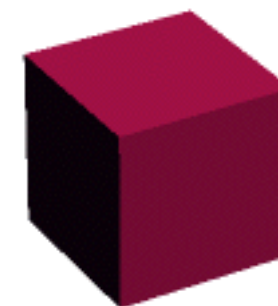
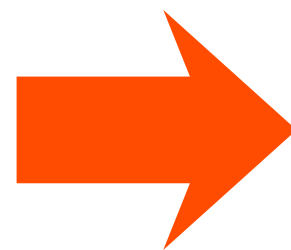




Computer Graphics:

Creating images from non-image data

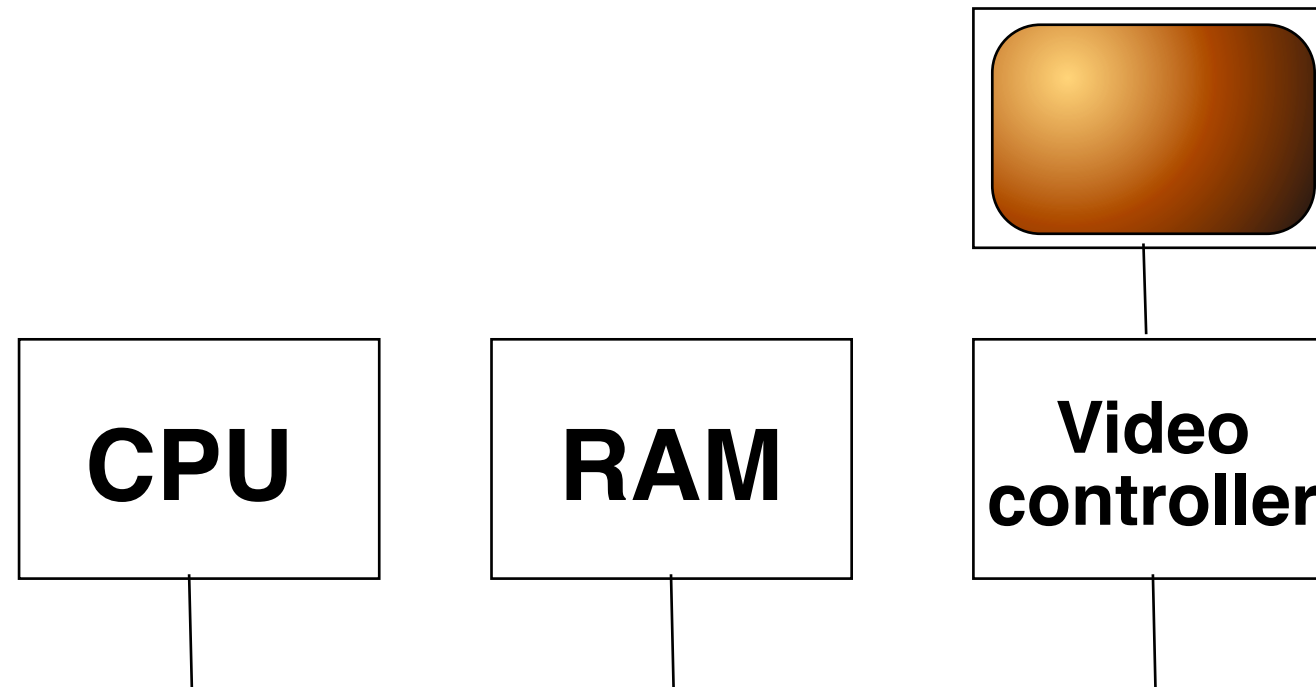
```
Cube =  
(10, 10, 10)  
(10, 10, 20)  
(10, 20, 10)  
(10, 20, 20)  
(20, 10, 10)  
(20, 10, 20)  
(20, 20, 10)  
(20, 20, 20)  
Camera =  
(80, 60, 60) (15,15,15)
```





