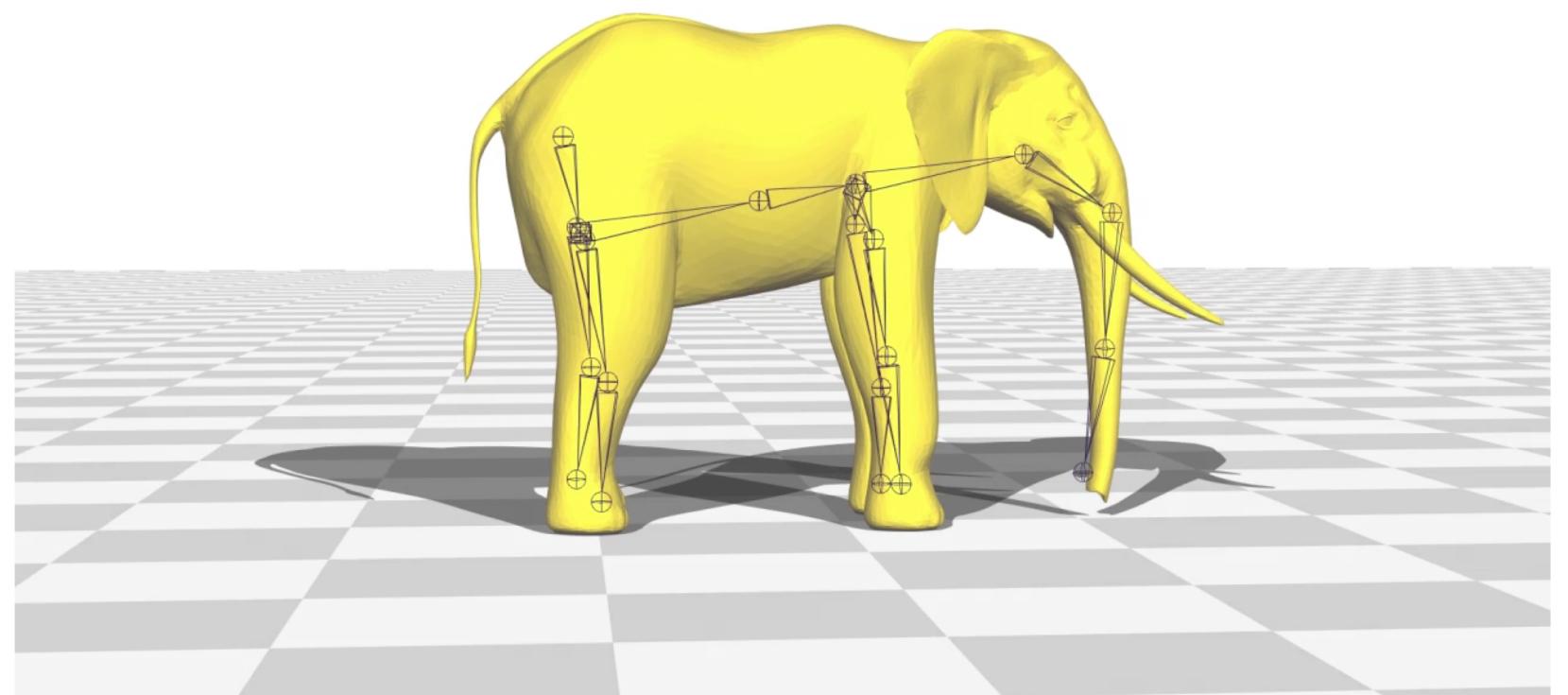
