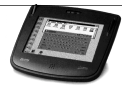
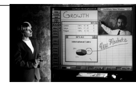
CS 4451A: Computer Graphics

- CCB 101, TT 9:30-11

Why Computer Graphics?

- Fun!
- Lots of uses:
  - Art, entertainment
  - "Visualizing" complex data/ideas
  - Concise representation of actions/commands/state
  - Design/task aids (visual feedback)

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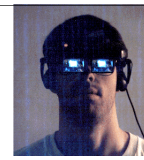
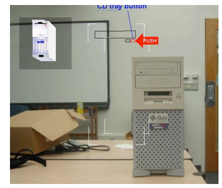
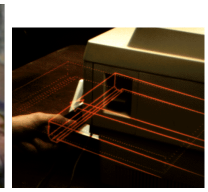


Intructor


- Blair MacIntyre
- HCI, Graphics, Systems
- Augmented Reality, Wearable Computers, Ubiquitous Computing








TAs

- Enylton Coelho
- Ben Carter

Basic Course Info

- Quarter equiv: CS 4390 and CS 4391
  - Need both. Only CS 4390? Stay here!
  - Anybody even remember quarters?
- PreReqs
  - MATH 2601 and CS 2330

More Info

- See the web
  - http://www.cc.gatech.edu/classes/AY2003/cs4451a_fall/
- Book (Watt, OpenGL PG) (FvDFH)
- Exams: 2 tests (30%), 1 final (20%)
- Assignments: 5 (50%)
  - Java/OpenGL on Sun/SGI/NT/Mac, lab or home
  - (section B will be using C)
- Syllabus: subject to change

Lectures

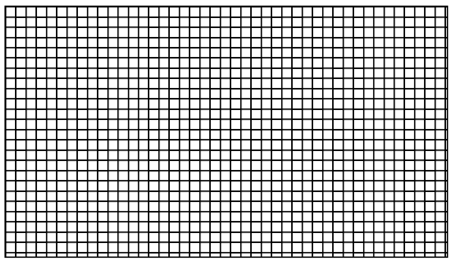
- Sometimes will be pre-prepared notes
  - Available on web page before lectures
    - print them and annotate during class!
- Required reading on syllabus
- eClass recording … alas no.

Introduction

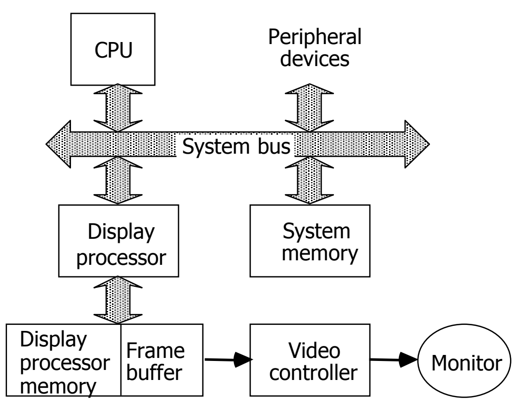
- Raster Graphics Hardware

Basic Definitions

- Raster: A rectangular array of points or dots.
- Pixel (Pel): One dot or picture element of the raster
- Scan Line: A row of pixels

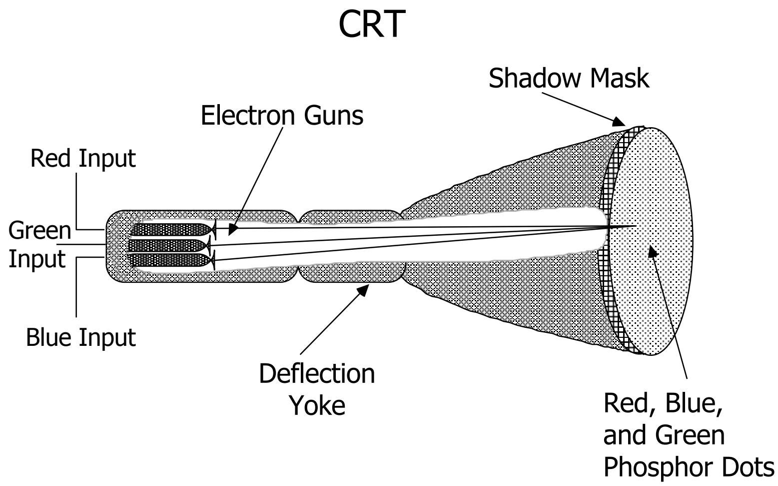


Example Raster Graphics Architecture

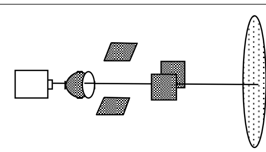


Raster system architecture with a display processor.
(from Computer Graphics: Principles and Practice.)

