Lecture 1
Introduction to Computer Graphics

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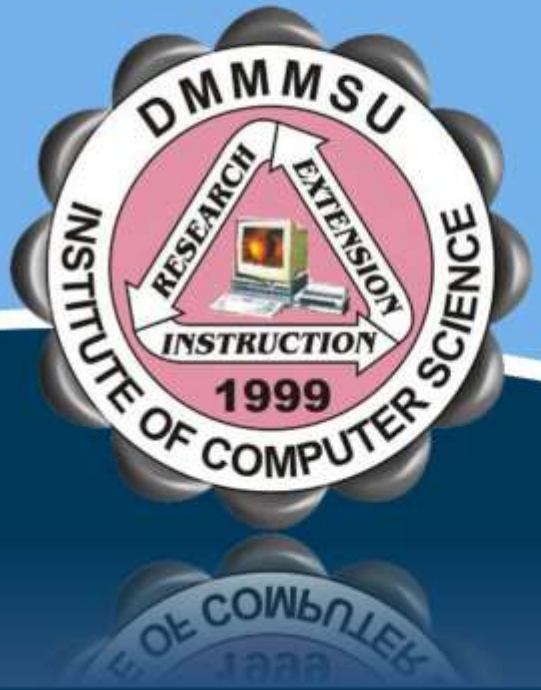


CS 302 – Computer Graphics

Objectives

- To be able to define computer graphics
- To have a historical review in order to understand the current computer graphics technologies
- To be able to describe some of the most important applications of computer graphics
- To be able to know the current state-of-the-art technologies of computer graphics hardware

Topics

- The Nature of Computer Graphics
- History and Evolution of Computer Graphics
- Computer Graphics Applications
- State-of-the-Art Computer Graphics

The Nature of Computer Graphics

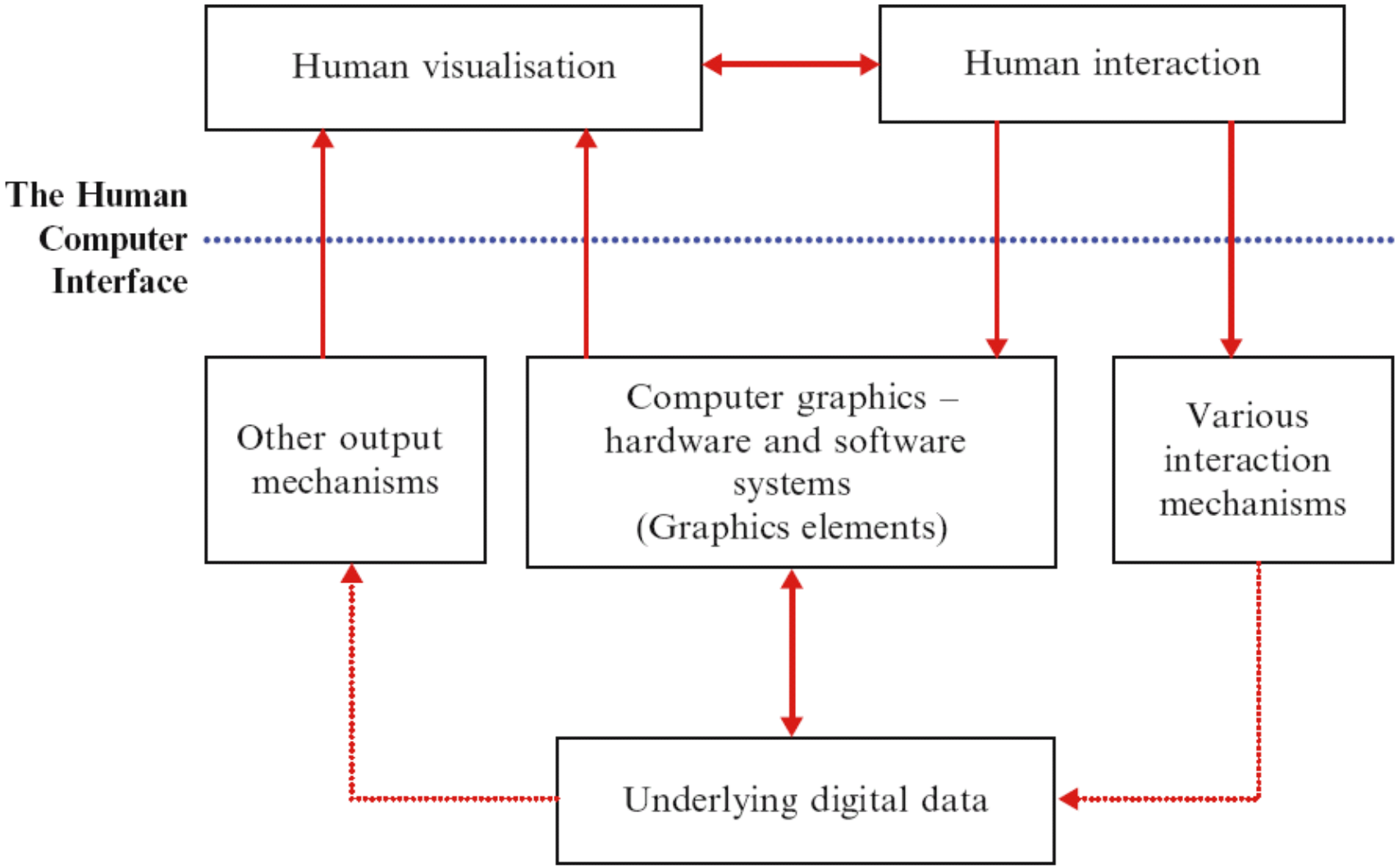


Figure 1. Aspects of the human-computer interface

The Nature of Computer Graphics (cont.)

Computer graphics embraces all aspects of the synthesis, depiction and manipulation of pictorial representations by computational machines together with their presentation to the human visual system.

The Nature of Computer Graphics (cont.)