Graphics systems

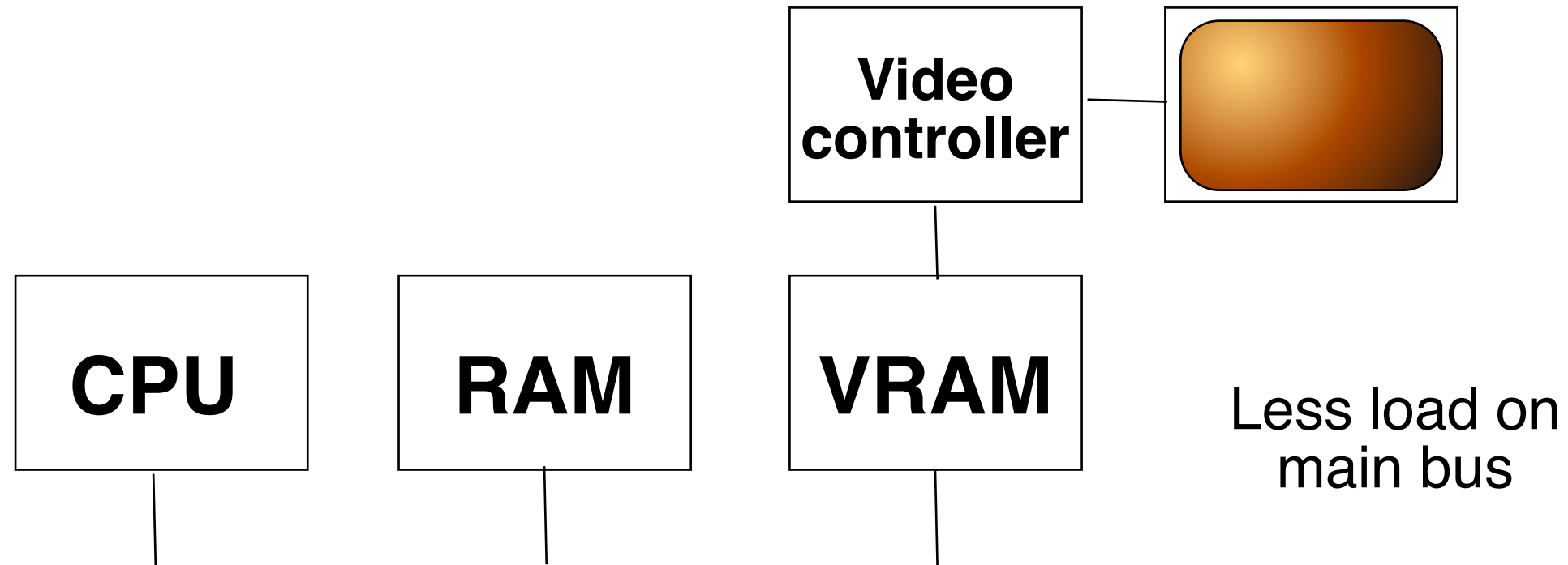
Simple system:





Graphics systems

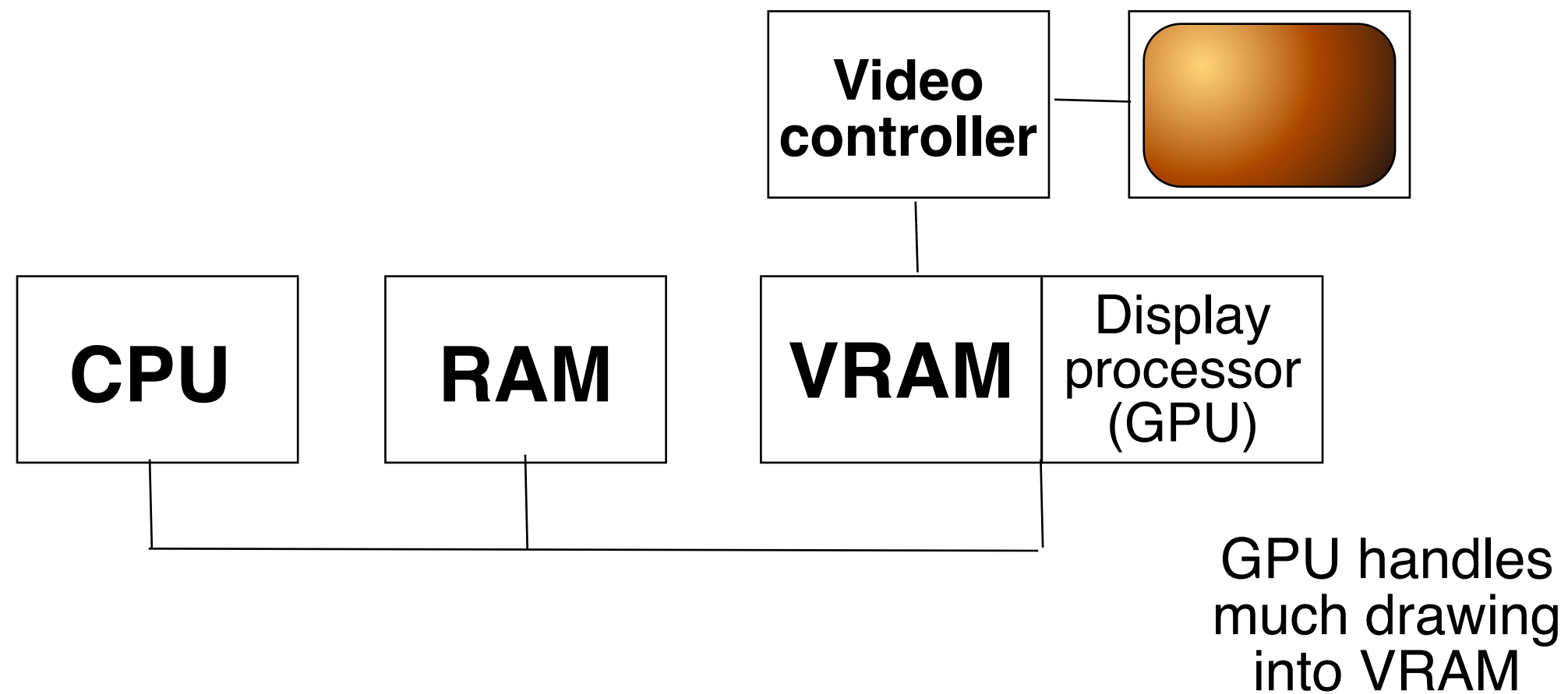
Better system:





Graphics systems

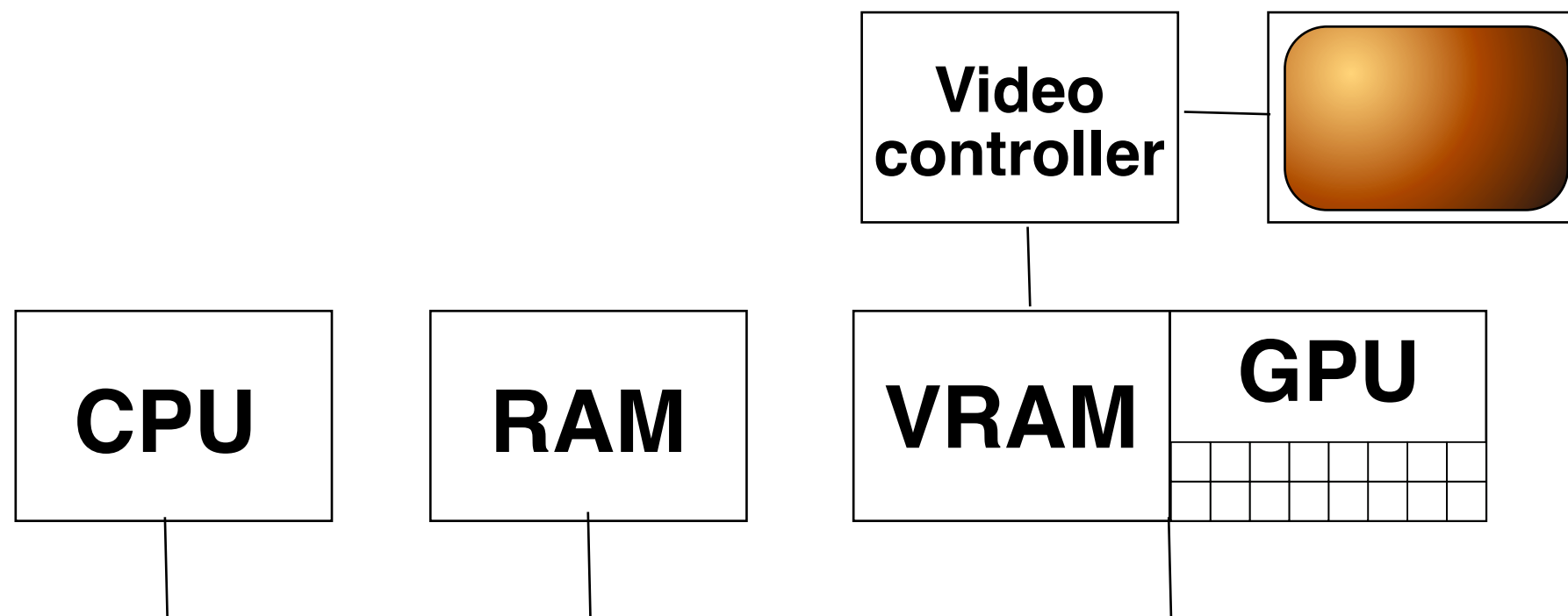
Even better system:





Graphics systems

Current system:



Multi-core,
programmable
GPU!