CRT Monitor



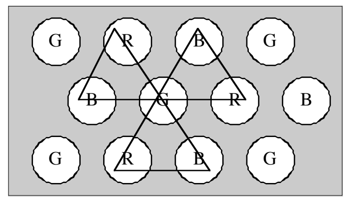
Electron Gun



- Stream of electrons directed to front
  - Num electrons controls brightness
- Phosphor, glows briefly
- Gaussian distribution of electrons, light

Color CRT

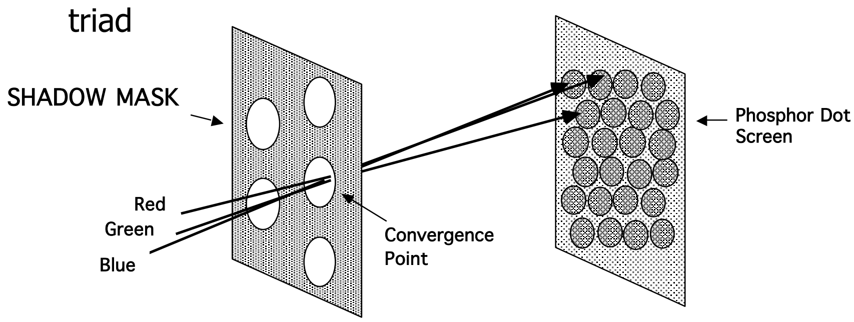
- RGB electron guns
- Screen coated with phosphor pattern



- Fluorescence
- Phosphorescence
- Persistence

Shadow Mask

- Phosphors arranged in triads
- Each triad has one R/G/B phosphor dot
- Typically 2.3 to 2.5 triads per pixel
- Shadow mask has one small hole for each phosphor triad

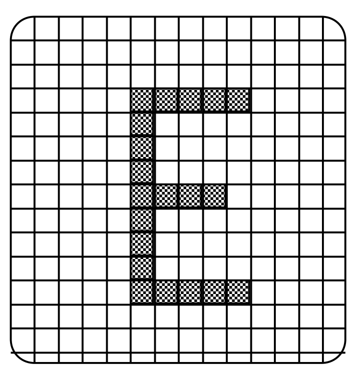


Aperture Grill

- i.e. Sony Trinitron
- Phosphors arranged in vertical stripes
- Shadow mask is a vertical "grill"

Scanning An Image

- Frame: image to be scanned on CRT
- Frame must be "refreshed" to eliminate flicker in the image.
- Critical Fusion Frequency
  - Typically 60 times/sec for raster displays
  - Varies with intensity, individuals, phosphor persistence, lighting, …

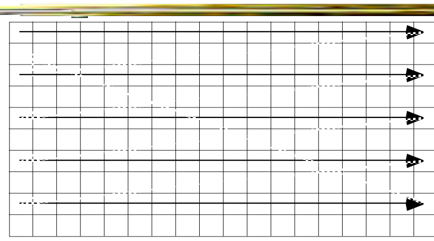


Interlaced Scanning

- Assume can only scan 30 times/sec
- To reduce flicker, divide frame into two "fields" (odd and even lines)

1/30 SEC		1/30 SEC	
1/60 SEC	1/60 SEC	1/60 SEC	1/60 SEC
FIELD 1	FIELD 2	FIELD 1	FIELD 2
FRAME		FRAME	

Scanning



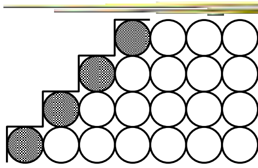
VERTICAL SYNC PULSE **— Signals the start of the next field.**

VERTICAL RETRACE **— Time needed to get from the bottom of the current field to the top of the next field.**

HORIZONTAL SYNC PULSE **— Signals the start of the new scan line.**

HORIZONTAL RETRACE **— Time needed to get from the end of the current scan line to the start of the next scan line.**

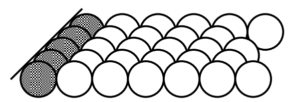
Resolution and Addressability



Resolution = Addressability

Resolution is a measure of the width of a single line drawn on the CRT screen (1/spotsize). Usually stated as the number of just merged lines per inch or centimeter.

