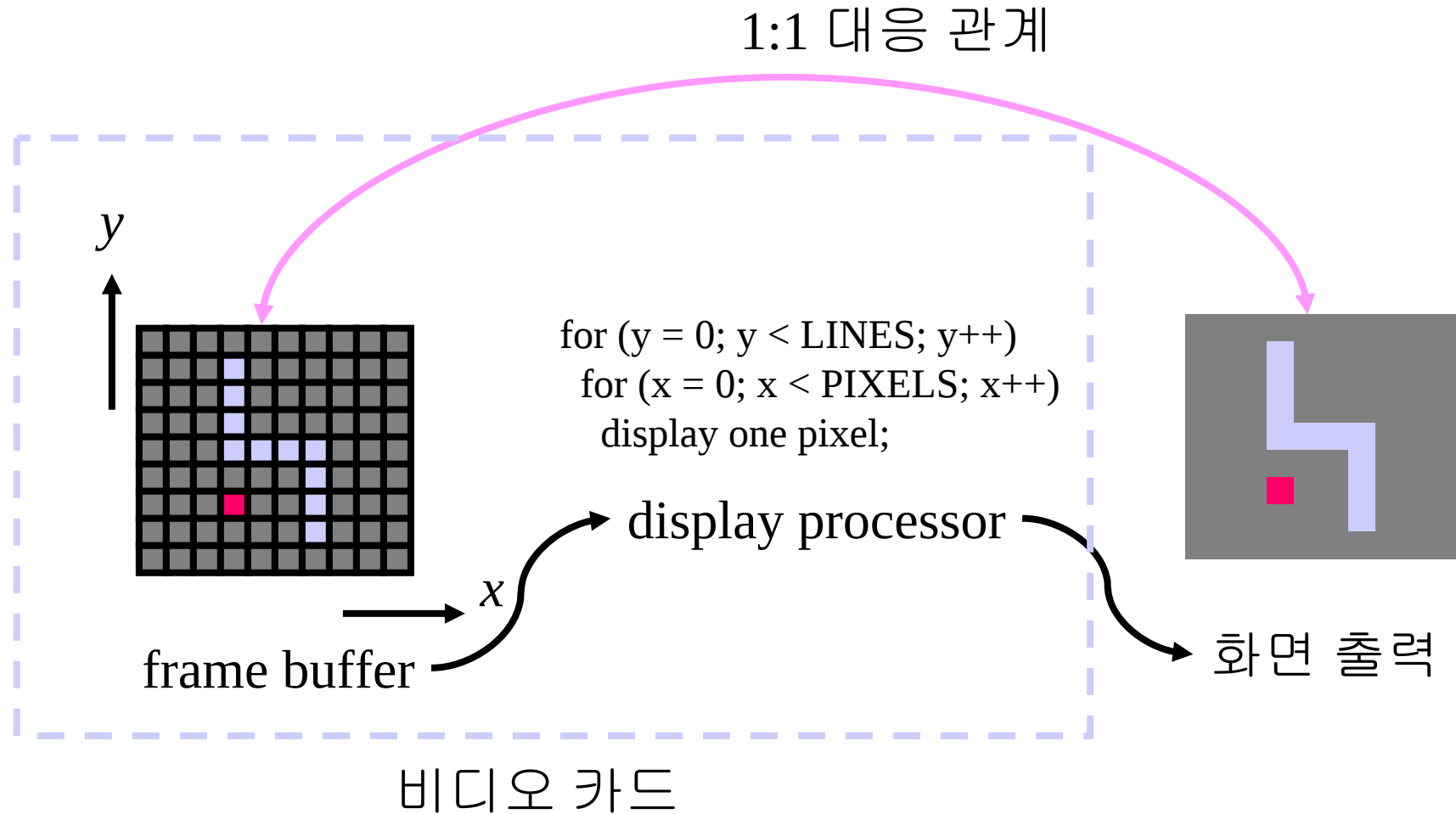
raster



바둑판 모델

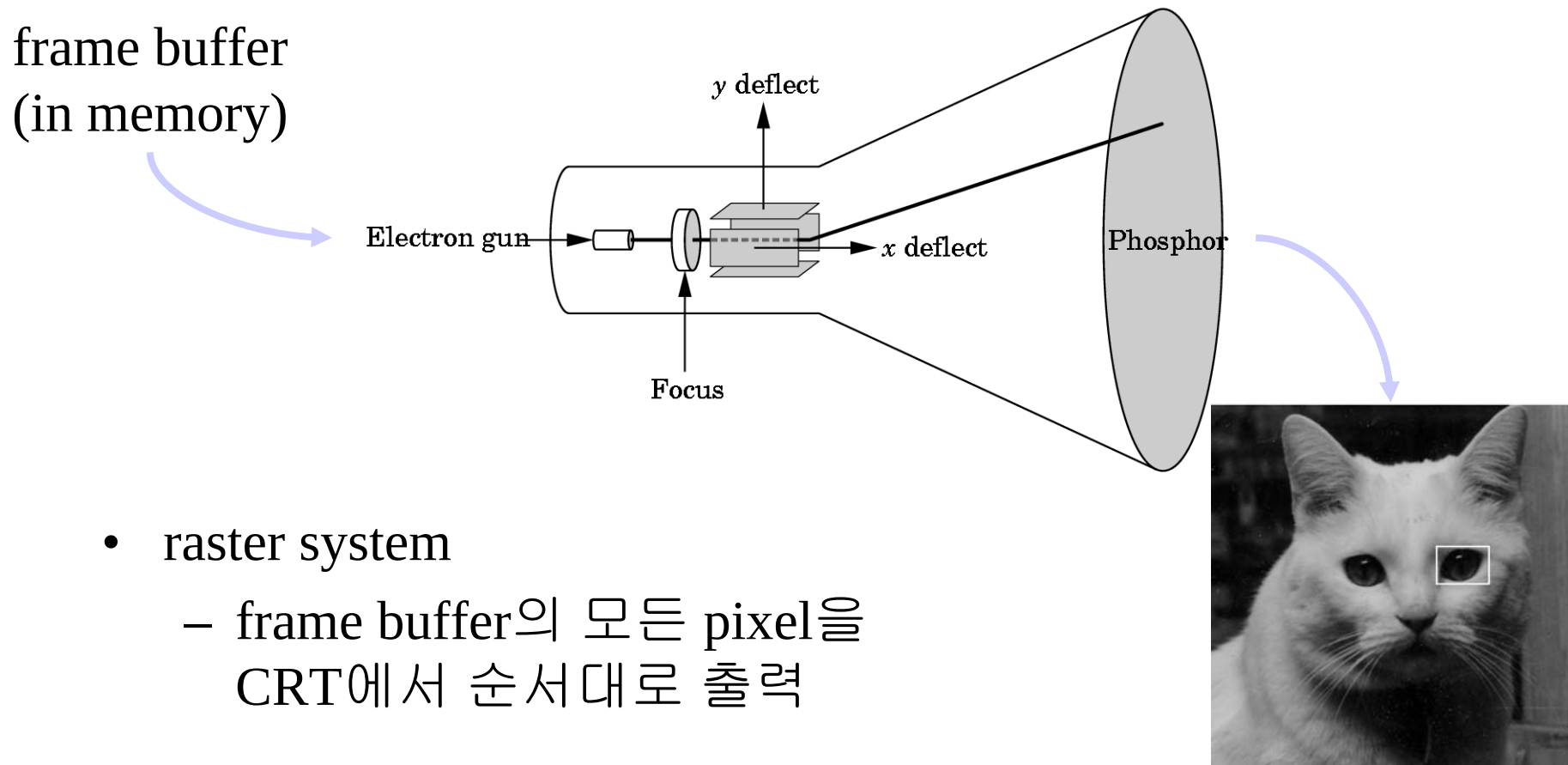
- pixel : picture element
- raster : an array of pixels
