

Chapter 1

An overview on Computer Graphics

Chap 1 Introduction

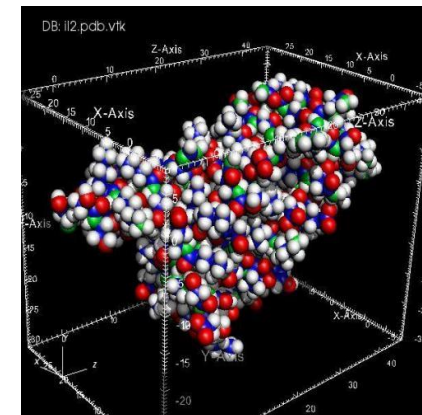
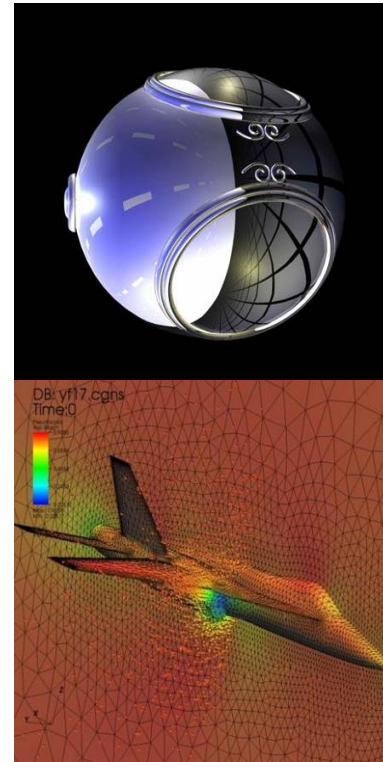
- **What is the computer graphics?**
- **Applications**
- **Historical Survey**
- **Modern graphics computing**
- **Current status**
- **Future developments**

What is the CG?

- **CG is concerned with all aspects of using computers to generate static or dynamic images. It includes**
 - **Scene modeling, object manipulation, model acquisition**
 - **Visibility computing**
 - **Lighting-effect calculation**
 - **Interaction, HCI**
 - **Simulation/animation**
- **Issues on quality, computing and space complexity**

Applications

- **Display of information**
 - **Geometric data**
 - **Volume data**
 - **Scientific data**
 - might be multidimensional
 - **Molecular data**
 - **Information, Big data**
 - **Information Visualization**
 - **Visual analytics**



Applications

- **Animation and special effects**
 - **Commercial animation, special effects, character animation,....**



– Animation movies



Applications

- **Real-time applications**

- **Games**

- **Virtual reality**

- **Visual simulation**

- **Large, complex, and dynamic scene**

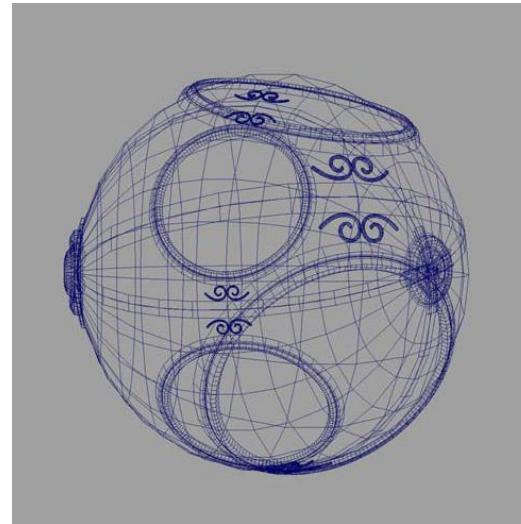
- **User interaction and manipulation**

- **Fast frame rate with acceptable quality**



Graphics system history

- **1950-1960**
 - Pen plotters/simple display using A/D converters to go from computer to CRT
- **1960-1970**
 - Wireframe graphics
 - Sketch pad – Ivan Sutherland's PhD work at MIT
 - Draw only lines



