Last time

- OpenGL
- Color
  - glVertex3f(r, g, b)
- Culling
- Vertex order

Questions

- ????

- I have a question for you:
  - Go to Piazza
From the reading

- Efficiency and Debugging (for graphics)
  - Why does efficiency matter?
  - Memory or speed?
  - How do you debug?

Today

- Images
- Displays

*Slides based on Steve Marschner lectures*
What is an image?

An Image

- A 2D distribution of intensity or color

- Mathematically
  - A function defined on a 2D plane

\[ I : \mathbb{R}^2 \rightarrow \ldots \]
An Image

- In graphics
- represent image in computer readable form
- display image

Image representation

- Raster image - 2D array that stores a pixel value for each pixel
- Each pixel is approximation

\[ I(x, y) : R \to V \]

\[ I - Image \]
\[ R - Rectangular area \subseteq R^2 \]
\[ V - Pixel values \]

Note: I do not believe in regurgitation of definitions
- Display Resolution
  - number of pixels (width x height)

\[ I(x, y) : R \rightarrow V \]
\[ R = [0,9] \times [0,9] \]
\[ V = [0,1] \]

How much memory do we need?
- Display Resolution
  - number of pixels (width x height)

\[ l(x, y) : R \rightarrow V \]
\[ R = [0,9] \times [0,9] \]
\[ V = [0,255]^3 \]

How much memory do we need?

- Common pixel formats
  - 1 bit grayscale
  - 8 bit RGB (24 bits/pixel)
    - computer display
  - 16 bit RGB (48 bits/pixel)
    - medical imaging

pp. 61
- framebuffer - drives video display from 2D array of complete frame data

```c
glutInitDisplayMode( GLUT_RGBA | GLUT_DOUBLE | GLUT_DEPTH);

glClear( GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
```

http://groups.csail.mit.edu

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**An Image**

- In graphics
  - represent image in computer readable form
  - display image
Cathode ray tube

- First widely used electronic display
- for TV in 1920s - 1930s

Raster CRT display

- Scan pattern fixed in hardware
- Intensity modulated to produce image
LCD or projection display

- Principle: block or transmit light by twisting its polarization
- Intermediate intensity levels possible by partial twist

Color displays

- CRT
- LCD
Stereopsis

- Impression of depth as seen with binocular vision
3D Displays

- Passive stereo
- Active stereo
- Auto stereoscopic
3D Displays

- Passive stereo

- Active stereo
3D Displays

- Auto stereoscopic

**Lenticular Lenslets**

- Pixels
- Right
- Left

**Parallax Barrier**

- Pixels
- Right
- Left