- frame buffer : pixel 저장용 memory area

Raster System의 개념



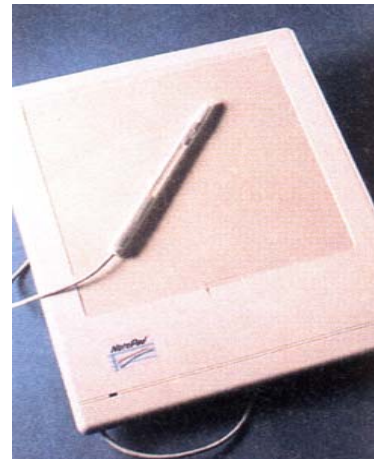
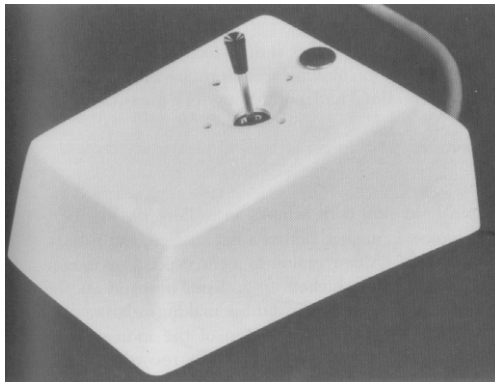
Output Devices

