CS174A Lecture 2

Announcements & Reminders

- 10/2: Assignment 1 due
- Syllabus updates: minor corrections, final exam date still TBD
- Canvas (BruinLearn) updates
  - Assignment #1 posted on Canvas
- Last date to add/drop without charges
- Last date to add courses without fee
- Last date to change to P/NP, with fee
  https://www.seasoasa.ucla.edu/deadlines-enrollment-policies-2/

TA Session This Week

- *Assignment #1*
- *Introduction to JavaScript, WebGL & tiny-graphics*
- *Grading criteria for projects: individual and team*
- *Intro to linear algebra and matrices*

Last Lecture Recap

- ***Intro to Computer Graphics***
  - Applications
  - History
  - First few animated games, interactivity
- ***Examples of 3D animated movies***
  - Realism
  - Special effects
  - Compositing
  - Cartoons

Last Lecture Recap (contd.)

- ***Areas***
  - Flight simulation
  - CAD
  - Modeling with clay
  - Scientific visualization
  - Architectural visualization
  - Information visualization
  - Art, texture mapping

Last Lecture Recap (contd.)

- ***Elements of CG***
  - **Modeling**: points, lines, polygons, curves, surfaces, voxels, plant, smoke, cloth
  - **Rendering**: 3D scene, lights, point-of-view, shading, projection, visibility
  - **Animation**: key-frame, procedural, behavioral, physics-based, motion capture
  - **Interaction**: gaming, VR