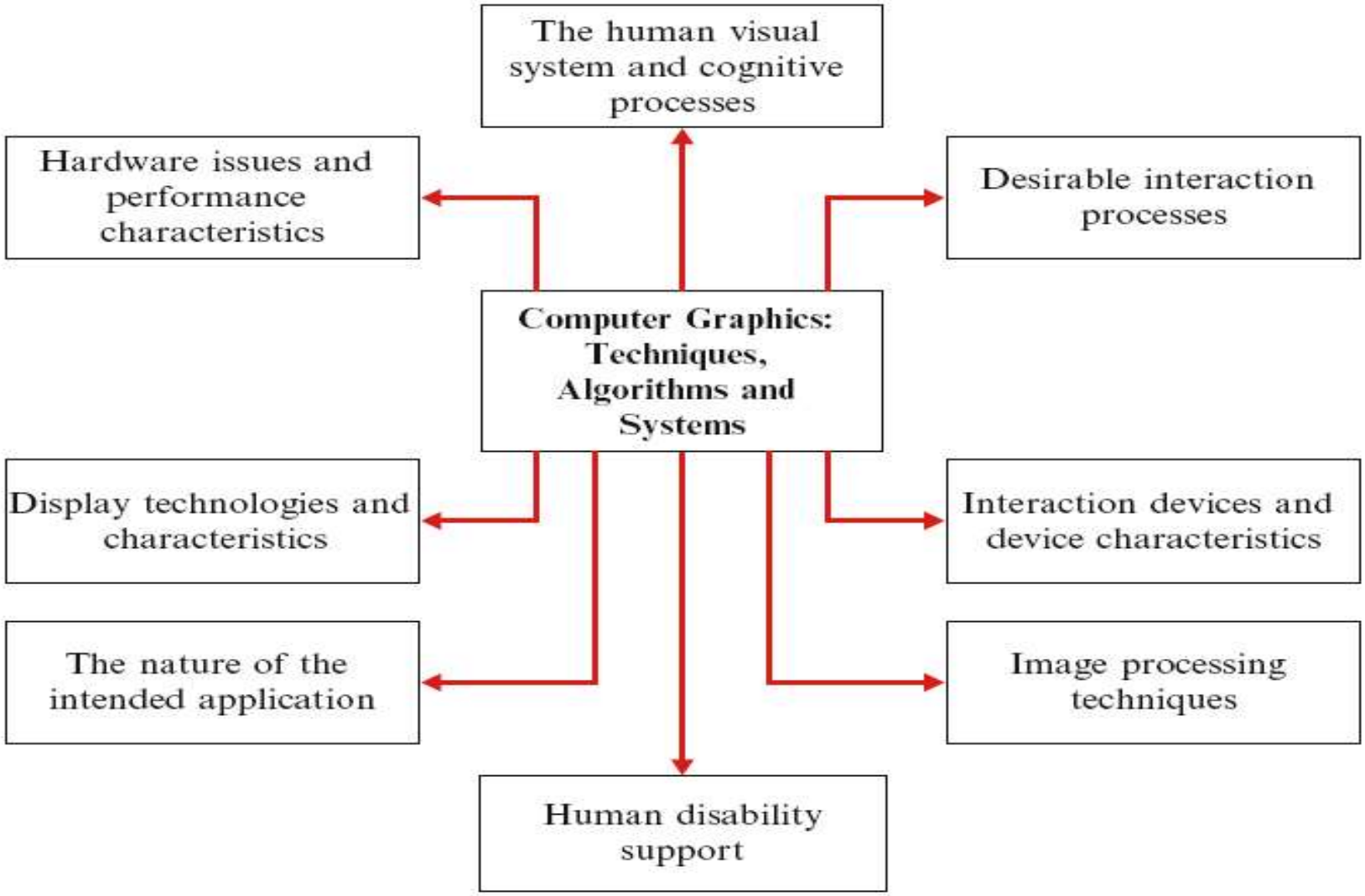


Figure 2

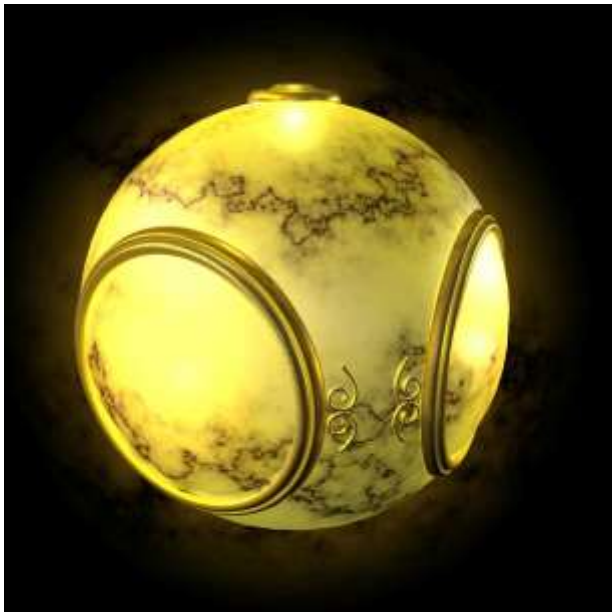
The Nature of Computer Graphics (cont.)

Computer Graphics deals with all aspects of creating images with a computer - hardware, software and applications

The Nature of Computer Graphics (cont.)

Example:

- Where did this come from?