Addressability is a measure of the spacing between the centers of those lines.



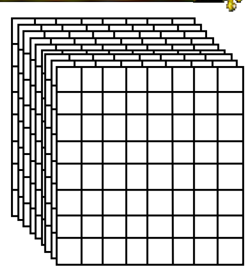
Resolution < Addressability

Smooths out the "jaggies" but the overlap will cause filled areas to be brighter than lines, and lines to be brighter than single pixels.

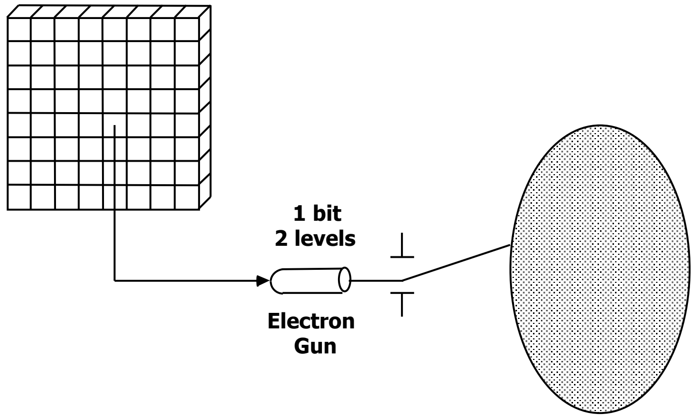
(Everybody, incorrectly, uses **resolution** when they mean **addressability**.)

Frame Buffers

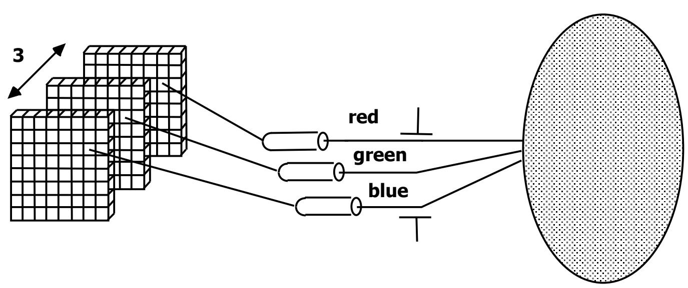
- 2D array
  - each (x,y) location = a pixel
- *Bit Planes, Bit Depth*
  - number of bits in a pixel
- Typical frame buffers:
  - 640 x 480 x 8
  - 1280 x 1024 x 8
  - 1280 x 1024 x 24



1-Bit = Monochrome Display (Bit-map Display)