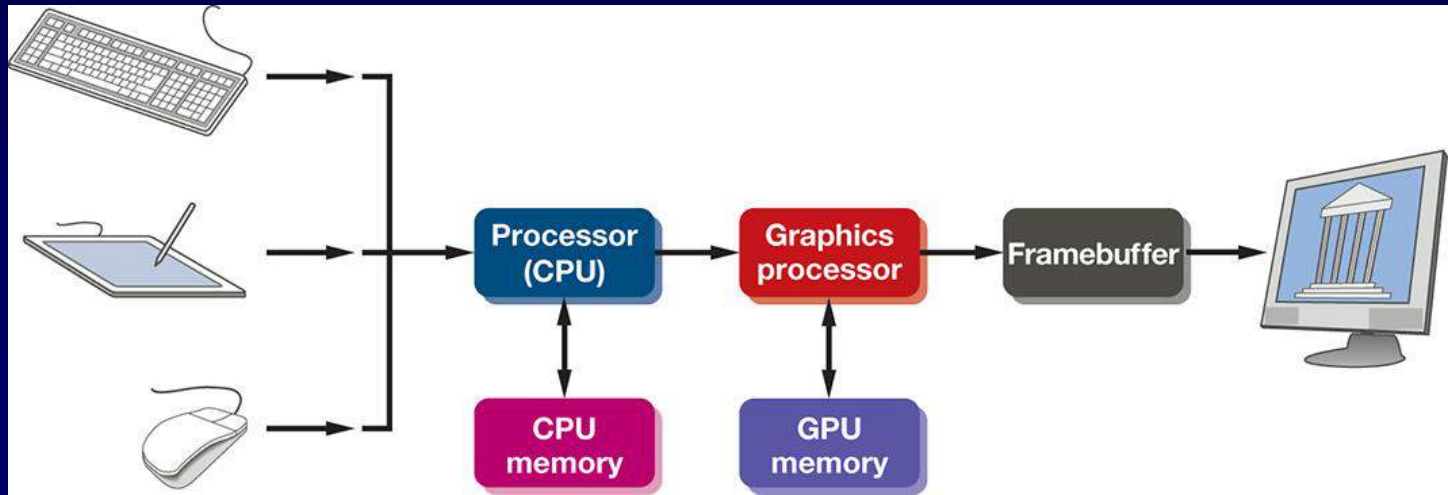
A Basic Graphics System

Input devices

CPU vs. GPU

Computing & rendering system

Output devices



Input Devices

Keyboard

Mouse

Game controller

Tablet & Pen

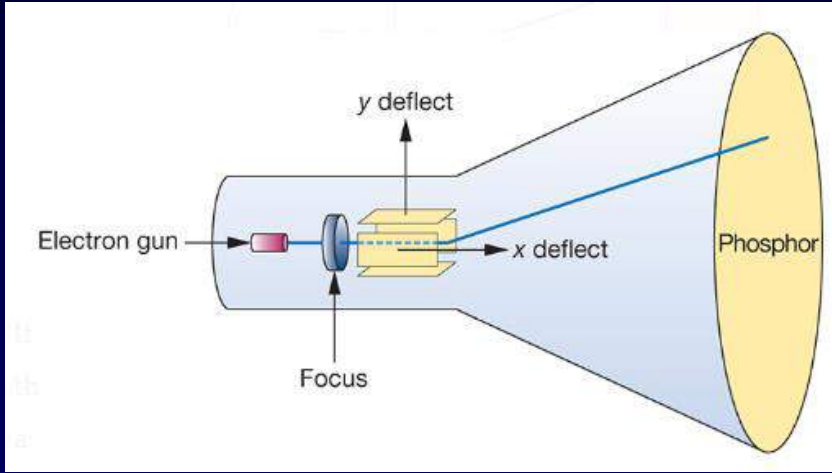
Other sensors

- *Data glove*
- *Sound*
- *Gesture*
- *Etc.*

Output Devices

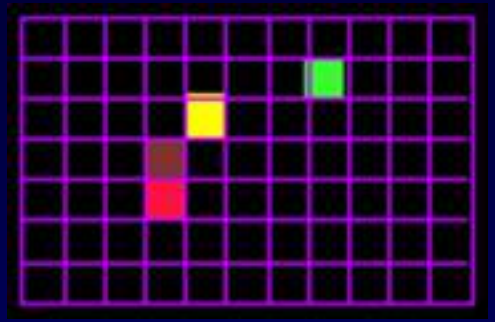
CRT (Cathode Ray Tube)

- Electrons strike Phosphor coating and emits light
- Direction of beam controlled by deflection plates
- Random-scan, calligraphic or vector CRT
- Moving beam to new location
- Refresh rate: 60 Hz – 85 Hz

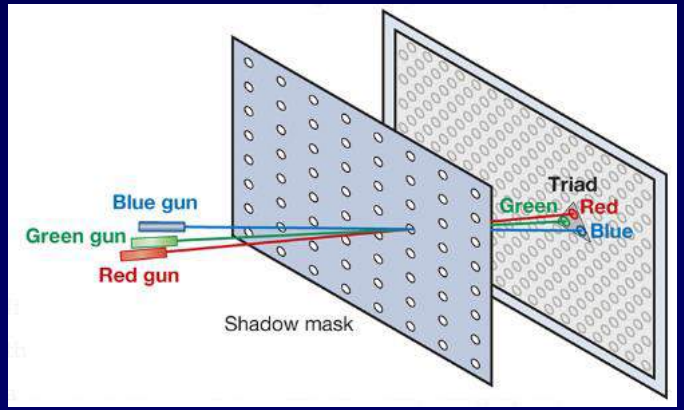


Output Devices (Contd.)

Raster CRTs (n x m phosphor)



- Framebuffer Depth
  - *1 bit: 2 levels only, b/w*
  - *8 bits: gray scale, 256 gray levels or colors*
  - *8 bits per color (RGB) = 24 bits = 16M colors*
  - *12 bits per color: HD*
- 3 different colored Phosphors: triads
- Shadow mask
- Interlaced vs. Non-Interlaced displays
- Interlaced: used in commercial TV
- Single vs. double buffering



Output Devices (Contd.)

Screen Resolutions of Raster CRTs (n x m phosphor)

- TV: 640x480 pixels
- HD: 1920x1080
- 4K LCD: 3840x2160
- 35mm: 3000x2000

How a TV works in slow motion:
https://youtu.be/3BJU2drrtCM?t=162

Output Devices (Contd.)