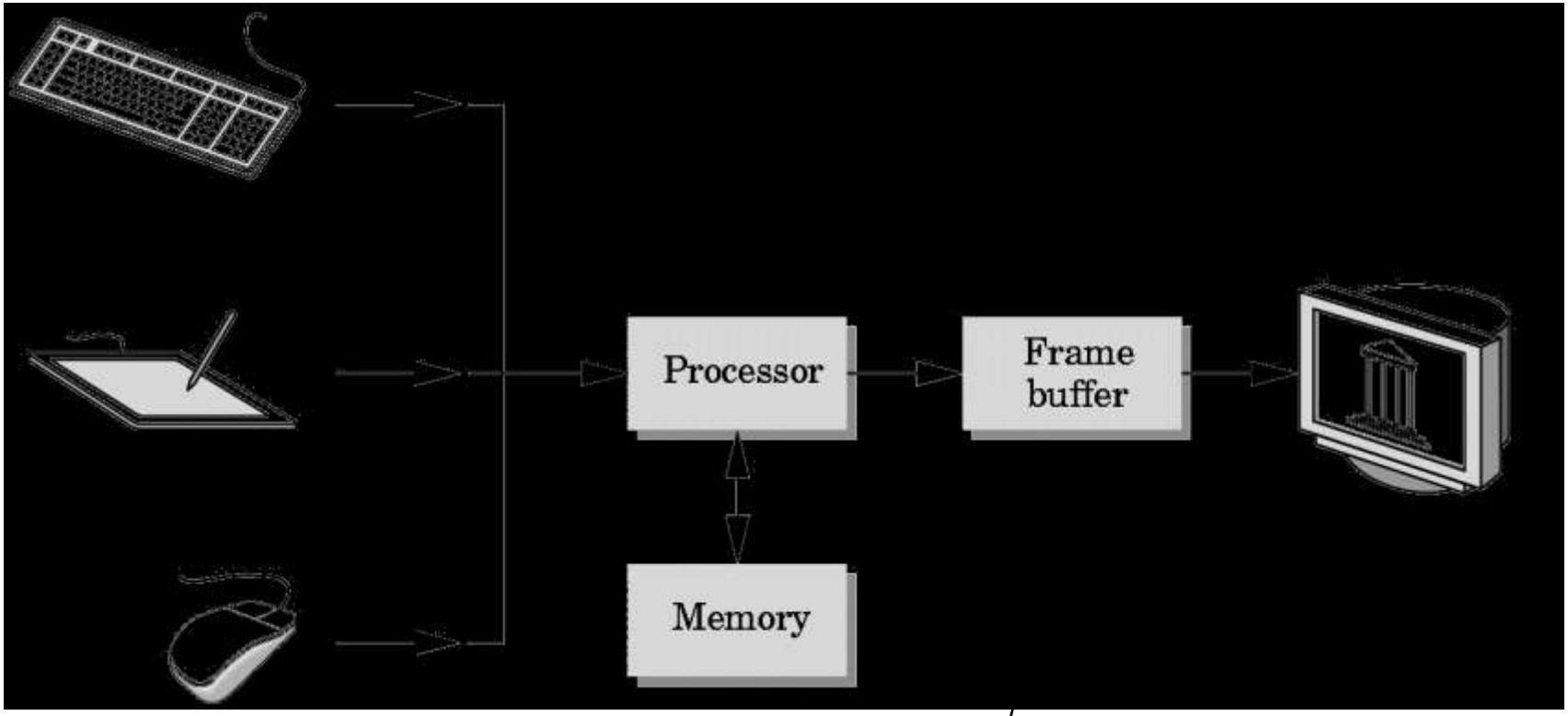
- What hardware/software did we need to produce it?

The Nature of Computer Graphics (cont.)

Preliminary Answer

- **Hardware**: PC with graphics card for modeling and rendering
- **Software**: Maya for modeling and rendering but Maya is built on top of OpenGL
- **Application**: The object is an artist's rendition of the sun for an animation to be shown in a domed environment (planetarium)

The Nature of Computer Graphics (cont.)



Input devices

Image formed in FB

Figure 3. Basic Graphics System

History & Evolution of CG

Computer Graphics: 1950-1960

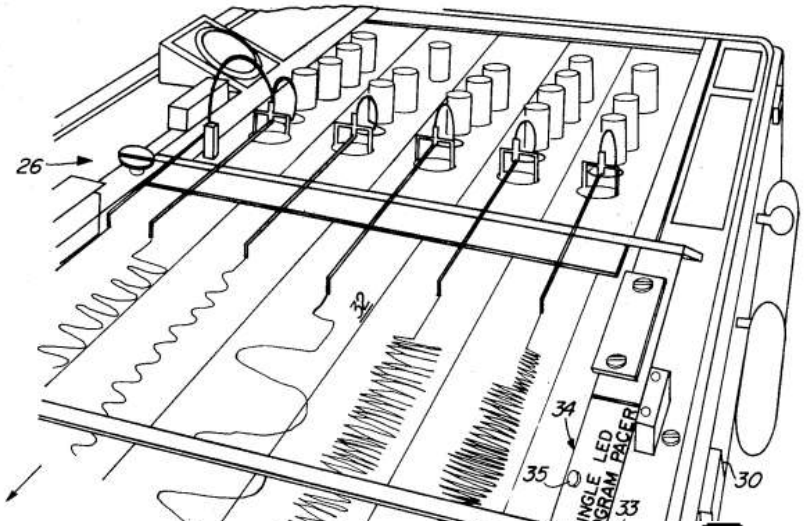
- Computer graphics goes back to the earliest days of computing
  - Strip charts
  - Pen plotters
  - Simple displays using A/D converters to go from computer to calligraphic CRT
- Cost of refresh for CRT too high
  - Computers slow, expensive, unreliable

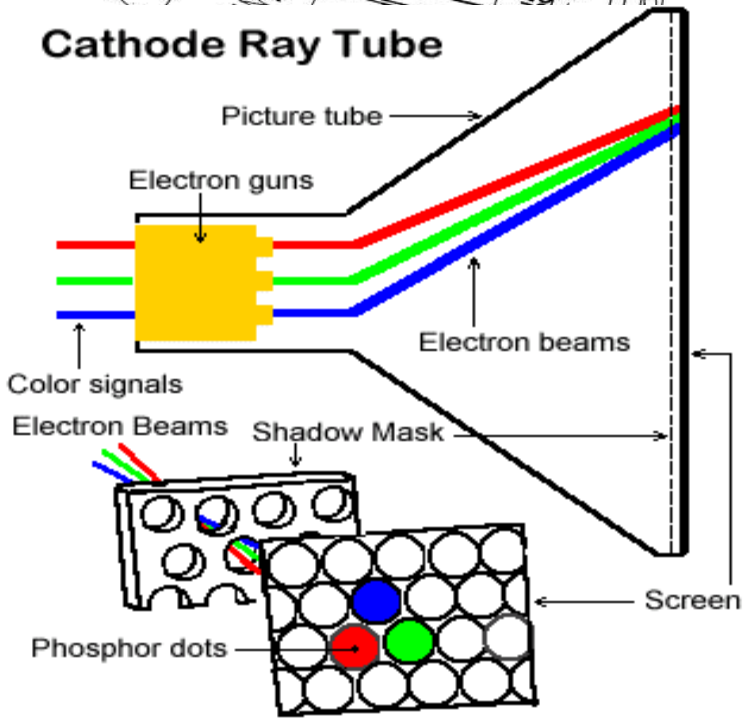
History & Evolution of CG (cont.)