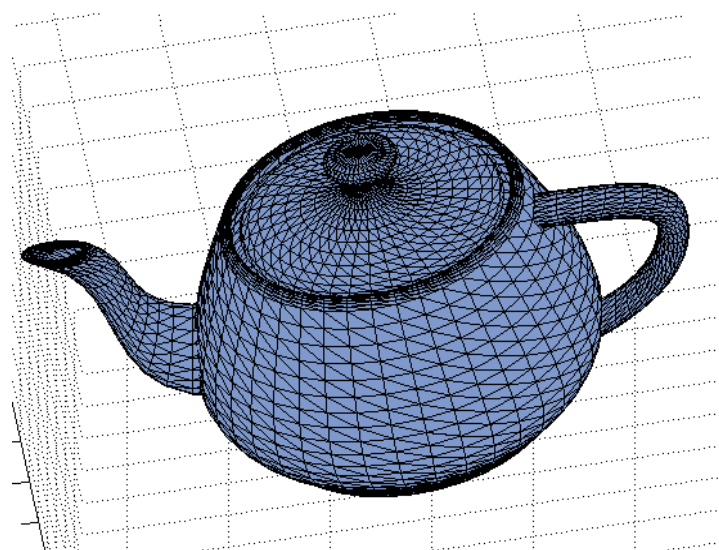
What is an image?



What is an image?

Array of pixels!

What is a pixel?



What is an image?

Array of pixels



What is a pixel?

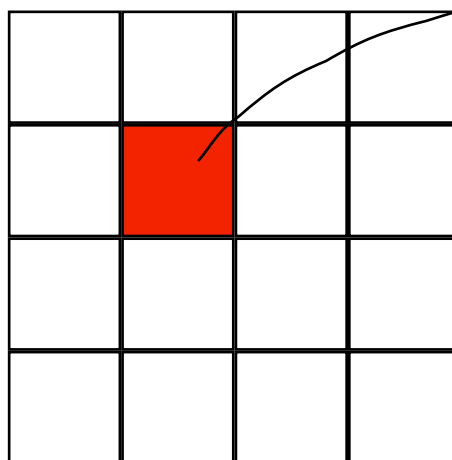
Picture element. Sample of a 2D signal.



Image = array of pixels?

Pixel = one chunk of memory (usually)

"Chunky pixels".



```
0ac807ffa0c860ff890102ff0c801d7fd0c90eff870b01ff5790s7ffe08730ff
4c7b94ff0s127eff741206ff6d562eff475665ff3e6141ff2121a2ff244d57ff
8c6c79ff8b7897ffd7e54aff4232e5ff4e6576ff789d78ff97d98cff798b78ff
97a987ffe56e67ff4563d4ffa675e3ff123112ffedleceff1490a7ff5ad8adff
987bc8ff9b98c6ff656745ff646769ff812912ff879632ff189101ff5010c0ff
```



How big chunk?

How many bits?

Pixel size	# of colors	Usage
1	2	Masks
2	4	?
4	16	?
8	256	Safe mode
16	Thousands	"High color"
24/32	Millions	"True color"
Up to 256	Billions	FP color



Information Coding / Computer Graphics, ISY, LiTH

What is **color**?



Colors

- beyond
Bamse

REMOVED FOR SAFETY



Experiments with inverse colors by a small child (me)