Memory Speed & Space Requirements

- Screen resolution = n x m
- Refresh rate = r Hz (frames/second)
- Interlaced vs. non-interlaced
- Color depth = b bits/pixel

Memory space per second = (n * m * b * r) / 8 bytes

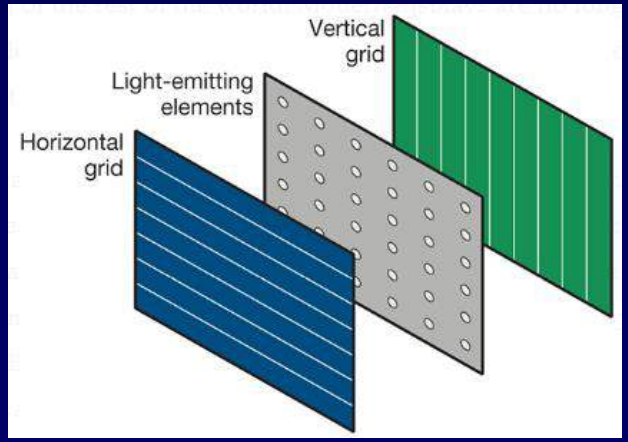
If non-interlaced, memory read time = 1 / (n * m * r) secs/pixel

If interlaced, memory read time = 2 / (n * m * r) secs/pixel

Output Devices (Contd.)

Flat Screen Displays

- **Raster Based**: active matrix with transistors at grid points
- **LEDs**: light emitting diodes
- **LCDs**: polarization of liquid crystals
- **Plasma**: energize gases to glow plasma



Output Devices (Contd.)

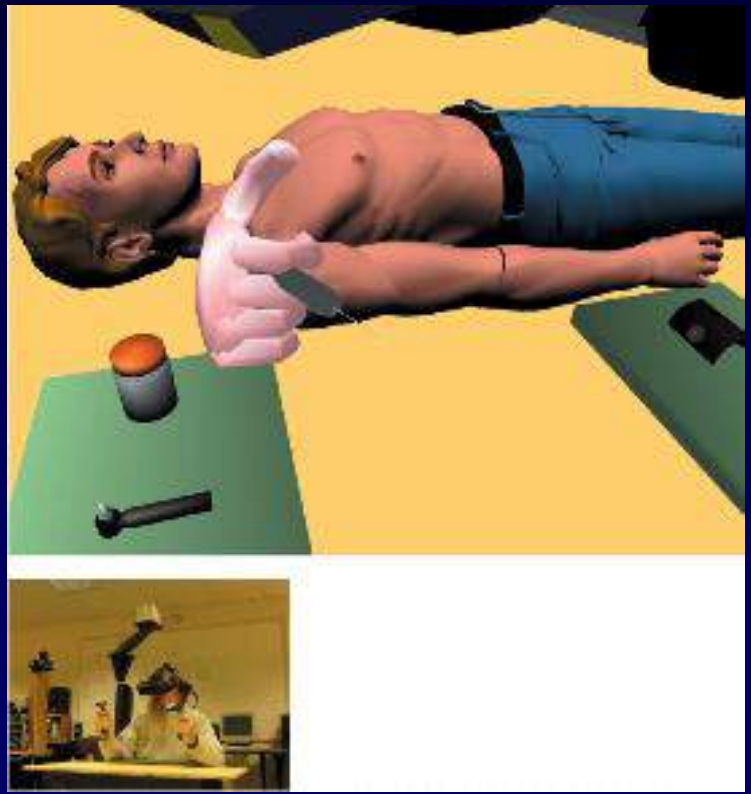
Other Output Devices

- Printers & Plotters: raster based, no refresh
- Stereo Displays: 3D TVs/movies, fast switching of left and right eye polarized images

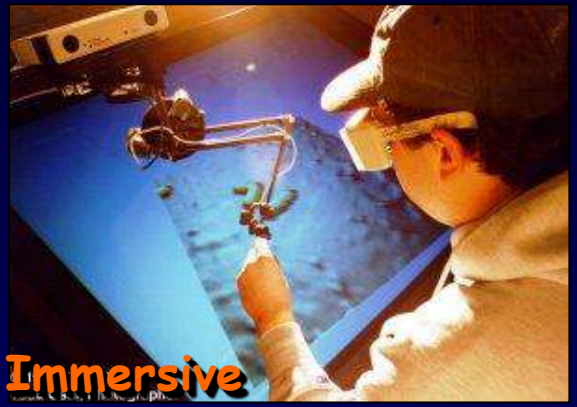
Output Devices (Contd.)