Strip charts

Pen plotters

CRT

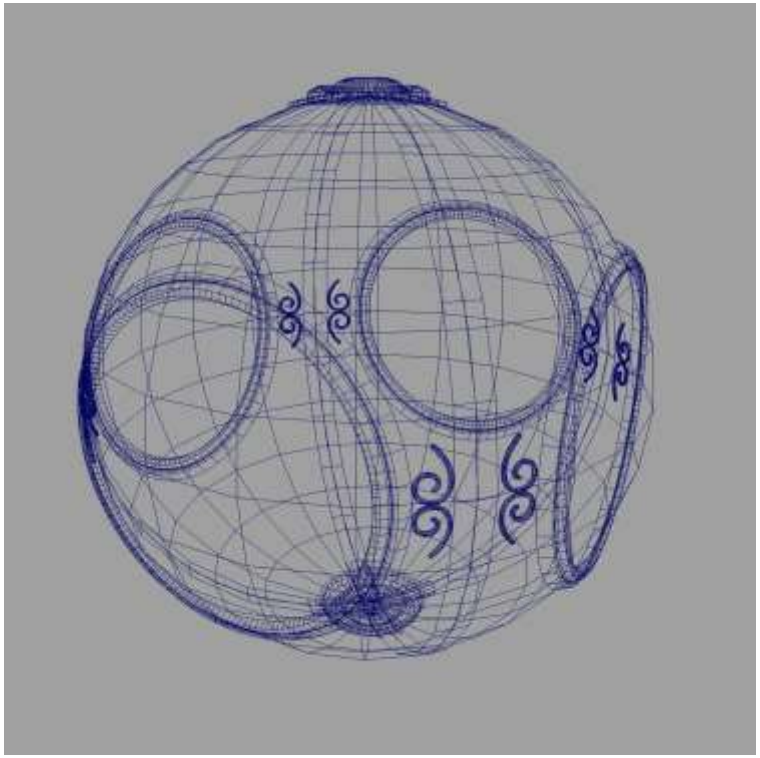




History & Evolution of CG (cont.)

Computer Graphics: 1960-1970

- Wireframe graphics
  - Draw only lines
- Sketchpad
- Display Processors
- Storage tube



wireframe representation
of sun object

History & Evolution of CG (cont.)

Sketchpad

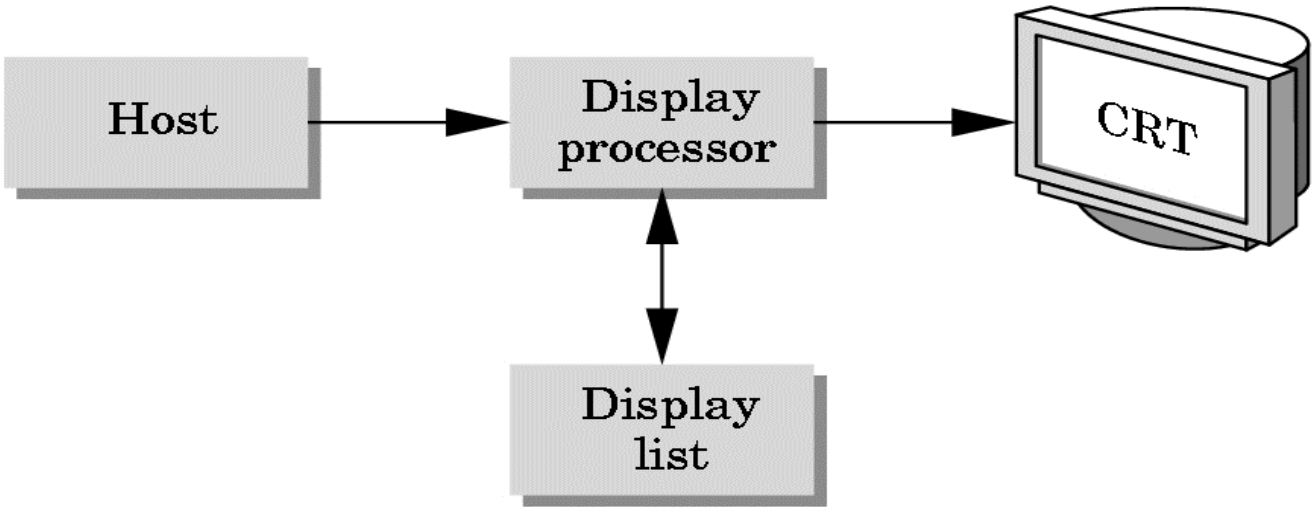
- Ivan Sutherland's PhD thesis at MIT
  - Recognized the potential of man-machine interaction
  - Loop
    - Display something
    - User moves light pen
    - Computer generates new display
  - Sutherland also created many of the now common algorithms for computer graphics

History & Evolution of CG (cont.)

History & Evolution of CG (cont.)

Display Preprocessor

- Rather than have the host computer try to refresh display use a special purpose computer called a display processor (DPU)



- Graphics stored in display list (display file) on display processor
- Host compiles display list and sends to DPU

History & Evolution of CG (cont.)

Direct View Storage Tube

- Created by Tektronix
  - Did not require constant refre
  - Standard interface to computers
    - Allowed for standard software
    - Plot3D in Fortran
  - Relatively inexpensive
    - Opened door to use of computer graphics for CAD community

History & Evolution of CG (cont.)