- CRT : cathode-ray tube 음극선관



Input Devices

- keyboard, mouse, joystick, data tablet



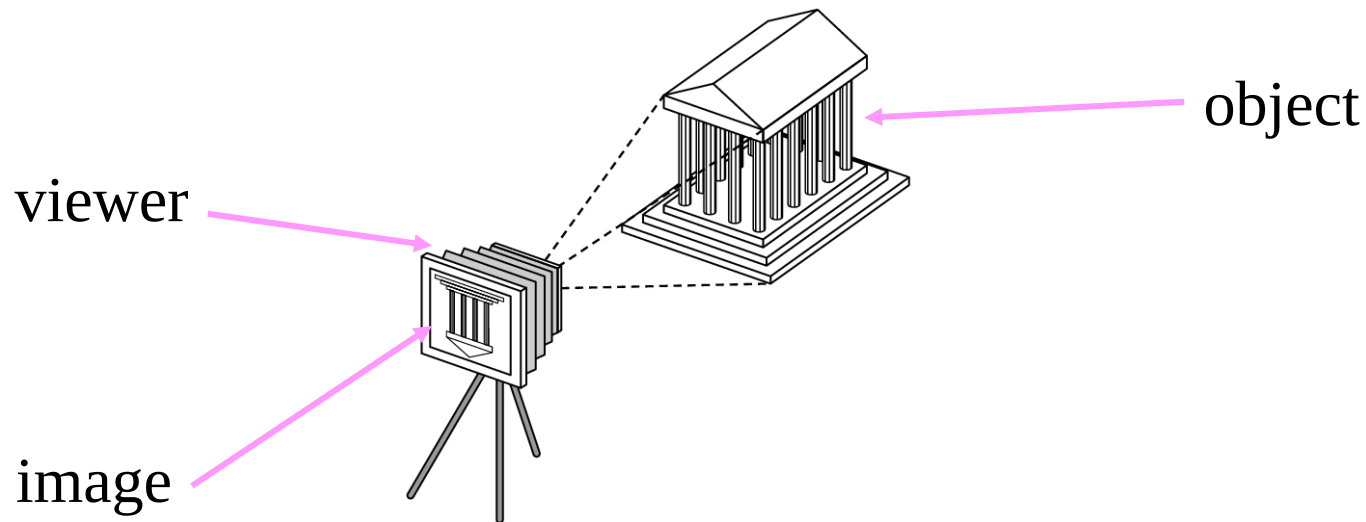
1.3 Images: Physical and Synthetic

Image 생성 과정

- 궁극적으로는 real world를 simulate
 - camera 또는 human visual system이 어떻게 작동하는 지를 그대로 simulate
- 주로, camera를 simulate
 - real world $\leftrightarrow$ 3차원 공간
 - 물체들 $\leftrightarrow$ object
 - camera $\leftrightarrow$ viewer
 - 필요한 기술 ? geometry, trigonometry

Camera System

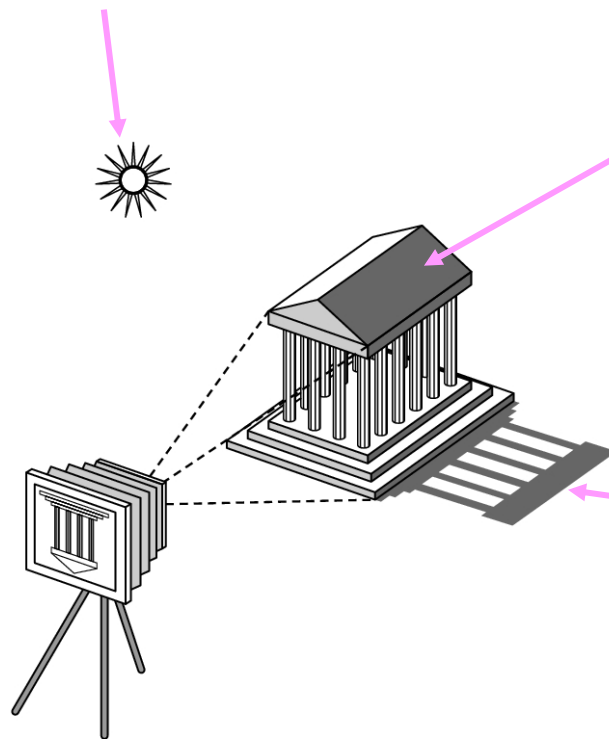
- computer graphics : 3D $\rightarrow$ 2D 로의 mapping
 - object : 3D
 - viewer : 3D (= camera)
 - image : 2D (camera의 film)