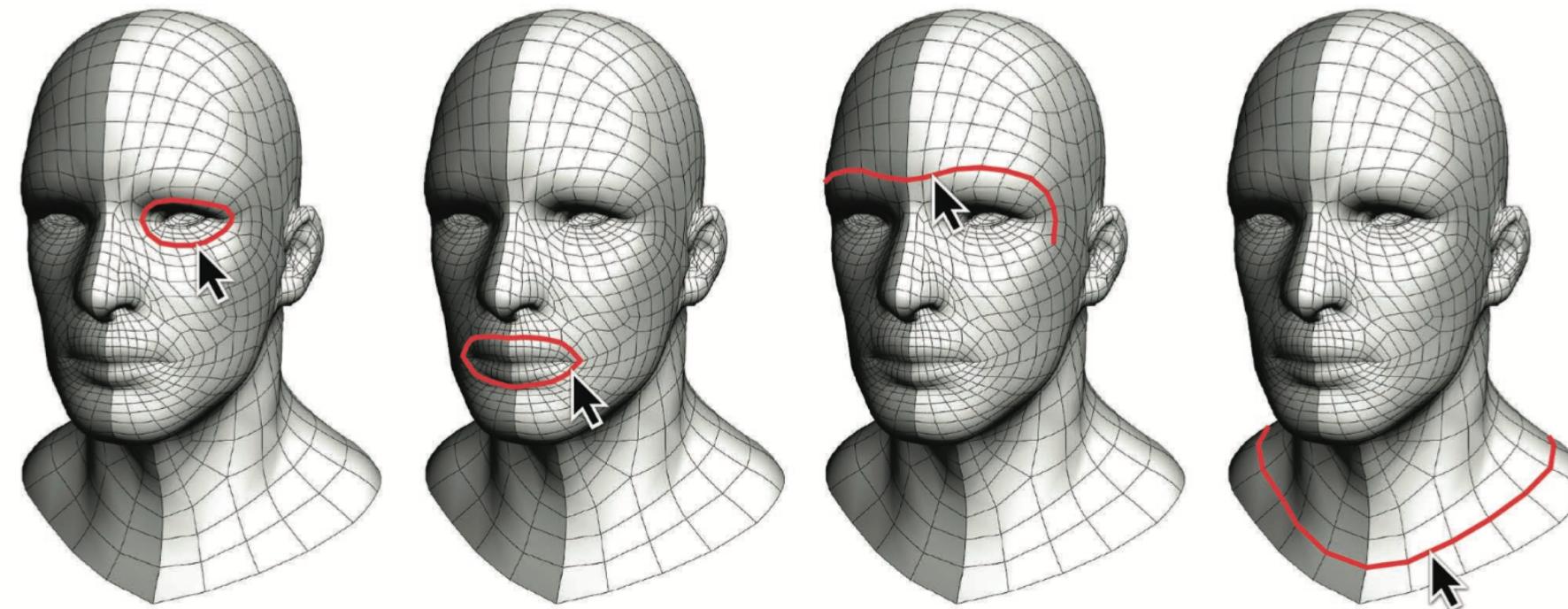
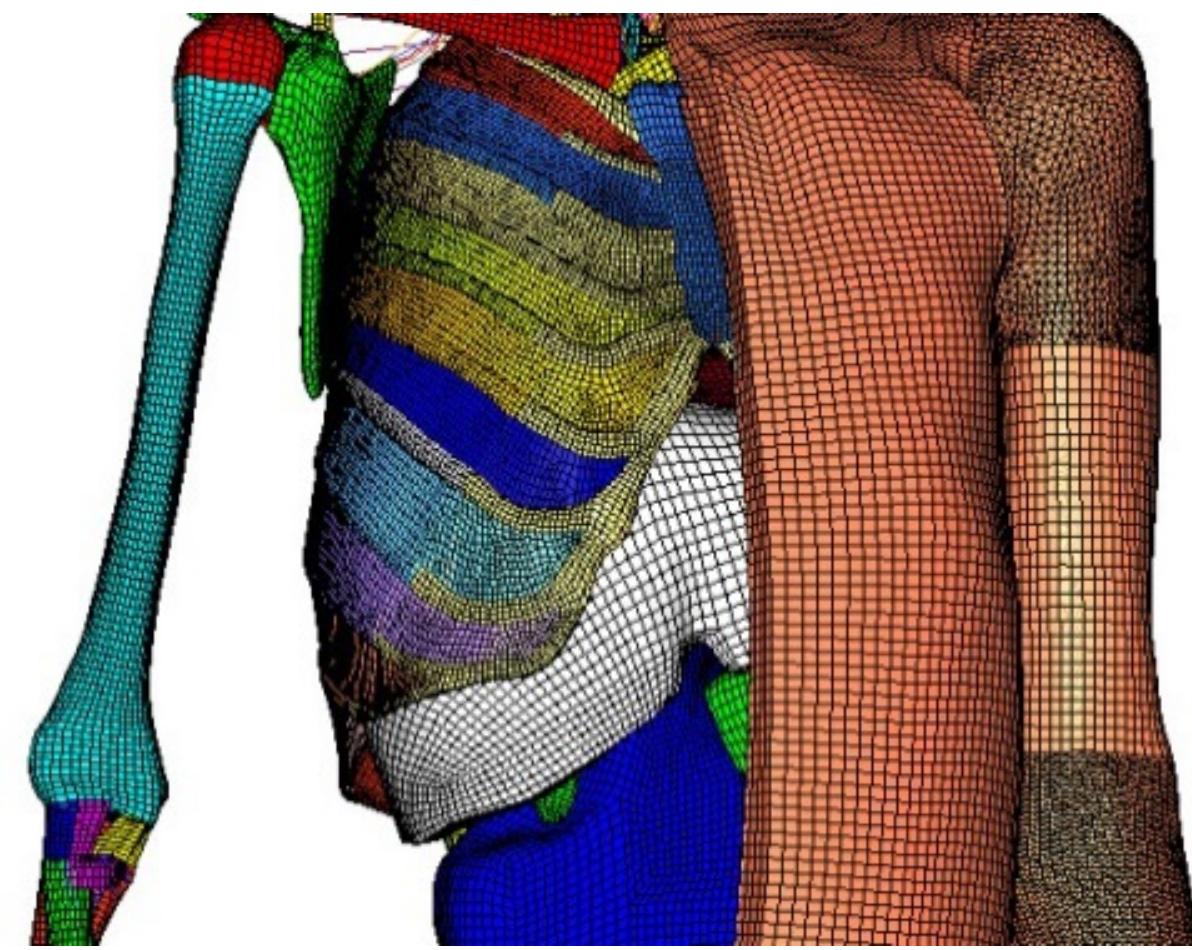