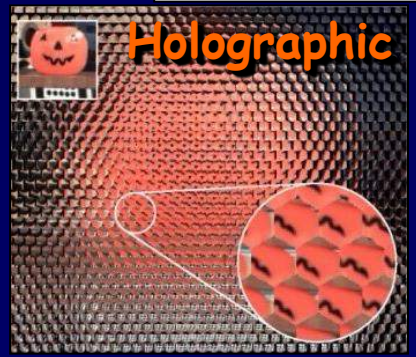
VR (Virtual Reality)

- Flat panel technology
- Stereoscopic
- Track body, finger, and head locations
- **Foveated Rendering**: hi-res where viewer is focusing, lo-res elsewhere
- Other input devices: force sensing gloves, sound



Exotic Display Devices





Anamorphic LED Displays

- ***Roaring Lion***
- ***Nike Ad***

Aliasing in Raster Displays

Aliasing

- **Lines**
- **Polygons**

Reasons for Aliasing

- **Location of pixels are fixed**
- **Size of pixels are fixed**

SIGGRAPH 2018 Research Trailers

May 2018:

https://www.youtube.com/watch?v=t952yS8tcg8

November 2018:

https://www.youtube.com/watch?v=wdKpXvF_3AU

SIGGRAPH 2017 Research Trailers

May 2017:

https://www.youtube.com/watch?v=3OGKh_9Rj_8

November 2017:

https://www.youtube.com/watch?v=5YvIHREdVX4

Industry Hacks

New Powerful Visual Effect tool for 3ds Max: tyFlow
https://www.youtube.com/watch?v=ct3vWWl86f8

- Tools packaged with production software suites
- Video does not claim to use any math that converges to real-life physics formulas
- Approximation is not convergence!

Linear Algebra Review

Linear Algebra:
The Algebra of Vectors and Matrices (and Scalars)

Vector spaces

Matrix algebra

Coordinate systems

Affine transformations

Vectors

N-tuple of scalar elements

$$\mathbf{v} = (x_1, x_2, \ldots, x_n), \quad x_i \in \Re$$

Vector:
Bold lower-case

Scalar:
Italic lower-case

Vectors

N-tuple:

$$\mathbf{v} = (x_1, x_2, \ldots, x_n), \quad x_i \in \Re$$

Magnitude:

$$|\mathbf{v}| = \sqrt{x_1^2 + \ldots + x_n^2}$$

Unit vectors

$$\mathbf{v} : |\mathbf{v}| = 1$$

Normalizing a vector

$$\hat{\mathbf{v}} = \frac{\mathbf{v}}{|\mathbf{v}|}$$

Operations with Vectors

Addition

$$\mathbf{x} + \mathbf{y} = (x_1 + y_1, \ldots, x_n + y_n)$$

Multiplication with scalar (scaling)

$$a\mathbf{x} = (ax_1, \ldots, ax_n), \quad a \in \Re$$

Properties

$$\mathbf{u} + \mathbf{v} = \mathbf{v} + \mathbf{u}$$

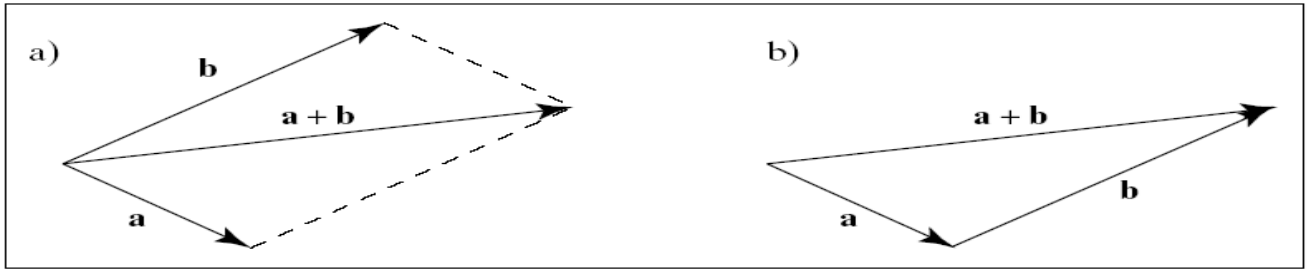
$$(\mathbf{u} + \mathbf{v}) + \mathbf{w} = \mathbf{u} + (\mathbf{v} + \mathbf{w})$$