Camera System with a light source

- light : 3D 에서 정의됨

light source

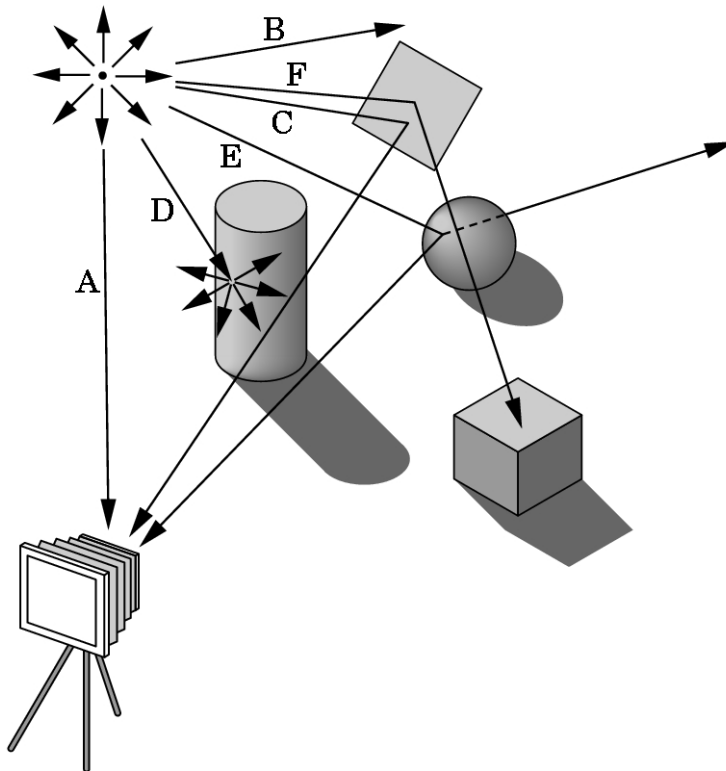


light → object → viewer
object의 표면 결정

light → object → shadow
그림자 생성

Light, Optics

- light : electro-magnetic radiation
 - light, color 는 modern optics에서 해석
- graphics 에서는 대부분 geometric optics 사용

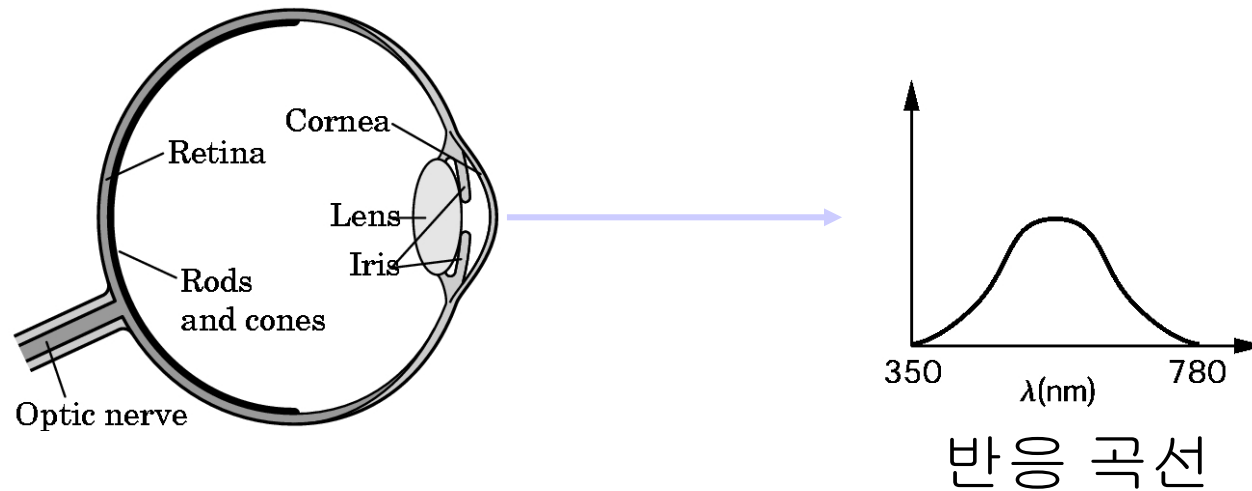


computer graphics :
반사, 굴절, 회절을 해석해야

1.4 The Human Visual System

Human Visual System

- rod (간상체 杆狀體) : night vision
- cones (원추체 圓錐體) : day vision

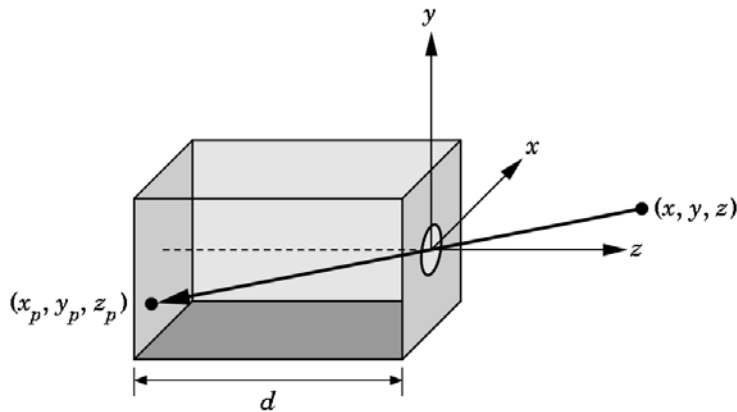


- human visual system
 - back-end에 brain 이 있기 때문에, simulation 거의 불가능...