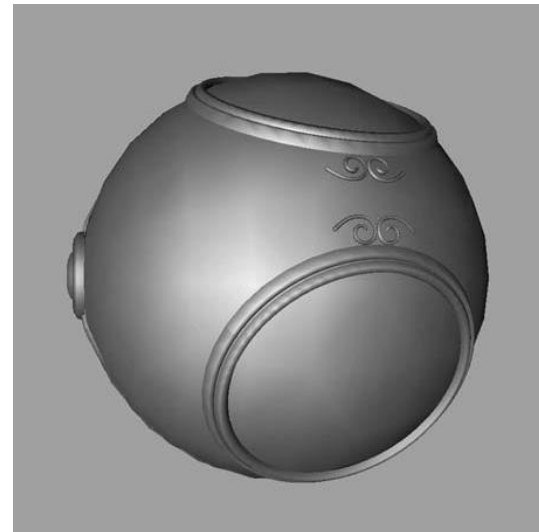
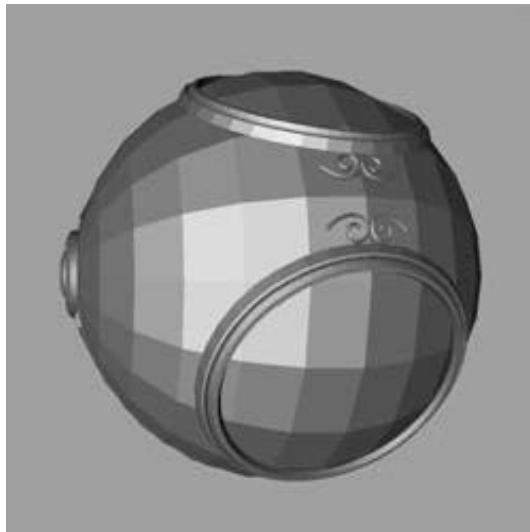
Graphics system history

- **1970-1980**

- **Main frame/Mini-computer graphics**

- **Raster graphics**

- **Image is an array of picture elements (pixels) in the frame buffer**
- **Wireframe drawing -> shaded polygons**



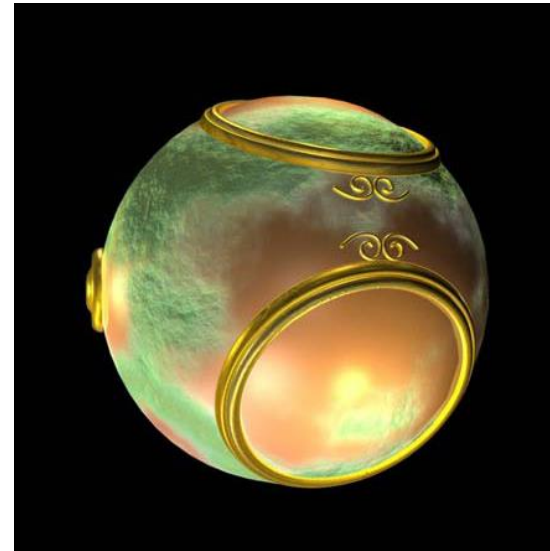
Graphics system history

- **1980-1990**

- **Workstation graphics –very expensive!**
- **Graphics API - from each hardware company**
 - **GKS, PHIGS (extension of GKS) -- GL of SGI**