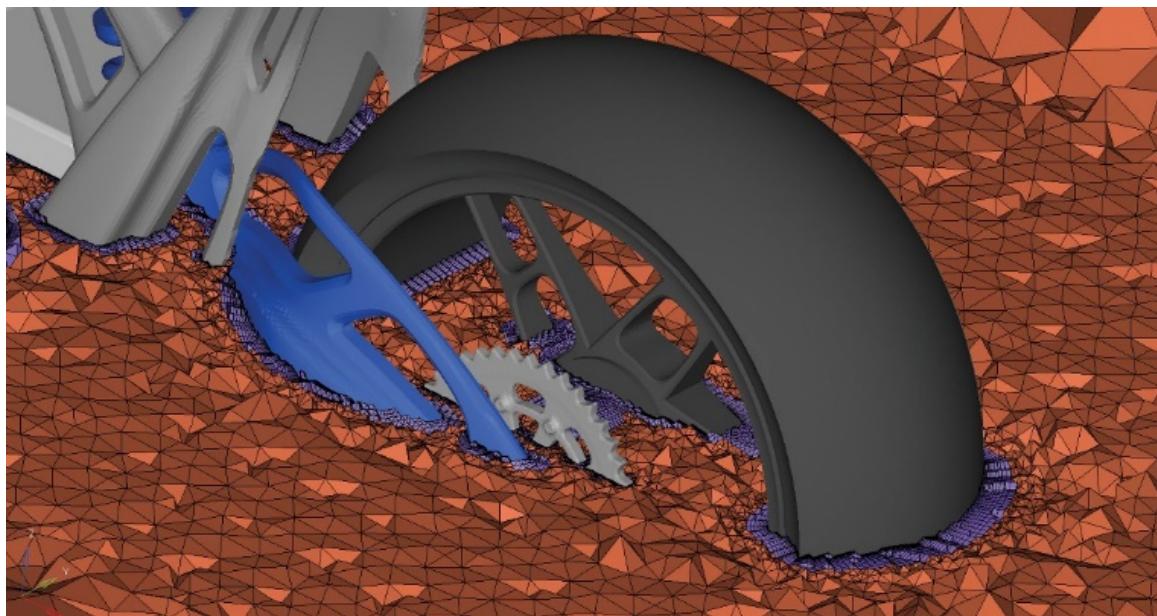