1.5 The Pinhole Camera

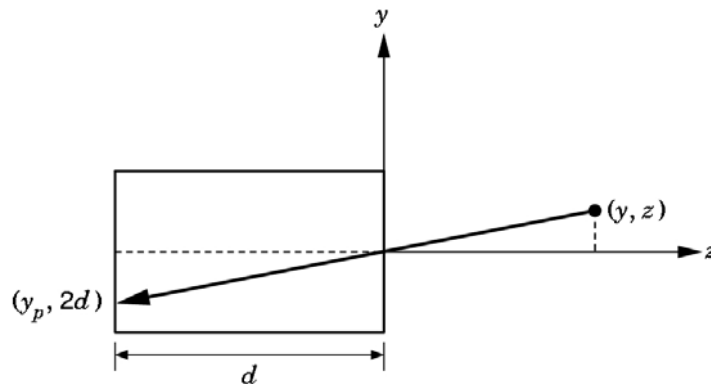
Pinhole Camera

- 바늘 구멍 사진기
 - 가장 간단한 geometric model



(x, y, z) : 3D point

(x_p, y_p, z_p) : projection



$$x_p = -\frac{x}{z/d}$$

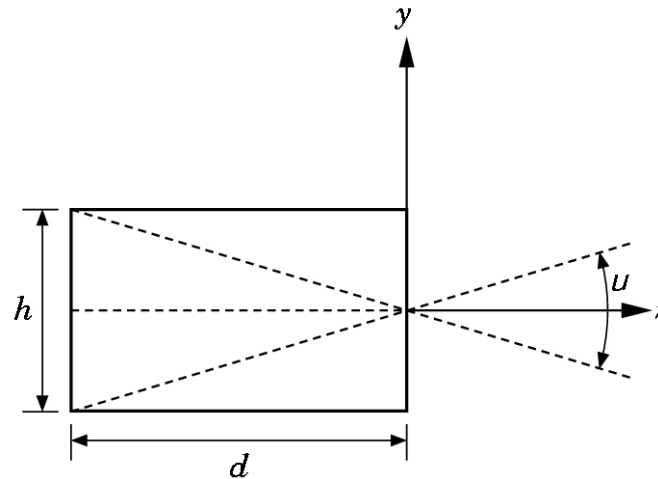
$$y_p = -\frac{y}{z/d}$$

$$z_p = -d$$

용어 정의

- projection of the point (x, y, z)
 - $(x_p, y_p, -d)$: film 상의 좌표
- FOV : field of view (= angle of view)
 - 화면을 보는 최대각