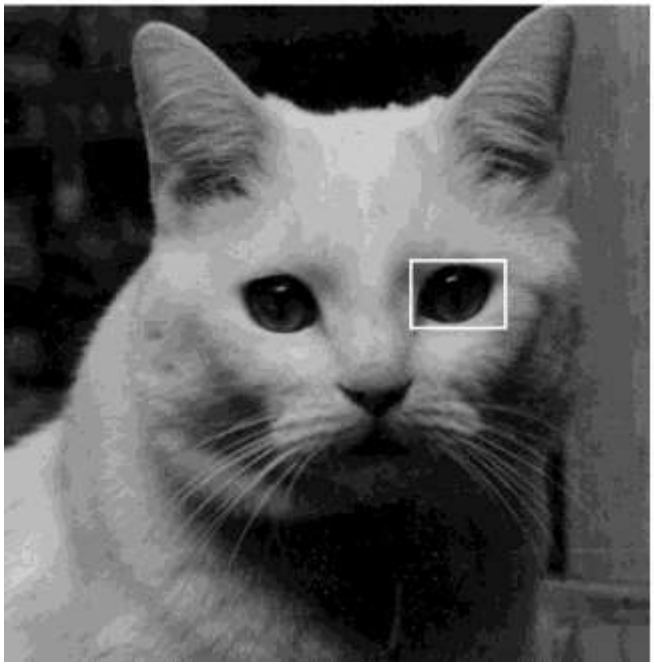
Computer Graphics: 1970-1980

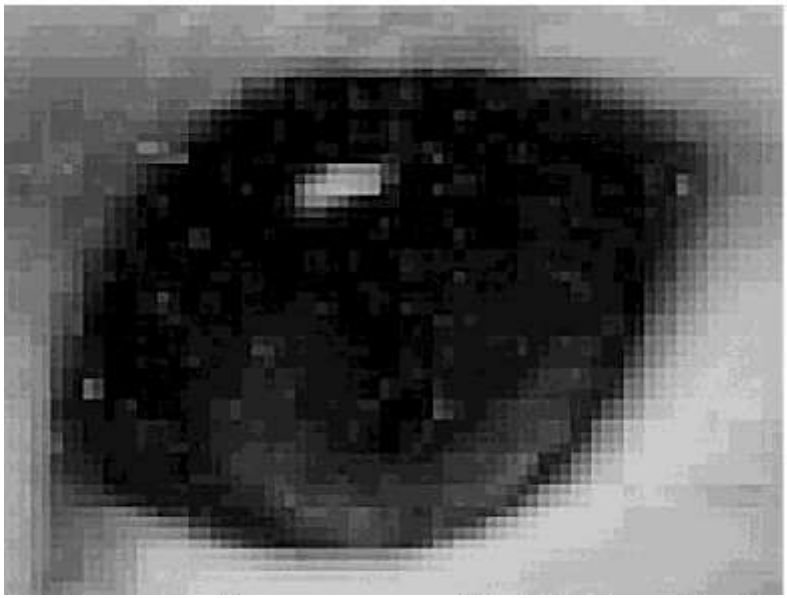
- Raster Graphics
- Beginning of graphics standards
  - IFIPS (International Federation of Information Processing Societies)
    - Graphics Kernel System (GKS): European effort
      - **Becomes ISO 2D standard**
    - Core: North American effort
      - **3D but fails to become ISO standard**
- Workstations and PCs

History & Evolution of CG (cont.)

Raster Graphics

- Image produced as an array (the *raster*) of picture elements (*pixels*) in the *frame buffer*

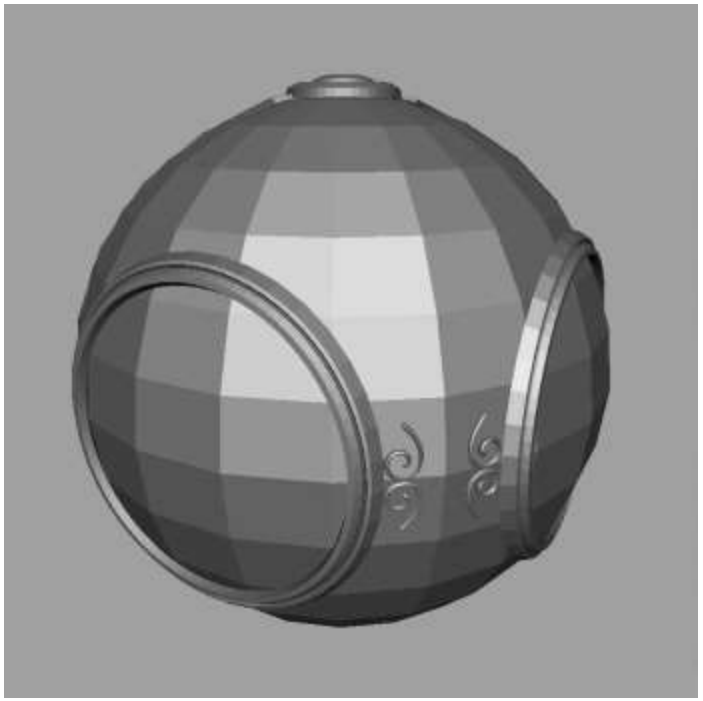




History & Evolution of CG (cont.)

Raster Graphics

- Allows us to go from lines and wire frame images to filled polygons



History & Evolution of CG (cont.)

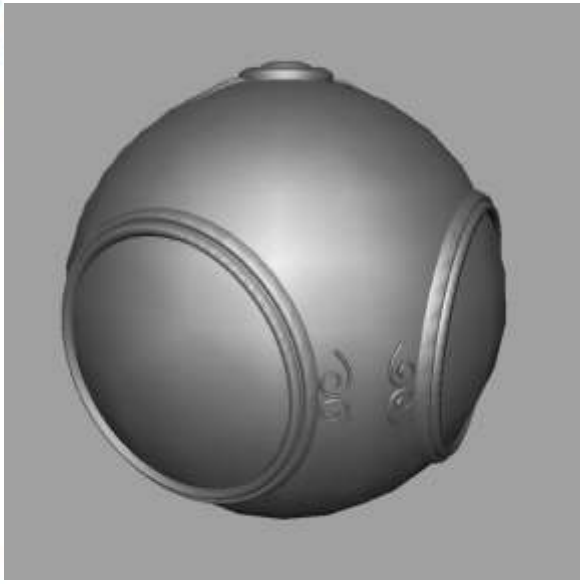
PCs and Workstations

- Although we no longer make the distinction between workstations and PCs, historically they evolved from different roots
  - Early workstations characterized by
    - Networked connection: client-server model
    - High-level of interactivity
  - Early PCs included frame buffer as part of user memory
    - Easy to change contents and create images

History & Evolution of CG (cont.)