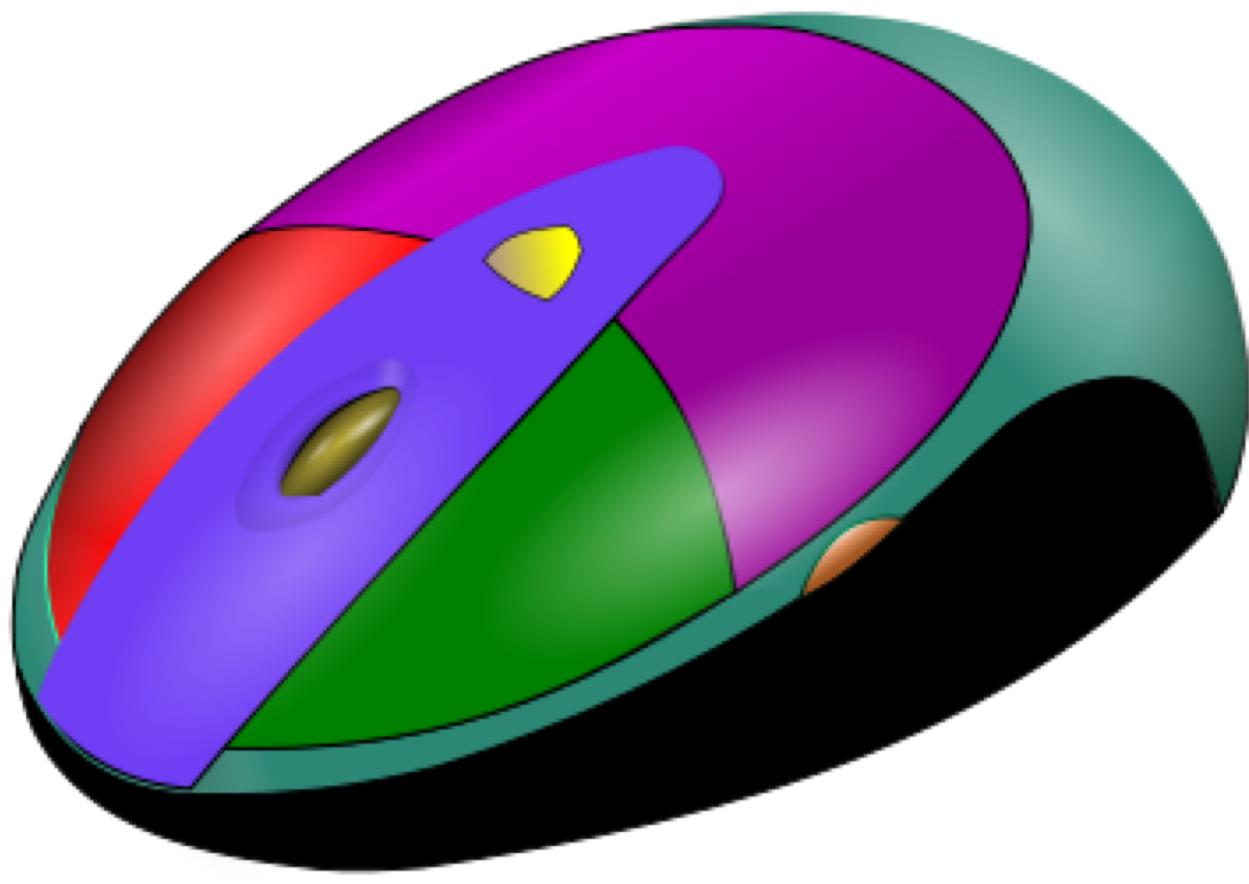