$$\theta = 2 \tan^{-1} \frac{h}{2d}$$

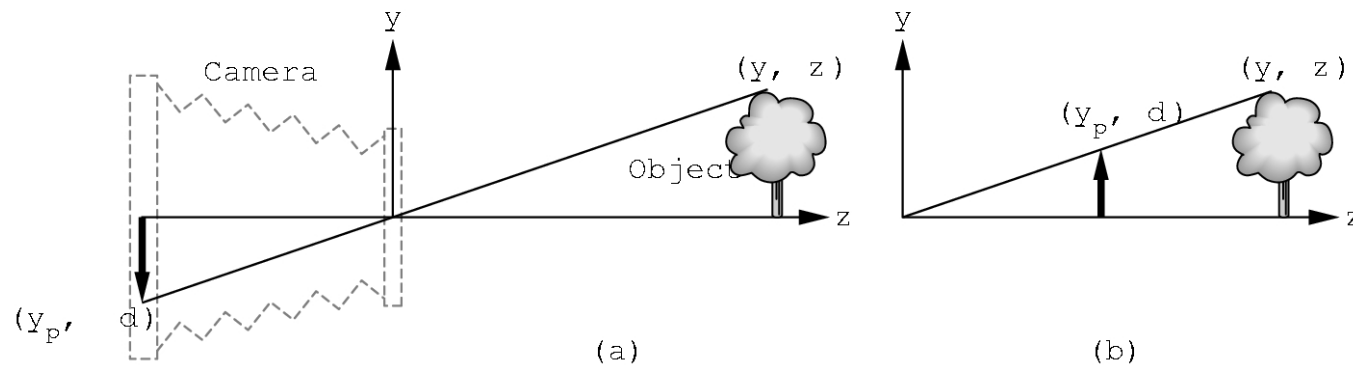


- DOF : depth of field
 - focus 가 맞는 거리
 - pinhole camera는 infinite DOF

1.6 The Synthetic-Camera Model

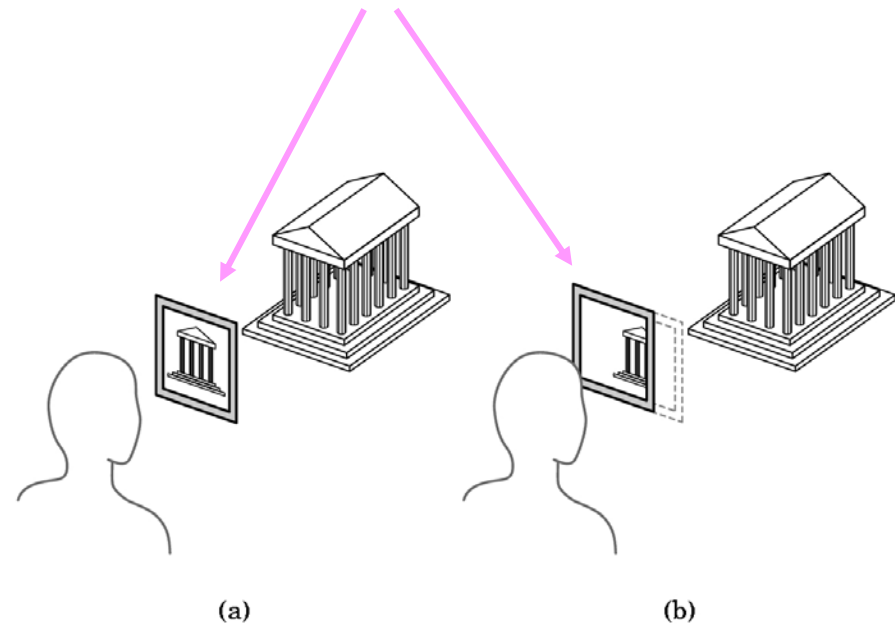
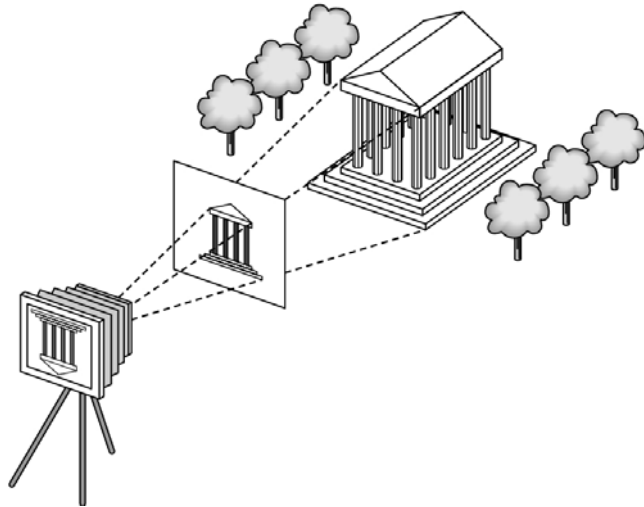
The Synthetic Camera Model

- graphics 에서 사용하는 camera model
 - object 정의는 viewer와는 독립적
 - object 정의 function을 별도로 독립
 - image 생성 시에는 trigonometry 계산 필요
 - projection plane
 - film을 center of projection 보다 앞으로



Projection plane, Clipping window

- projection plane : 계산의 편의
- clipping rectangle
 - projection plane 상에서 실제로 보이는 부분



1.7 The Programmer's Interface

Why Programming ?

- graphics system을 사용하는 방법 ?
 - CAD, animation tool
 - mouse로 interaction
 - 누구나 다 한다...
 - someone should develop the graphics program !
 - 단순 사용자도 자신 만의 code 필요
 - 예: 3DS, MAYA 의 plug-in
- graphics library : 개발용 function 들

API

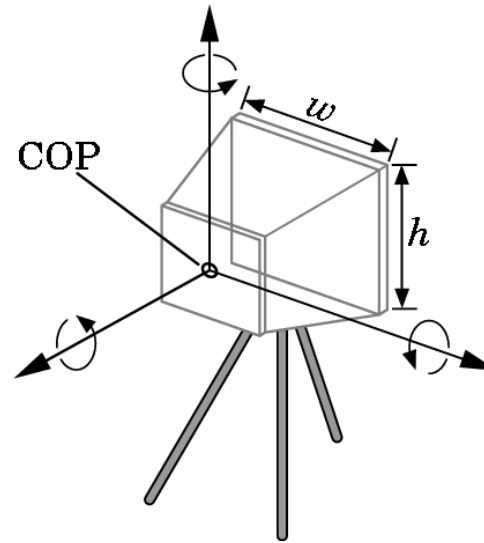
- application programmer's interface
 - graphics library
 - graphics library의 함수들을 쓰는 방법
- popular API's
 - OpenGL, Direct3D, Java3D, ...
- API 기본 구성
 - object 정의
 - viewer 정의
 - light source, materials, etc.