$$a(\mathbf{u} + \mathbf{v}) = a\mathbf{u} + a\mathbf{v}, \quad a \in \Re$$

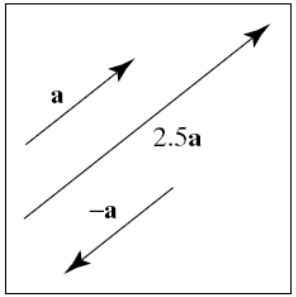
$$\mathbf{u} - \mathbf{u} = \mathbf{0}$$

Visualization of 2D and 3D Vectors

Addition

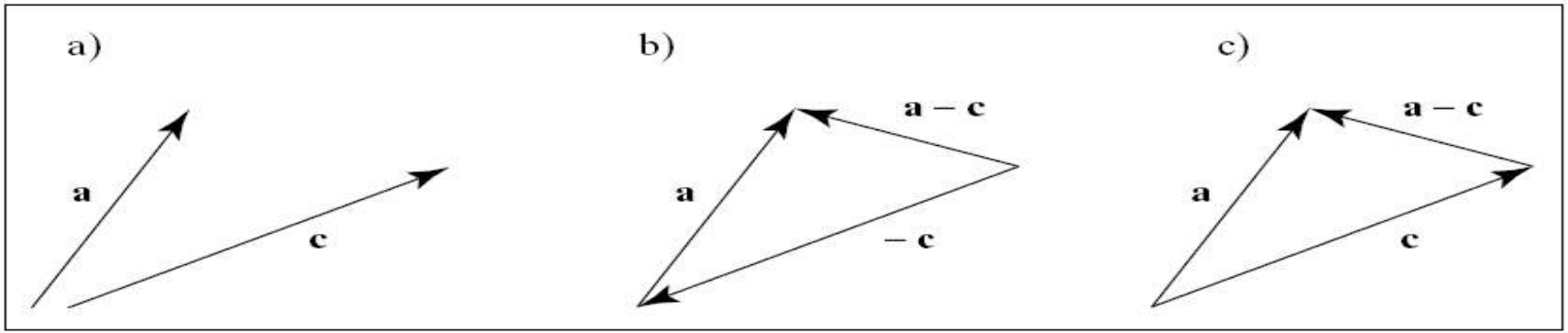


Scaling



Subtraction

Adding the negatively scaled vector



Linear Combination of Vectors

Definition

A linear combination of the m vectors $\mathbf{v}_1, \ldots, \mathbf{v}_m$ is a vector of the form:

$$\mathbf{w} = a_1\mathbf{v}_1 + \ldots + a_m\mathbf{v}_m, \qquad a_1, \ldots, a_m \text{ in } \mathbb{R}$$

Special Cases

Linear combination

$\mathbf{w} = a_1\mathbf{v}_1 + \ldots a_m\mathbf{v}_m, \qquad a_1, \ldots, a_m \text{ in } R$

Affine combination:

A linear combination for which $a_1 + \ldots + a_m = 1$

Convex combination

An affine combination for which $a_i \geq 0 \text{ for } i = 1, \ldots, m$

Linear Independence

For vectors $\mathbf{v}_1, \ldots, \mathbf{v}_m$

If $a_1\mathbf{v}_1 + \ldots + a_m\mathbf{v}_m = \mathbf{0}$ iff $a_1 = a_2 = \ldots = a_m = 0$

then the vectors are linearly independent