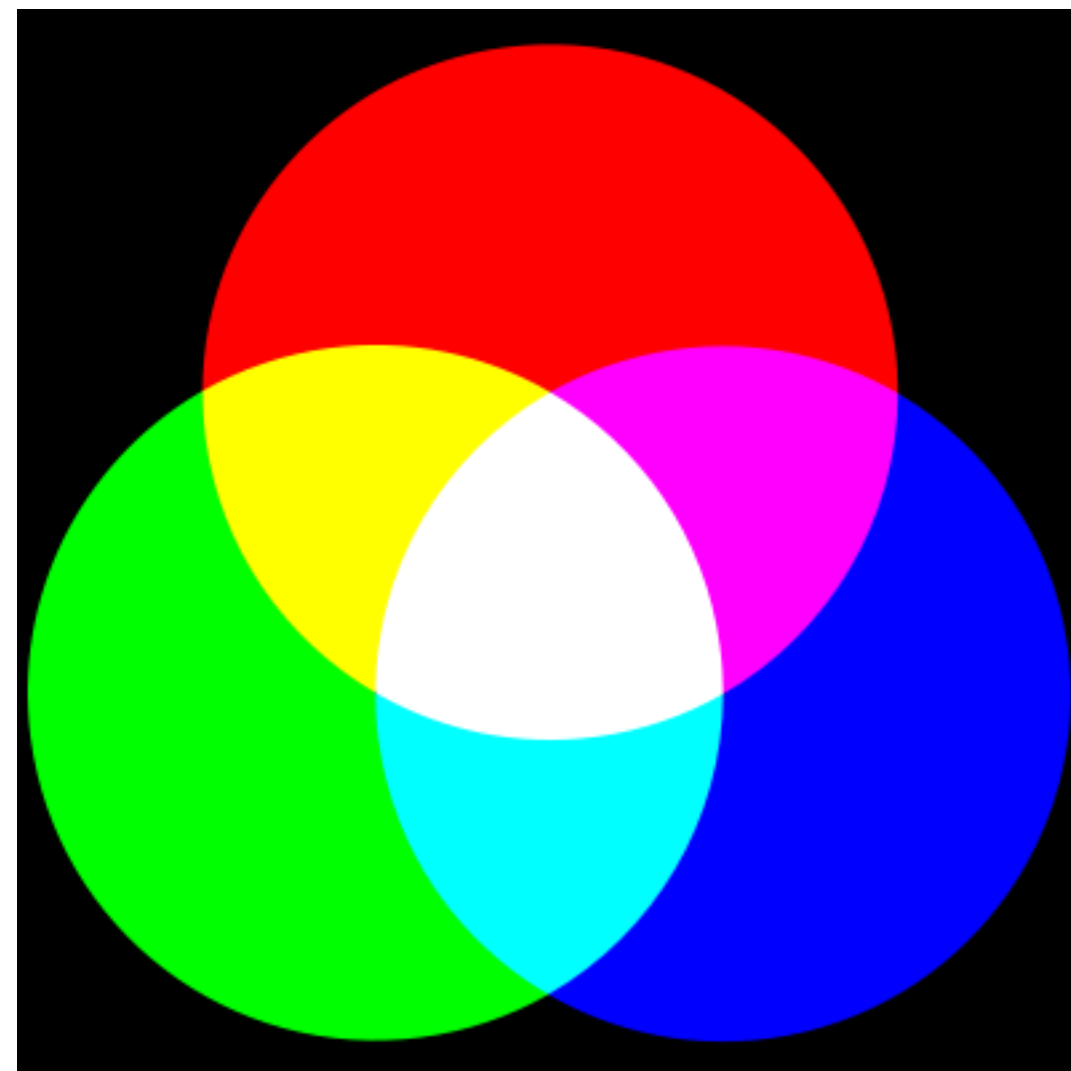


Additive colors

Red
Green
Blue

Corresponds to
receptors in the eye!