API 구성

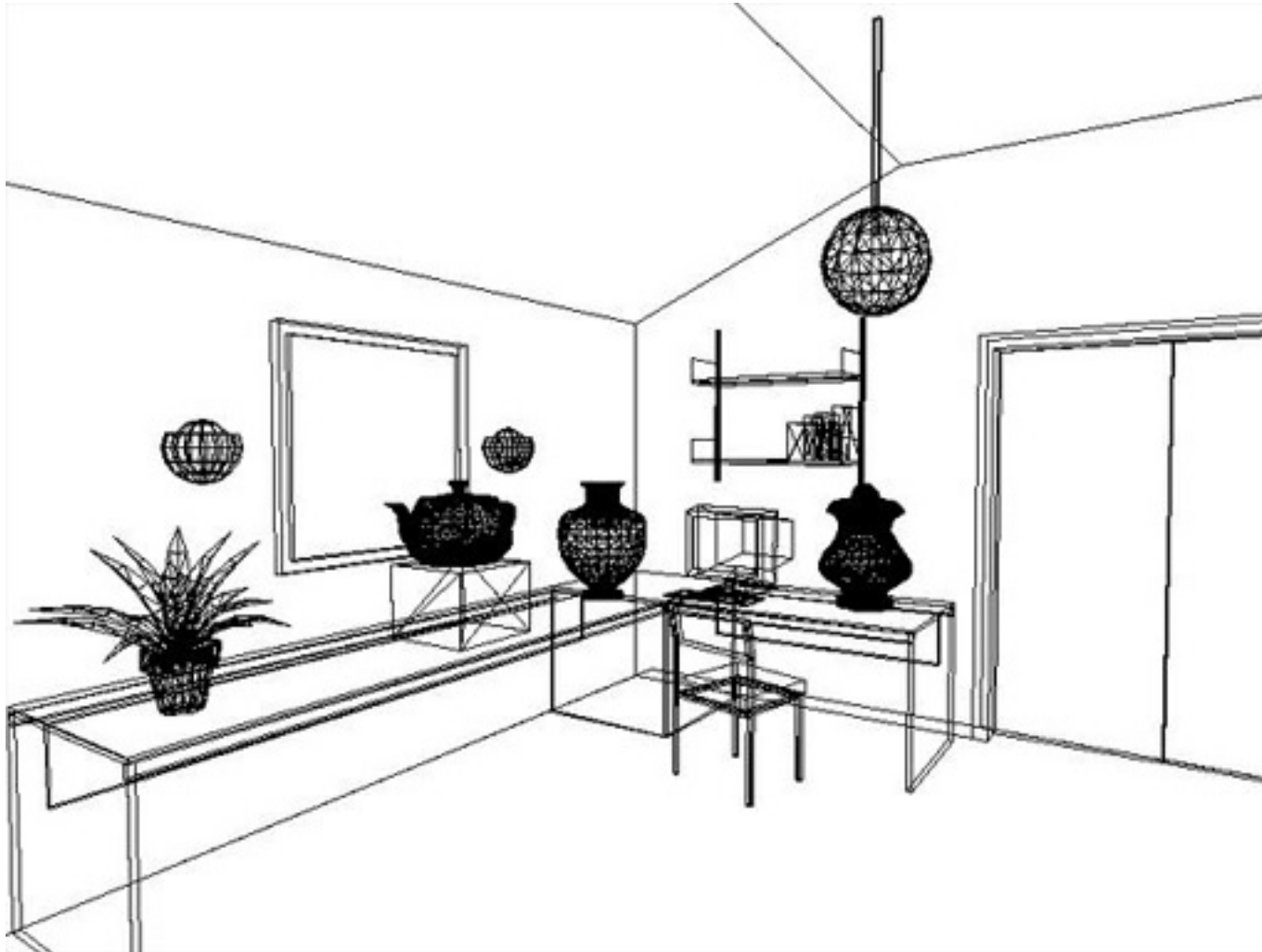
- object 정의
 - OpenGL 구현 예
 - glBegin(GL_POLYGON);
glVertex3f(0.0, 0.0, 0.0);
glVertex3f(0.0, 1.0, 0.0);
glVertex3f(0.0, 0.0, 1.0);
glEnd();
 - GL_POLYGON, GL_LINE_STRIP, GL_POINTS, ...