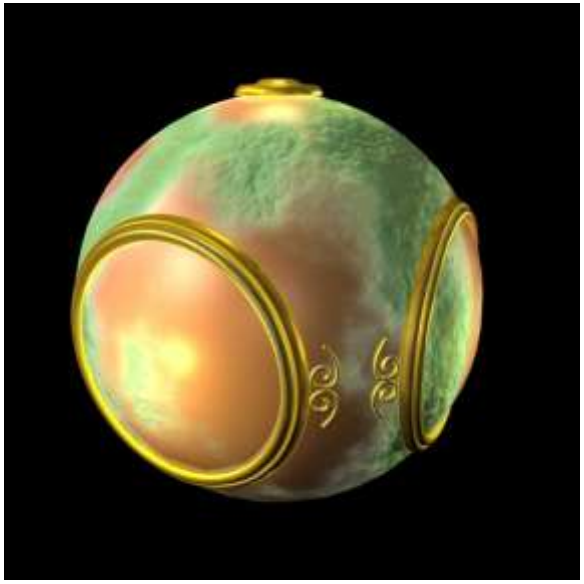
Computer Graphics: 1980-1990

- Realism comes to computer graphics



smooth shading

environment mapping



bump mapping

History & Evolution of CG (cont.)

Computer Graphics: 1980-1990 (cont.)

- Special purpose hardware
  - Silicon Graphics geometry engine
    - VLSI (Very-large-scale integration) implementation of graphics pipeline
- Industry-based standards
  - Programmer's Hierarchical Interactive Graphics System (PHIGS)
  - RenderMan
- Networked graphics: X Window System
- Human-Computer Interface (HCI)

History & Evolution of CG (cont.)

Computer Graphics: 1990-2000

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

History & Evolution of CG (cont.)

Computer Graphics: 2000-

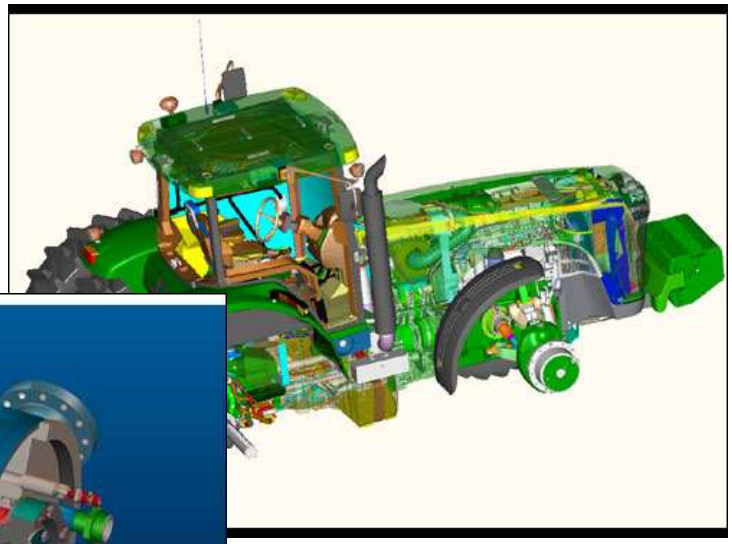
- Photorealism
- Graphics cards for PCs dominate market
  - Nvidia, ATI
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry: Maya, Lightwave
- Programmable pipelines

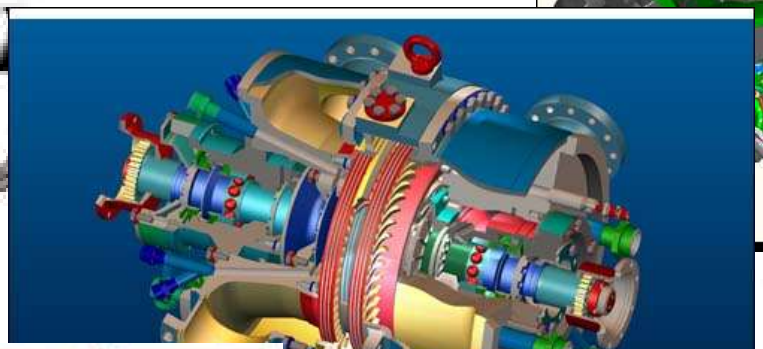
CG Applications (cont.)

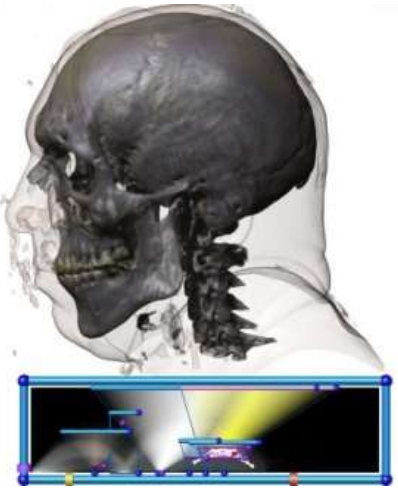
- Computer Games

CG Applications (cont.)

