

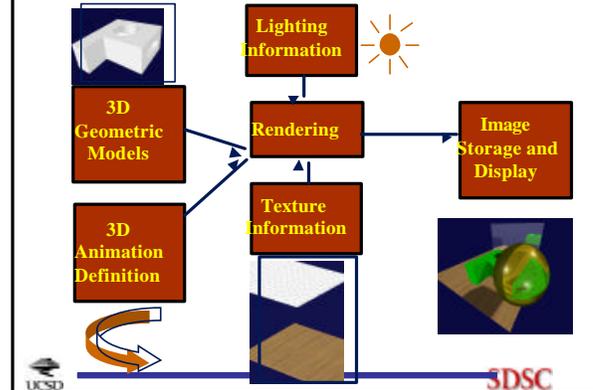
SIGGRAPH 2001 Fundamentals Seminar: Computer Graphics Hardware

Mike Bailey
San Diego Supercomputer Center
University of California San Diego
mjb@sdsc.edu

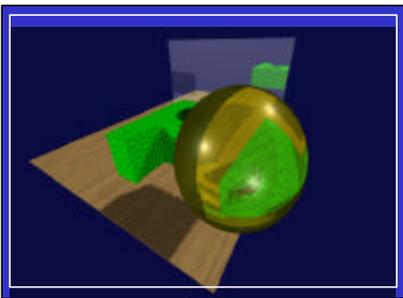


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The Generic Graphics Process

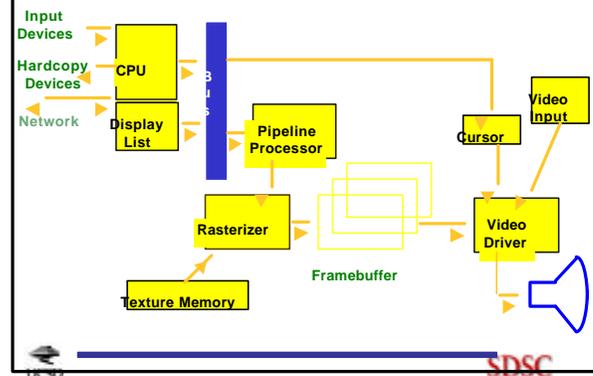


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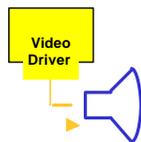
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The Generic Computer Graphics System



SDSC

The Computer Graphics Monitor



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Displaying Color on a Computer Graphics Monitor

- 3 color guns
 - Red-green-blue phosphors
 - Gun voltage » color brightness
-



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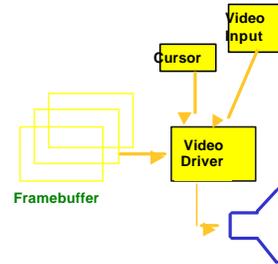
Display Resolution

- *Pixel* resolutions (640x480 - 1600x1024 are common)
- Screen size (13", 16", 19", 21" are common)
- Human acuity: 1 arc-minute is achieved by viewing a 19" monitor with 1280x1024 resolution from a distance of ~40 inches
- FYI: HDTV is talking about resolutions in the 2048x1152 range



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The Video Driver



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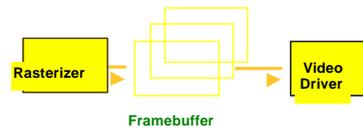
The Video Driver

- *N refreshes/second* (N is usually between 40 and 80)
- Framebuffer contains the R,G,B that defines the color at each pixel
- Cursor
 - Appearance is stored near the video driver in a "mini-framebuffer"
 - x,y is given by the CPU
- Video input



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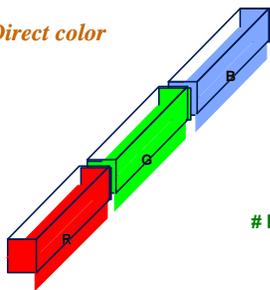
The Framebuffer



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The Framebuffer

- *Direct color*



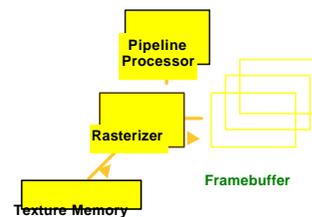
# Bits/pixel	Total colors:
12	$2^{12} = 4\text{K}$
18	$2^{18} = 256\text{K}$
24	$2^{24} = 16.7\text{M}$

# Bits/color	# Shades per color
4	$2^4 = 16$
6	$2^6 = 64$
8	$2^8 = 256$



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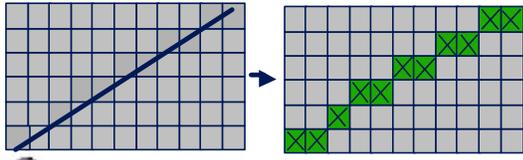
The Rasterizer



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Rasterization

- Turn screen space vertex coordinates into pixels that make up lines and polygons
- A great place for custom electronics



Texture Mapping

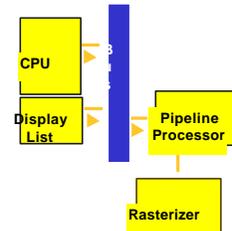
- “Stretch” an image onto a piece of geometry
- Image can be generated by a program or scanned in
- Very useful for realistic scene generation



Pipeline Processor

- Coordinates enter in world (application) coordinate space
- Coordinates leave in screen (pixel) coordinate space
- Another great place for custom electronics