Used on color
displays



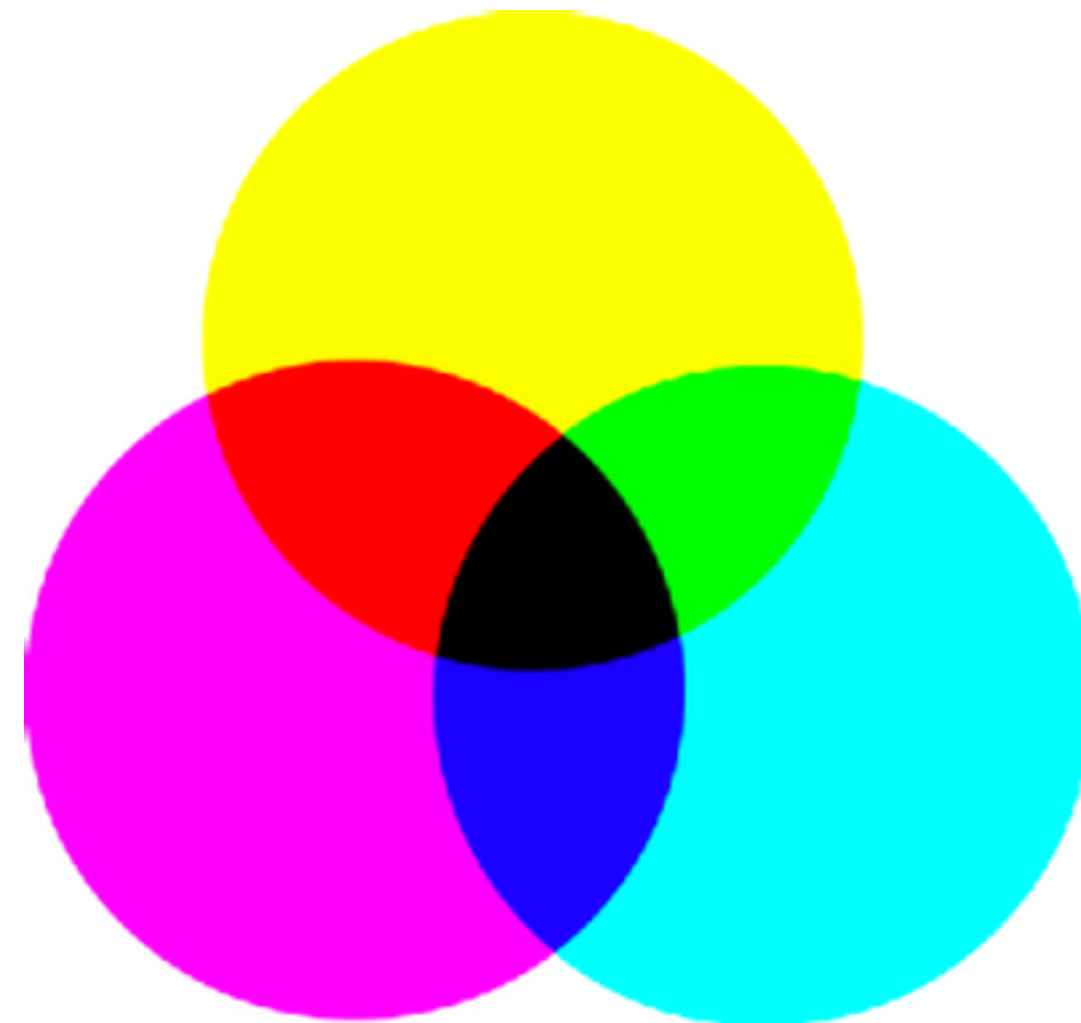


Subtractive colors

Cyan
Magenta
Yellow

Filters away primary
colors

Used in printers

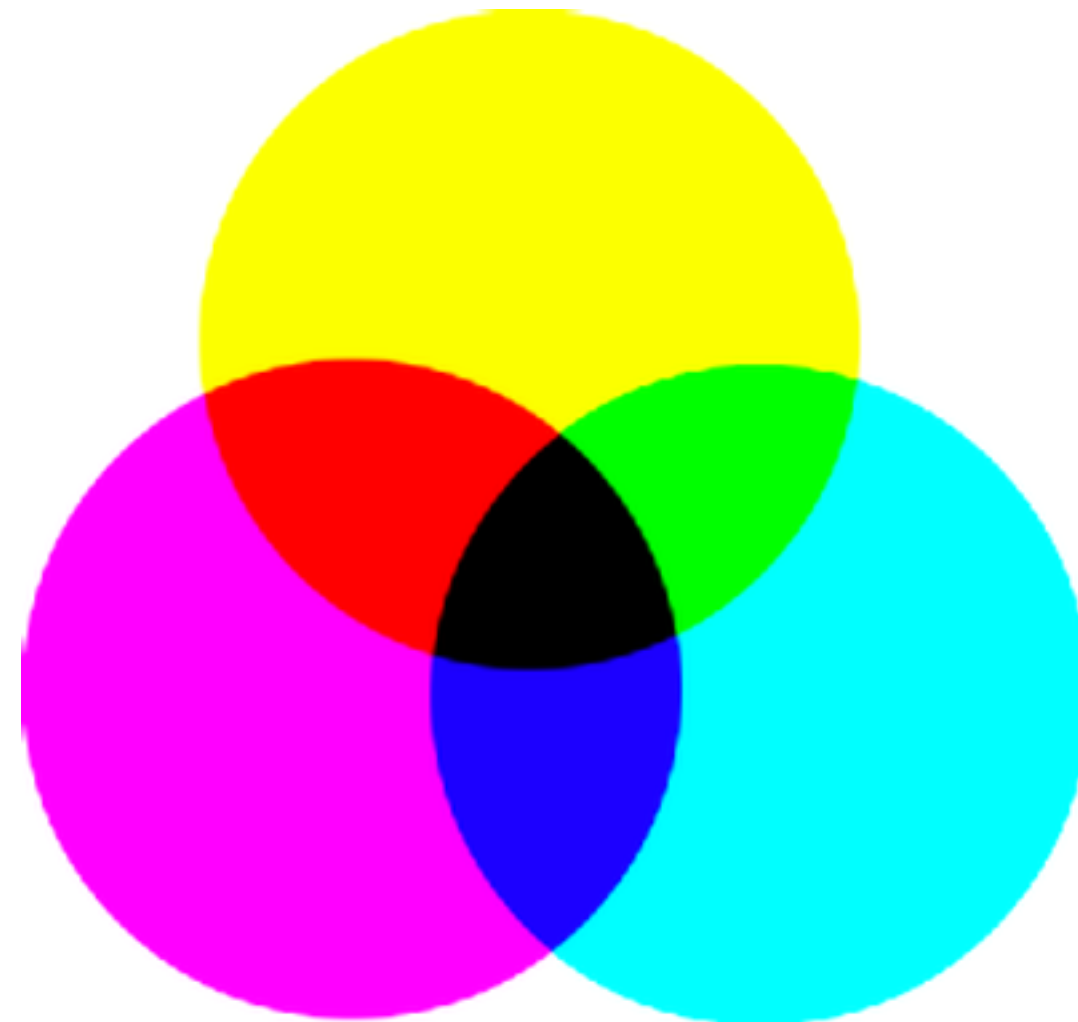




Subtractive colors

C+M+Y colors
usually not perfect
enough for a good
black!

Printers often use
CMYK = CMY plus
black!





Colors in pixel values

Example: 24-bit color



Typical: 8 bits per channel (256 shades)

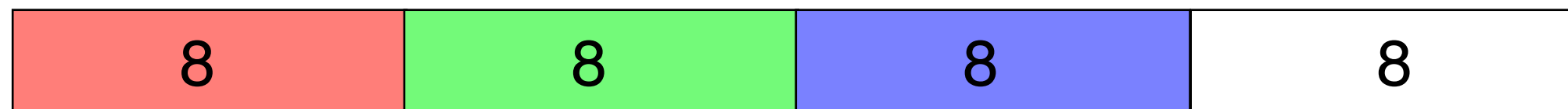


24-bit color

3 bytes per pixel bad for addressing efficiency!

Add fourth byte for getting a power of 2 size.
Good for memory access!

The fourth byte is often used for transparency -
the alpha channel = 32-bit