- Science, Engineering and Technology





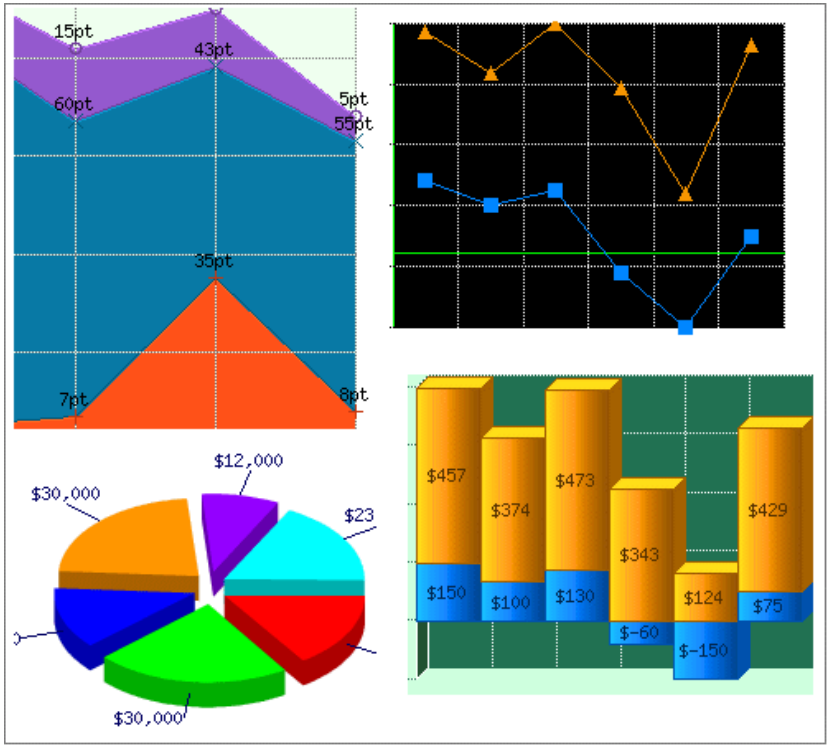


CG Applications (cont.)

- Art and Design

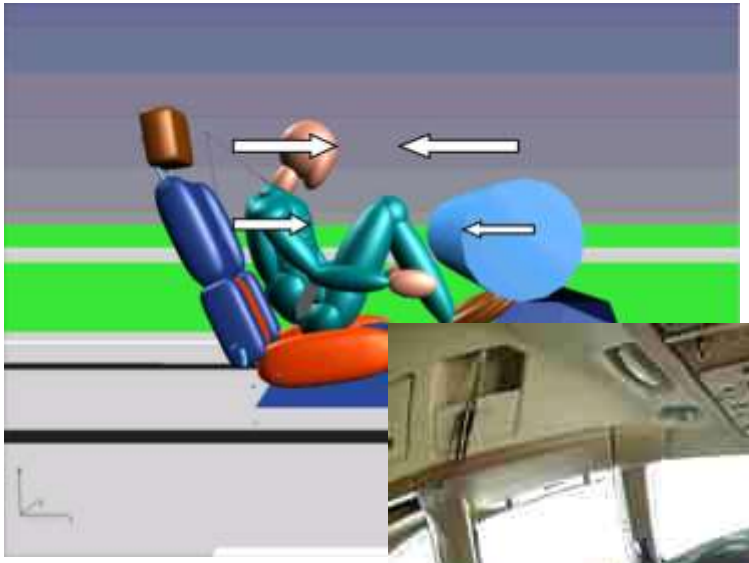
CG Applications (cont.)

- Business
  - Movie industry, business data analysis, etc



CG Applications (cont.)