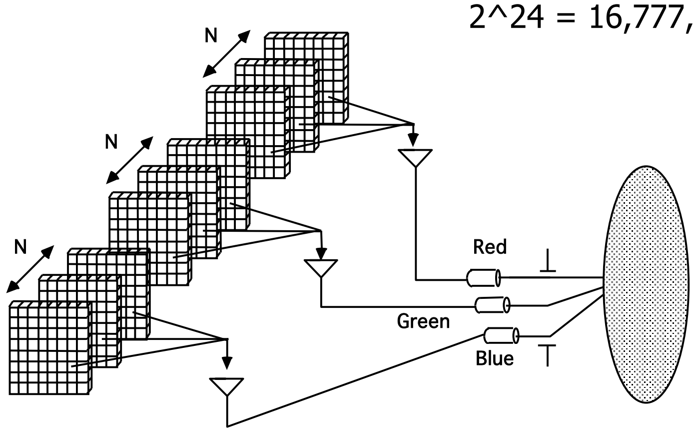
3-Bit Color Display



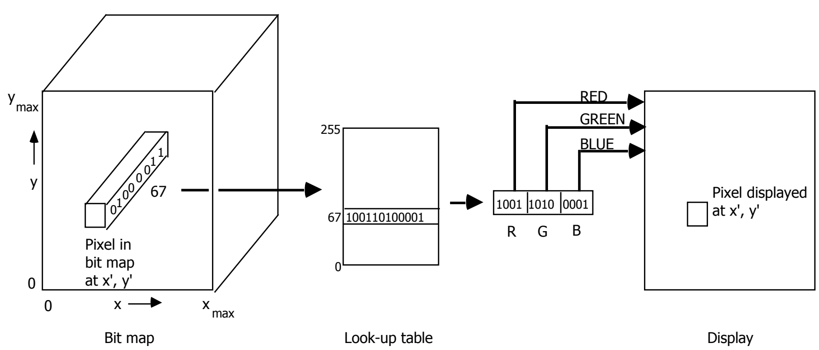
COLOR:	black	red	green	blue	yellow	cyan	magenta	white
R	0	1	0	0	1	0	1	1
G	0	0	1	0	1	1	0	1
B	0	0	0	1	0	1	1	1

True Color Display
24 bitplanes, 8 bits R/G/B

2^24 = 16,777,216

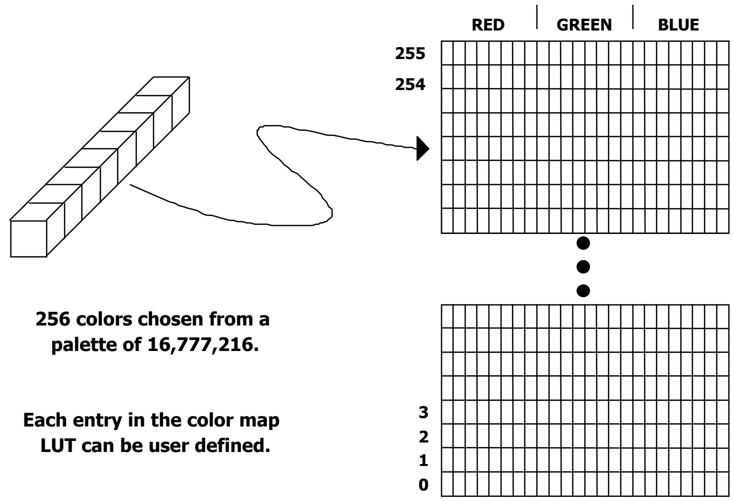


Color Map Look-Up Tables



LUT Video look-up table organization. A pixel with value 67 (binary 01000011) is displayed on the screen with the red electron gun at 9/15 of maximum, green at 10/15, and blue at 1/15. This look-up table is shown with 12 bits per entry. Up to 24 bits per entry are common.

Pseudo Color: 2^8 x 24 Color Map LUT



256 colors chosen from a palette of 16,777,216.

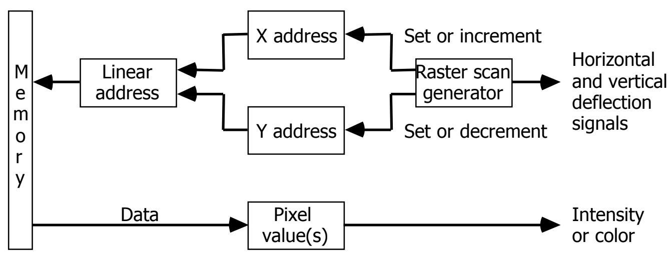
Each entry in the color map LUT can be user defined.

Display Processor

- Specialized hardware
  - i.e. scan converts primitives into frame buffer
- Fundamental difference between graphics systems
  - work done by display processor vs. CPU

Video Controller

- Cycles through frame buffer
  - FB contents used the control the electron beam intensity (color)



Input Hardware: Logical Devices

- Locator
  - position and/or orientation
- Keyboard
  - characters and strings
- Valuator
  - single values in the space of real numbers
- Choice
  - select from a set of actions or choices

Physical Device Examples

- Locator Devices
  - Tablet, mouse, trackball, touch panel, Light pen
- Keyboard devices
  - Alphanumeric keyboard (coded or unencoded)
- Valuator Devices
  - Rotary dials (bounded or unbounded), sliders
- Choice Devices
  - Function keys