- **Brought more realism to computer graphics**



Environment mapping



Bump mapping

Graphics system history

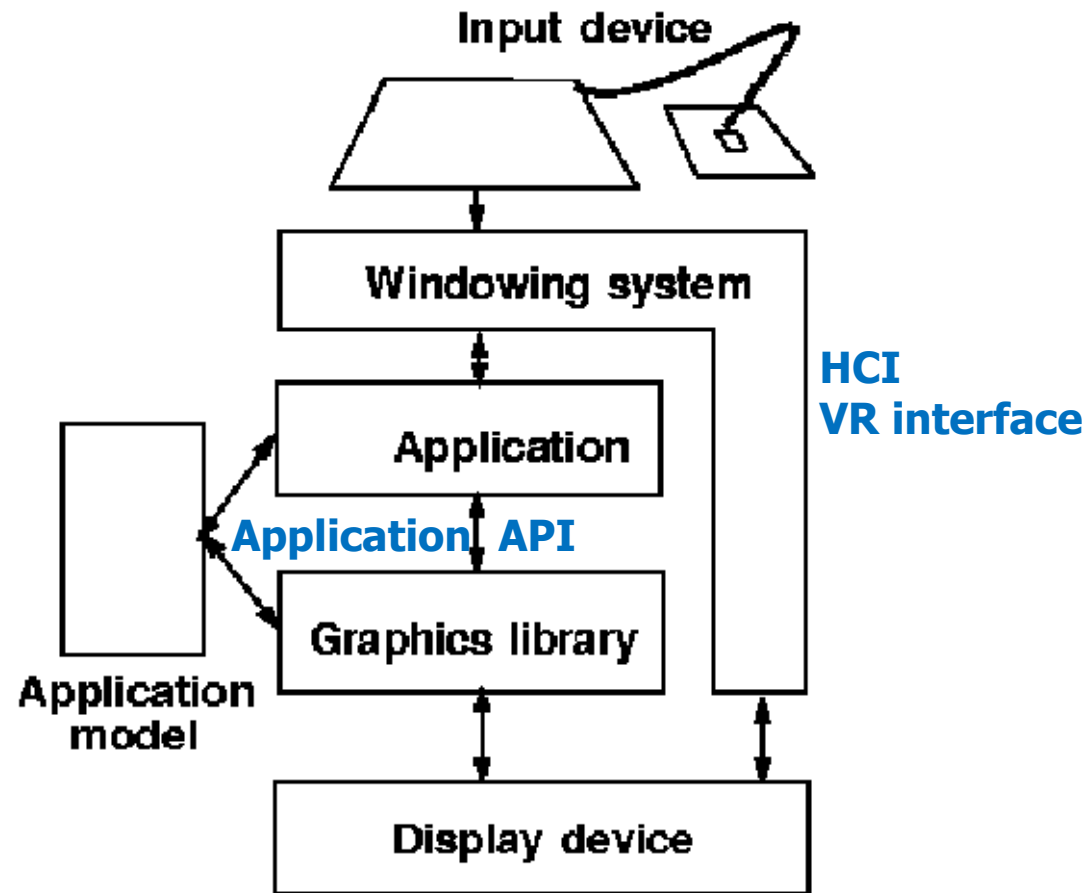
- **1990-2000**
 - **Workstation graphics – expensive!**
 - **OpenGL API**
 - a hardware-independent version of SGI's GL
 - **New hardware capabilities**
 - Texture mapping, stencil buffer, accumulation buffer
- **2000-**
 - **PC graphics**
 - Nvidia GeForce, ATI Radeon
 - **Game box hardware**
 - Sony PS, Nintendo, MS Xbox
 - **Programmable pipeline -- GPU**