Recap: What is Computer Graphics?



Involves the creation and manipulation of 2D and 3D data

Recap: Why is Computer Graphics?



Basic Math

- Sets
- Functions/Maps
- Intervals
- Logarithm
- Solving Quadratic Equations
- Trigonometry
- Basic Linear Algebra
- Curves and Surfaces
- Linear Interpolation
- Triangles



Florida State University

Basic Math

- Sets
- Functions/Maps
- Intervals
- Logarithm
- Solving Quadratic Equations
- Trigonometry
- Basic Linear Algebra
- Curves and Surfaces
- Linear Interpolation
- Triangles

If you are not familiar with some of these topics,
refresh them before the next class!



Florida State University

What is an image?

- A 2D distribution of intensity or color
- A function defined on a two-dimensional plane,

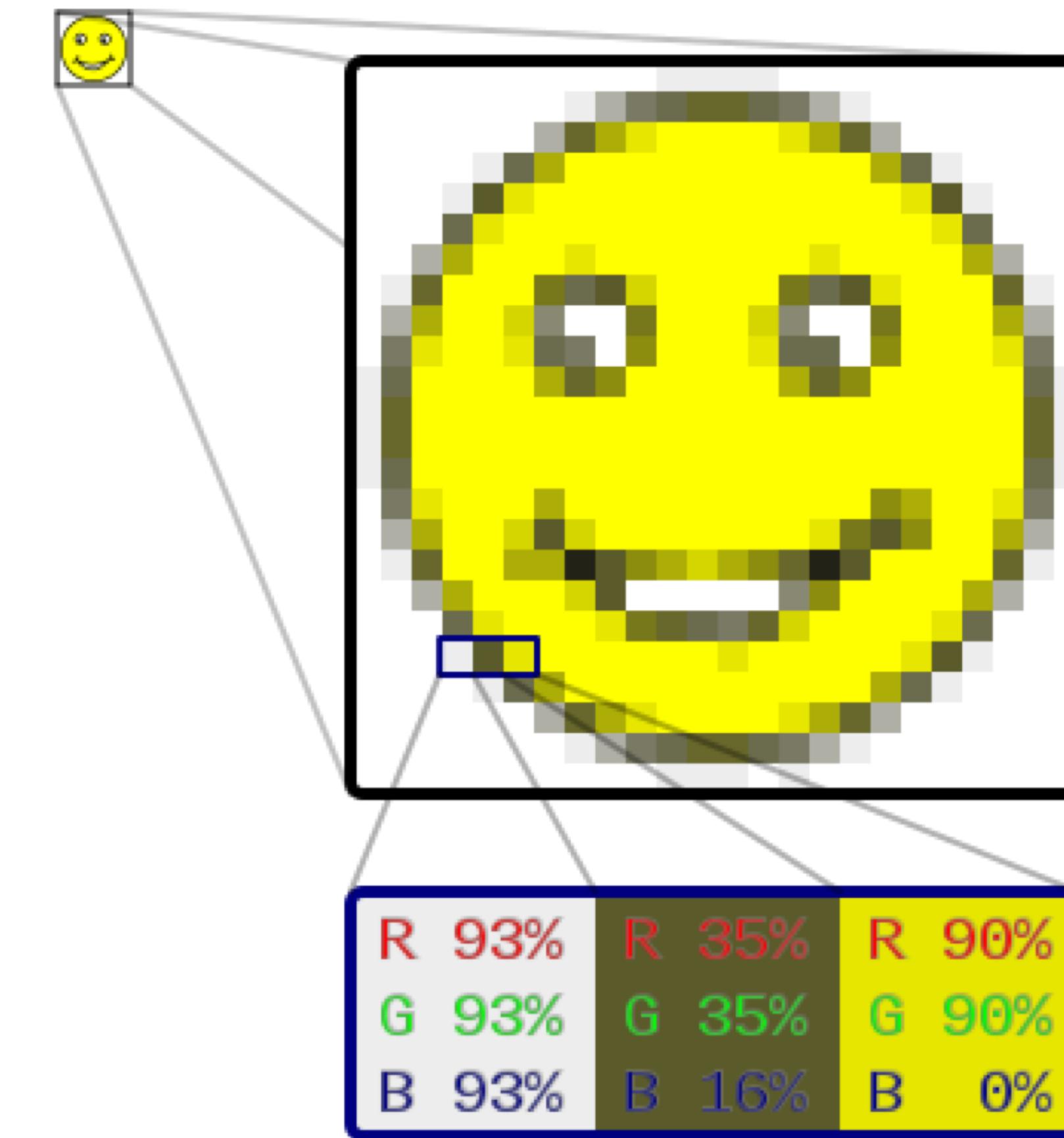
$$I: \mathbb{R}^2 \rightarrow V$$

- To do graphics,
 - represent images — encode them numerically
 - display images — realize them as actual intensity distributions