RGBA color!



Colors in pixel values

Example: 16-bit color

5	5	5	1
6	6	4	-

Note that a lower number of bits can be used for blue. Why?



More to say about colors

- XYZ color system
 - Eye physiology
- Receptor ranges and sensitivity
 - Perceptual issues

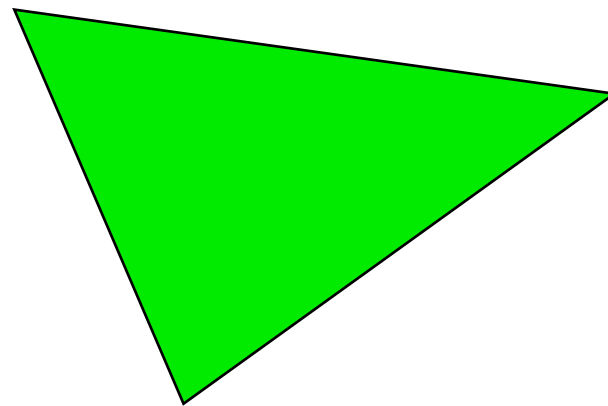
but this is enough for our purposes

The RGBA system is the important thing!



Computer graphics program:

- Main program on CPU
- Send primitives (e.g. triangles) to GPU
- Shaders, kernels on GPU





How do I code this?

Use the source, Luke!



Next time:

2D graphics

2D transformations

Algebra for computer graphics

Introduction to OpenGL