Hardware

- **Workstation graphics (\$17K-250K)**
- **PC graphics accelerators (\$300)**
 - **Nvidia GeForce, ATI Radeon**
 - **Programmable GPU**
- **Game consoles (\$300-800)**
 - **Sony PS2, Nintendo Dolphin, MS X-box**

Modern graphics computing environments

- **Hardware**
 - **Graphics card**
- **Software**
 - **Graphics API**
 - OpenGL, Direct 3D
 - **Application API**
 - Game engine
 - VR engine
- **Applications**
 - **Games, VR systems, animation, special effect**



Application programmer's interfaces

- **Graphics API**

- **Interface between application programs and the graphics system.**
- **Deal with polygons and rendering**
- **Examples: OpenGL, Direct3D,...**

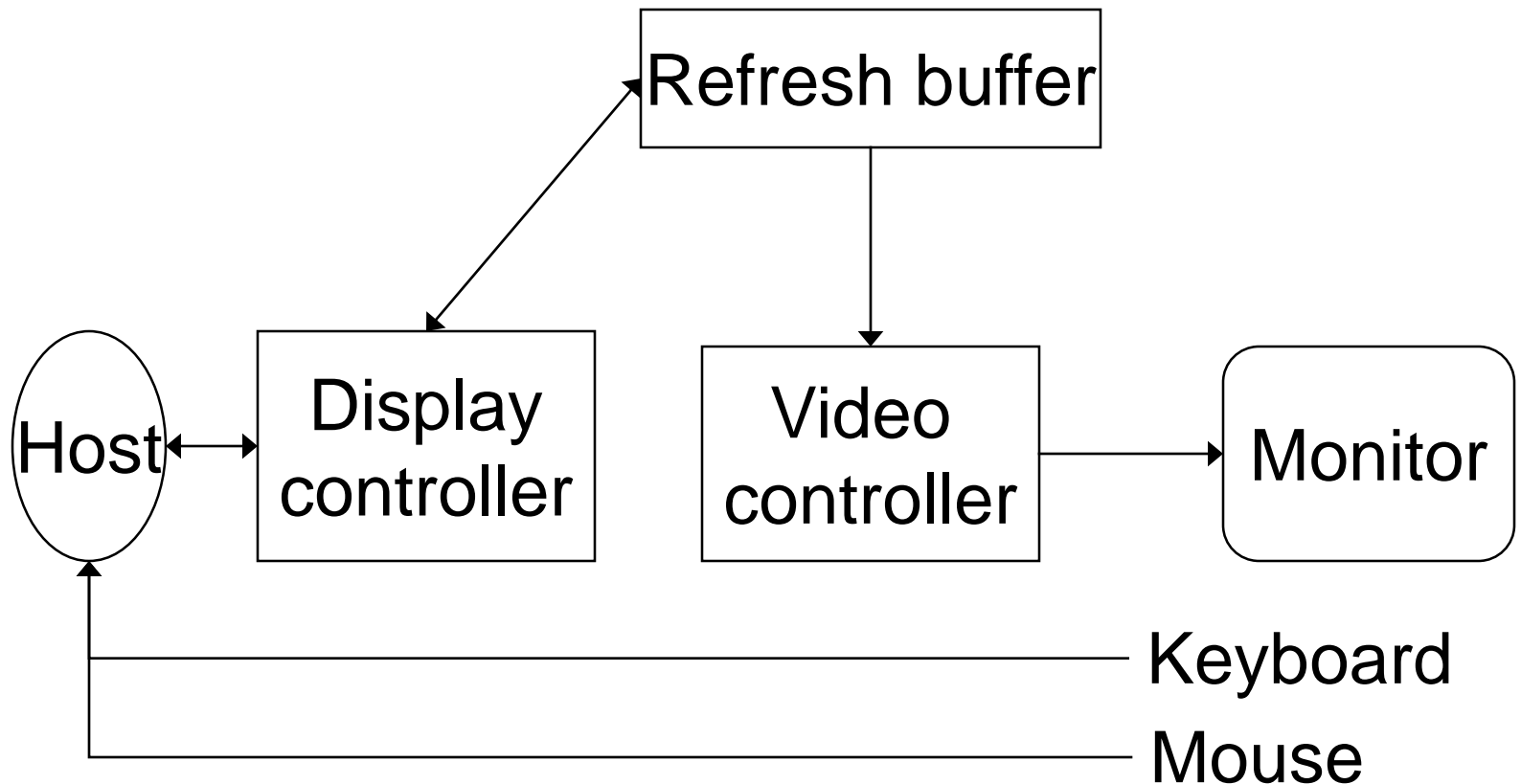
- **Application API**

- **Interface between applications and graphics API.**
- **Deal with whole scene and includes many modules**
 - **Rendering, scene management, character animation, dynamics, sound,...**
- **Examples: OpenInventor, WTK, game engines....**

Hardware

- **Common components**
 - **Processor (CPU)**
 - **Memory**
- **Graphics components (3D顯示卡)**
 - **Display controller (Graphics accelerator)**
 - **Video controller**
 - **Buffers**
 - **frame buffer, Z-buffer, stencil buffer, accumulation buffer**
 - **Video memory**
 - **I/O devices**
- **Fixed pipeline vs. programmable pipeline**