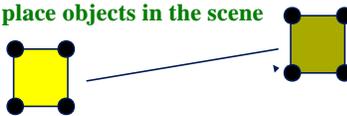
The Pipeline Processor



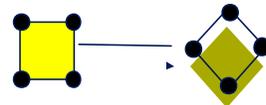
Pipeline Processor: Transformations

- Used to correctly place objects in the scene

Translation



Rotation



Scaling



Pipeline Processor: Projection

- Turn 3D coordinates into 2D

Parallel projection

Parallel lines remain parallel



Perspective projection

Some parallel lines appear to converge

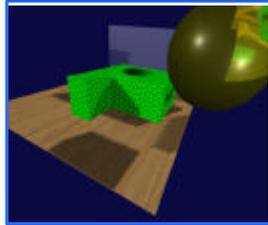


Pipeline Processor: Projection

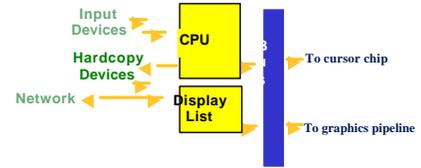


Parallel

Perspective



The CPU



Input Devices: General Categories

- Text input
- Choice input
- Value input
- Coordinate input
 - 2D coordinates
 - 3D coordinates



2D Coordinate Input

- Mouse
- Joystick
- Trackball
- Digitizing pen
- Touchpad
- Touchscreen

3D Coordinate Input

- 3D joystick
- Spaceball
- Linkage
- 3D Trackers
- Glove



Graphics Hardcopy Devices

- Color paper plotters
- Film recorders
- Video
- Solid

Color Paper Plotting

- Uses *subtractive colors*
- Cyan, magenta, yellow, black

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Digital Film Recording

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The Limitations of using NTSC Video

- Cannot display saturated colors well
- Expect an effective resolution of (at best) ~640x480
- Do not use single-pixel thick lines
- Stay away from the edges of the screen
- Some colors have better video resolution than others

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NTSC Cycles of Encoding per Scanline

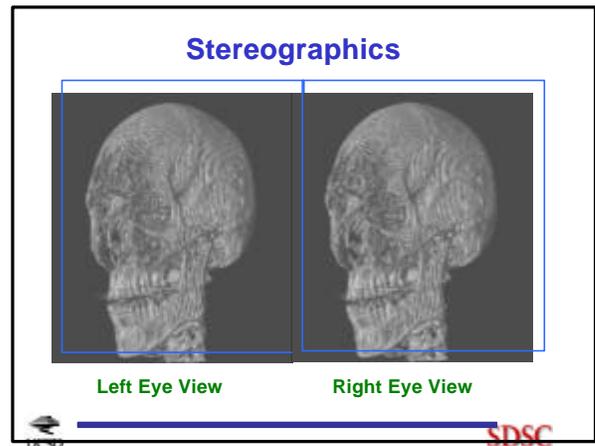
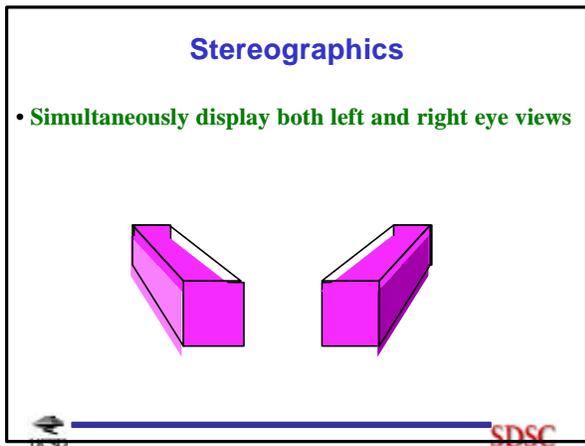
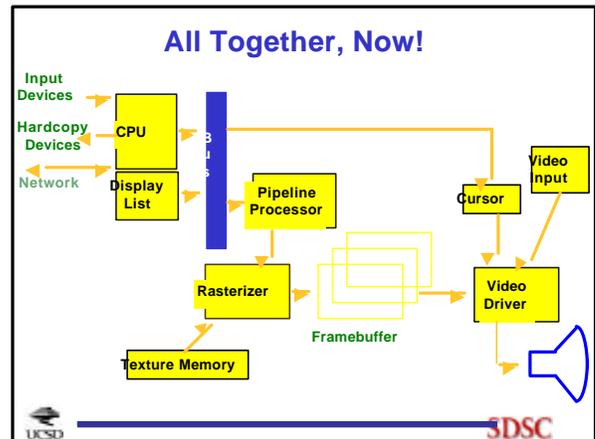
What:	Cycles/Scanline:
Intensity	267
Orange-Blue	96
Purple-Green	35

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Solid Hardcopy

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If You are Interested in Learning More:

Hardware will be discussed in more detail in the *Introduction to Computer Graphics* course on **Monday, 11:15 - 12:00**

If You are Interested in Learning More:

Physical model hardcopy will be discussed in more detail in the *3D Hardcopy: Converting Virtual Reality to Physical Models* course on **Tuesday morning**

**If You are Interested in
Hardware, Remember:**

**The Exhibition closes
at 5:00 on Thursday !!**



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***Have fun this week,
and Thanks for Coming!***

Computer Graphics Hardware

Mike Bailey

`mjb@sdsc.edu`



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