- Simulations

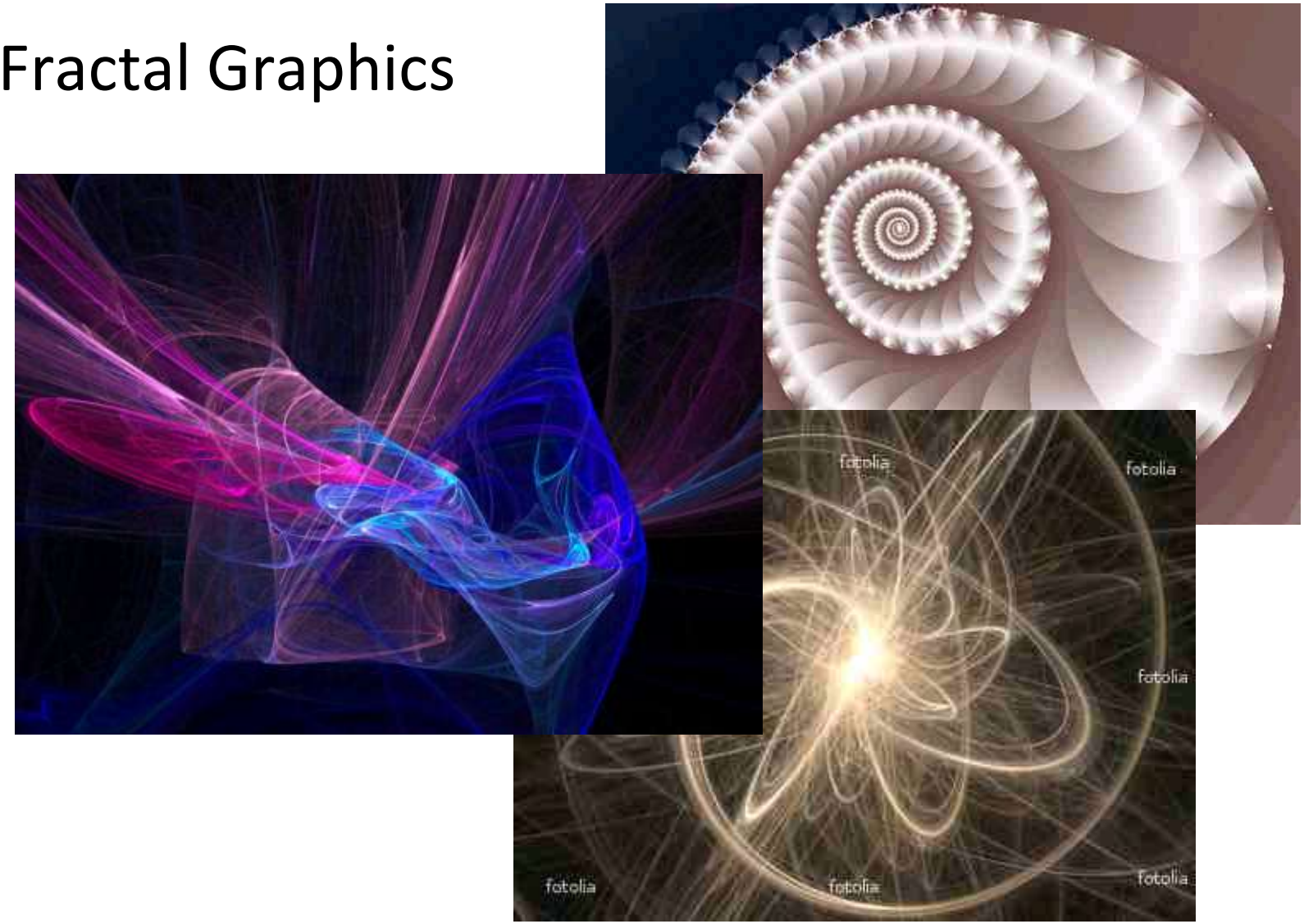


CG Applications (cont.)

- Virtual Reality

CG Applications (cont.)

- Fractal Graphics



State-of-the-Art CG

- During the first half of the nineties, PC graphics were mostly DOS-based. But it was not until the introduction of 32-bit Windows, and especially after the release of Windows 95, that PC graphics took off as a mainstream force. The hegemony of Windows 95 and its successors greatly contributed to the current graphics prosperity.

State-of-the-Art CG (cont.)

- **Graphics Boards**
  - PC graphics boards available at this time can be roughly classified by their functionality into 2D and 3D accelerators, and by their interface into *Peripheral Component Interconnect (PCI) and Accelerated Graphics Port (AGP) systems.*
  - The 16-bit *Industry Standard Architecture (ISA)* expansion bus is in the process of being phased out and few new graphics cards are being made for it.

State-of-the-Art CG (cont.)

- **Graphics Boards (cont.)**

Specifications of PC System Buses

BUS	WIDTH	CLOCK SPEED	DATA RATE
ISA	16 bits	8 MHz	(varies)
PCI	32 bits	33 MHz	132 MBps
AGP 1X	32 bits	66 MHz	264 MBps
AGP 2X	32 bits	133 MHz	528 MBps
AGP 4X	32 bits	266 MHz	1024 MBps

State-of-the-Art CG (cont.)

- **Graphics Coprocessors**
  - While presently it is easy to pick AGP as the best available graphics bus for the PC, selecting a graphics coprocessor is much more complicated. Several among half a dozen graphics chips share the foreground at this time.

State-of-the-Art CG (cont.)

- **Graphics Coprocessors**

  Examples:

  - Voodoo line from 3Dfx (Voodoo2 and Voodoo Banshee)
  - Nvidia's RIVA and GeForce processors
  - MGAG200
  - S3 Savage 3D chips
  - Other well known graphics chips are 3D Labs Permedia, S3's Virge, Matrox's MGA-64, and Intel's i740.

  All of these chips are used in top-line boards in PCI and AGP forms.

State-of-the-Art CG (cont.)

- **Graphics Coprocessors**
  - Recently Nvidia announced their new GeForce3 graphics processing unit with a 7.63GB/sec memory bandwidth and other state-of-the-art features. Several graphics cards and on-the-motherboard graphics systems that use the GeForce3 chip are currently under development. Hercules Computer Technologies 3DProphet III is one of the graphics cards that uses Nvidia's GeForce3.

State-of-the-Art CG (cont.)

- **CPU On-Board Facilities**
  - Graphics, especially 3D graphics, is a calculation-intensive environment. The calculations are usually simple and can be performed in integer math, but many operations are required to perform even a simple transformation. Graphics coprocessors often rely on the main CPU for performing this basic arithmetic.

State-of-the-Art CG (cont.)

- **CPU On-Board Facilities**
  - For this reason, graphics-rendering performance is, in part, determined by the CPU's mathematical throughput. Currently the mathematical calculating engines are the math unit and the ***Multimedia Extension (MMX)***. The register size of the math unit and the MMX were expanded in the Pentium 4 CPU.

State-of-the-Art CG (cont.)

- **CPU On-Board Facilities**
  - The math unit is a fast and efficient numerical calculator that finds many uses in graphics programming.
  - MMX contains new instructions and additional registers designed to support the mathematical calculations required in 3D graphics and multimedia applications.
    - The instruction set includes arithmetic operations (add, subtract, and multiply), comparisons, conversions, logical operations (AND, NOT, OR, and XOR), shifts, and data transfers. The result is a parallel, simple, and fast calculating engine quite suitable for graphics processing, especially in 3D.

State-of-the-Art CG (cont.)

- **Application Programming Interface**
  - One 3D graphics programming interface that has attained considerable support is *OpenGL,* developed by Silicon Graphics International (SGI). OpenGL, which stands for *Open Graphics Language*, originated in graphics workstations and is now part of many system platforms, including Windows 95, 98, and NT, DEC's AXP, OpenVMS, and X Windows. This led some to believe that OpenGL will be the 3D graphics standard of the future. In 1999 Microsoft and SGI joined in a venture that was, reportedly, to integrate OpenGL and DirectX. The project, code named Fahrenheit, was later cancelled.

State-of-the-Art CG (cont.)

- **Application Programming Interface**
  - At this time the mainstream of 3D graphics programming continues to use Microsoft's DirectX. The main advantage offered by this package is portability and universal availability on the PC. DirectX functionality is part of Windows. Microsoft provides, free of charge, a complete development package that includes a tutorial, support code, and sample programs. Furthermore, developers are given license to provide DirectX runtime code with their products with automatic installation that can be made transparent to the user.

SEATWORK

- Discuss the Sketchpad and the contribution made by Ivan Sutherland to the development of modern computer graphics.

HOMEWORK:

- State your own understanding of the scope of modern computer graphics.
- Give 5 examples of modern computer graphics technologies in terms of:
  - Hardware
  - Software
  - Application
- Give examples of computer graphics applications excluding those already given in the lecture discussion.