API 구성

- camera 정의
 - position
 - orientation
 - focal length
 - film plane
- light source API
 - location
 - strength
 - color
 - direction



Example : Wire-frame



Example : Flat Shading



Example : Sophisticated Shading



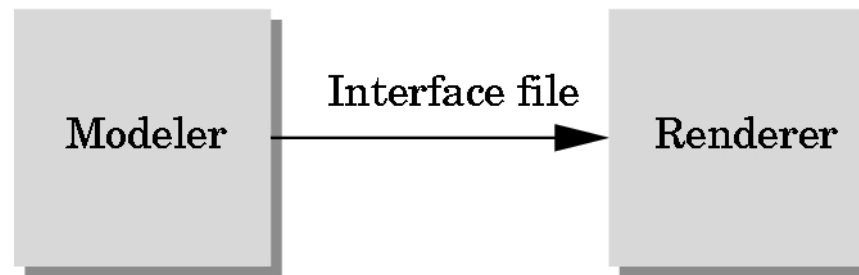
Example : Texture, Shadow



1.8 Graphics Architecture

Modeling-Rendering Paradigm

- 가장 간단한 graphics architecture
 - modeler, renderer 가 별도의 program
 - 예 : Pixar's RenderMan Interface
 - modeler / renderer 연결은 file 로



AutoCAD, 3DS, MAYA, etc.

RenderMan, BMRT, etc.

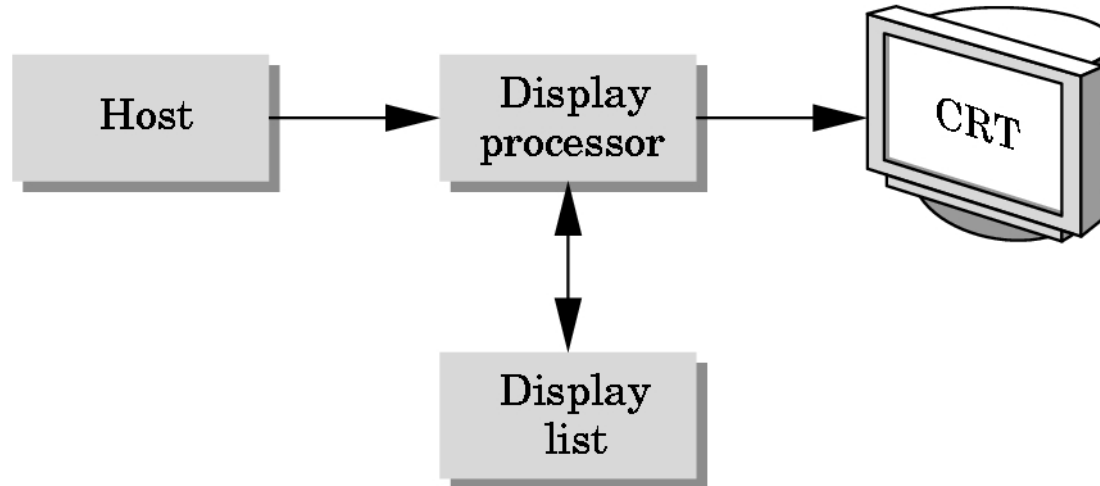
Single CPU Model

- 초기의 computer 에서 사용
 - CPU 에 너무 많은 부하가 걸린다
 - Intel x86 : SSE (streaming SIMD extension)
 - single CPU model을 위한 지원책



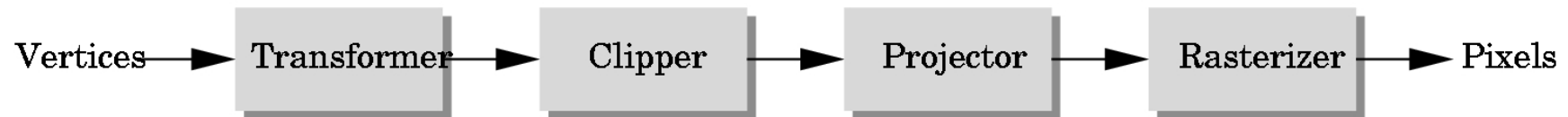
Display Processor Model

- DPU : display processor
- graphics 처리 전용의 CPU를 추가
 - pipeline architecture로 넘어가는 과도기



Pipeline Architecture

- 가장 진보된 형태
- VLSI 기술의 발달로 가능
 - SGI (Silicon Graphics Inc.) IRIS series
→ ... → nVIDIA GeForce chips
 - graphics 처리를 몇 단계로 나누어서
각각을 별도의 VLSI chip이 처리



Pipeline Architecture

- transformation
 - 좌표 변환을 위한 4×4 matrix multiplication
- clipping
 - projection plane 상에서 불필요한 부분 제거
- projection
 - 3D object $\rightarrow$ 2D image 로의 mapping
- rasterization
 - image 를 frame buffer에 저장하는 과정

Suggested Readings

- Foley, van Dam, Feiner, and Hughes, *Computer Graphics, 2nd Ed., C version*, Addison-Wesley, 1996.
 - graphics encyclopedia
- Hearn & Baker, *Computer Graphics, 2nd Ed., C version*, Prentice-Hall, 1994.
 - good introduction to computer graphics
 - for undergraduate students