Raster Display Architecture

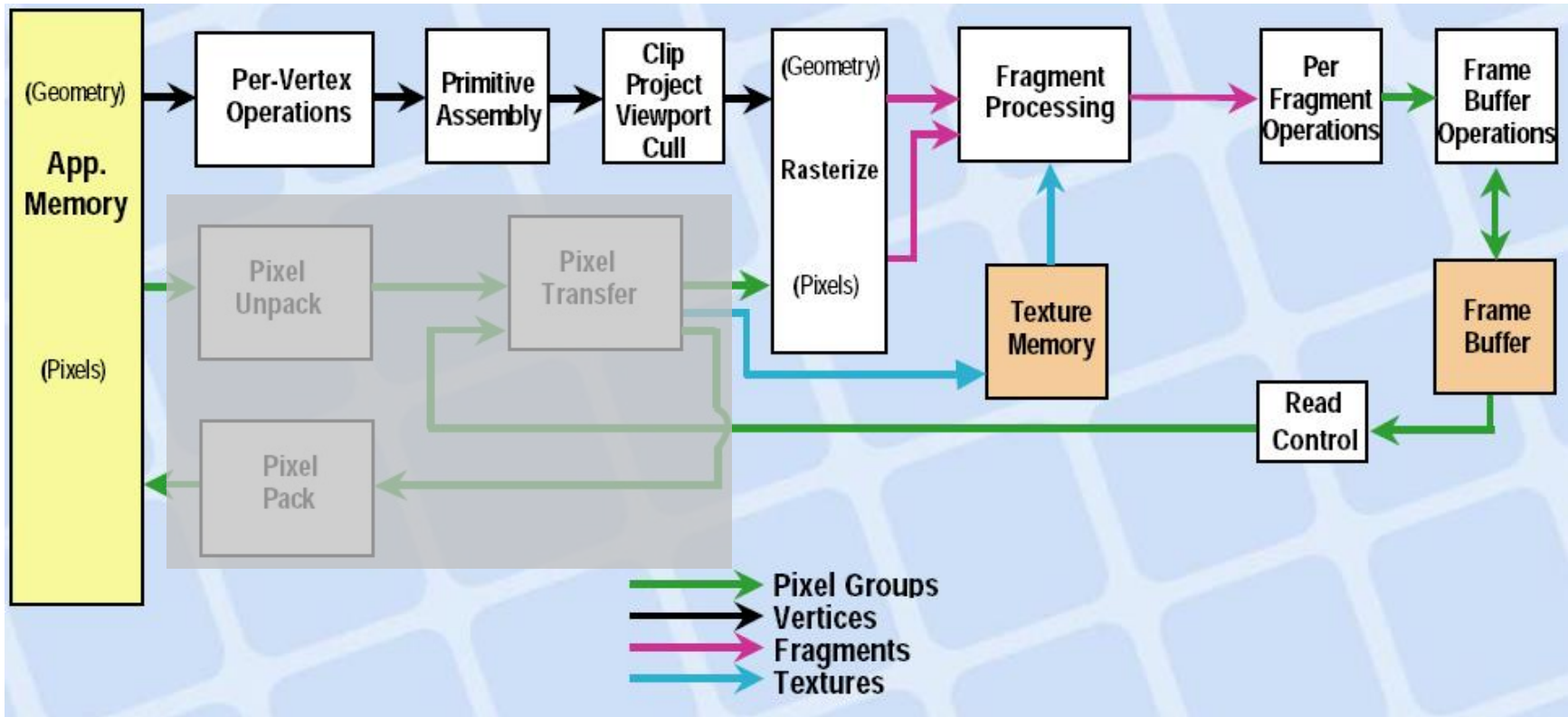


What display controller does?

Fixed Pipeline Architecture

- **Lighting**
 - Vertex lighting with local illumination
- **Transformation and Projection**
 - 3D-2D projection, window-viewport mapping
- **Clipping**
 - view volume culling, Back-face culling
- **Rasterization and shading**
 - Scan conversion
 - Pixel operations
 - polygon shading with bilinear interpolation, plus texture modulation
 - Depth interpolation
- **Hidden surface removal**
 - Per-pixel Z-buffer test

Pipeline Architecture



Graphics research history

Summary

- **1960-1990**
 - Main-frame → Workstation-based graphics
 - Research: Quest of photorealistic rendering
 - Application: Very limited, CAD rendering and animation
- **1990-1997**
 - Virtual reality became attractive
 - Research: real-time graphics became very important, attract more research attentions
- **1998-**
 - PC graphics became popular
 - 3D game graphics became attractive
 - Many research in real-time graphics
 - Vertex/pixel shader became available

Recent Developments

Real-Time Graphics

- **In the past 10 years**
Seek for real time frame rates and high-quality rendering
 - **Level-of-detail modeling**
 - **Image based rendering**
 - **Hybrid rendering**
 - **Visibility culling**
 - **Per-pixel lighting**
 - **GPU-based global illumination**

Recent Developments

Real-Time Graphics

- **Current trends**

Seek for real-time realistic rendering

- **Rendering**

- **Shadowing, global illumination, physically-based rendering**

- **Physics**

- **Collision detection/response, fracturing**

- **Natural phenomenon**

- **Simulation and rendering**

- **GPU computing**

- **Rendering, computations**

Recent Developments

Integration w/ IP, video proc., vision

- **Integration of IP and graphics**
 - Many problems in graphics are transferred to frequency domain for simplicity and efficient computations
 - Image matting, interacting with images,...
- **Integration of video processing and graphics**
 - Video matting, video synthesis and editing,...
- **Integration of computer vision and graphics**
 - **Capturing**
 - Motion, specific object modeling (ex., hair)
 - **Acquisition**
 - Material properties for physical-based rendering
 - **Image based modeling and rendering**

Current status

- **CG computing is not expensive, including recent features**
 - **Assembly language interface to the transformation and lighting hardware (vertex shader) and**
 - **Pixel pipeline (pixel shader)**
- **Combining geometry, image, volume techniques**
- **Efficient/friendly API and application software are popular**
- **Has very diverse areas in application**
 - **Game, VR, AR, and animation are driven force for the development**
- **Have gained enough confident for the future**
 - **Real-time realistic imaging is possible**
 - **Real-time realistic dynamics is possible**

Future Trends

- **CG becomes popular**
- **More diverse areas in application**
- **More serious applications are coming**
 - **VR, AR, Animation movies with interaction**
- **Real-time, stereo display of 3D (or multidimensional) dynamic data will become common**
- **Quest for real-time rendering and realistic imaging**
- **GPU computing becomes anywhere**