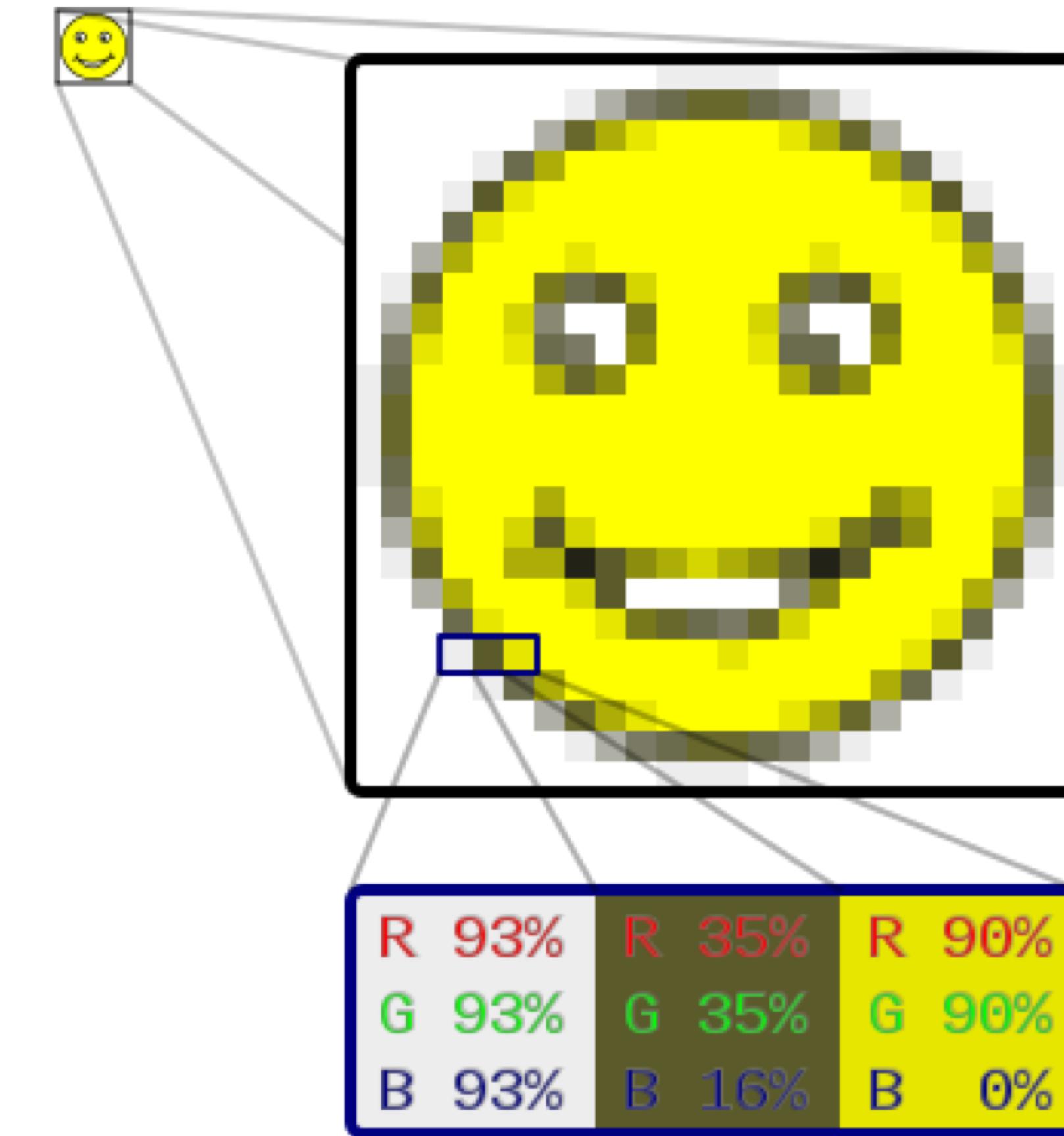
Florida State University

Raster Images

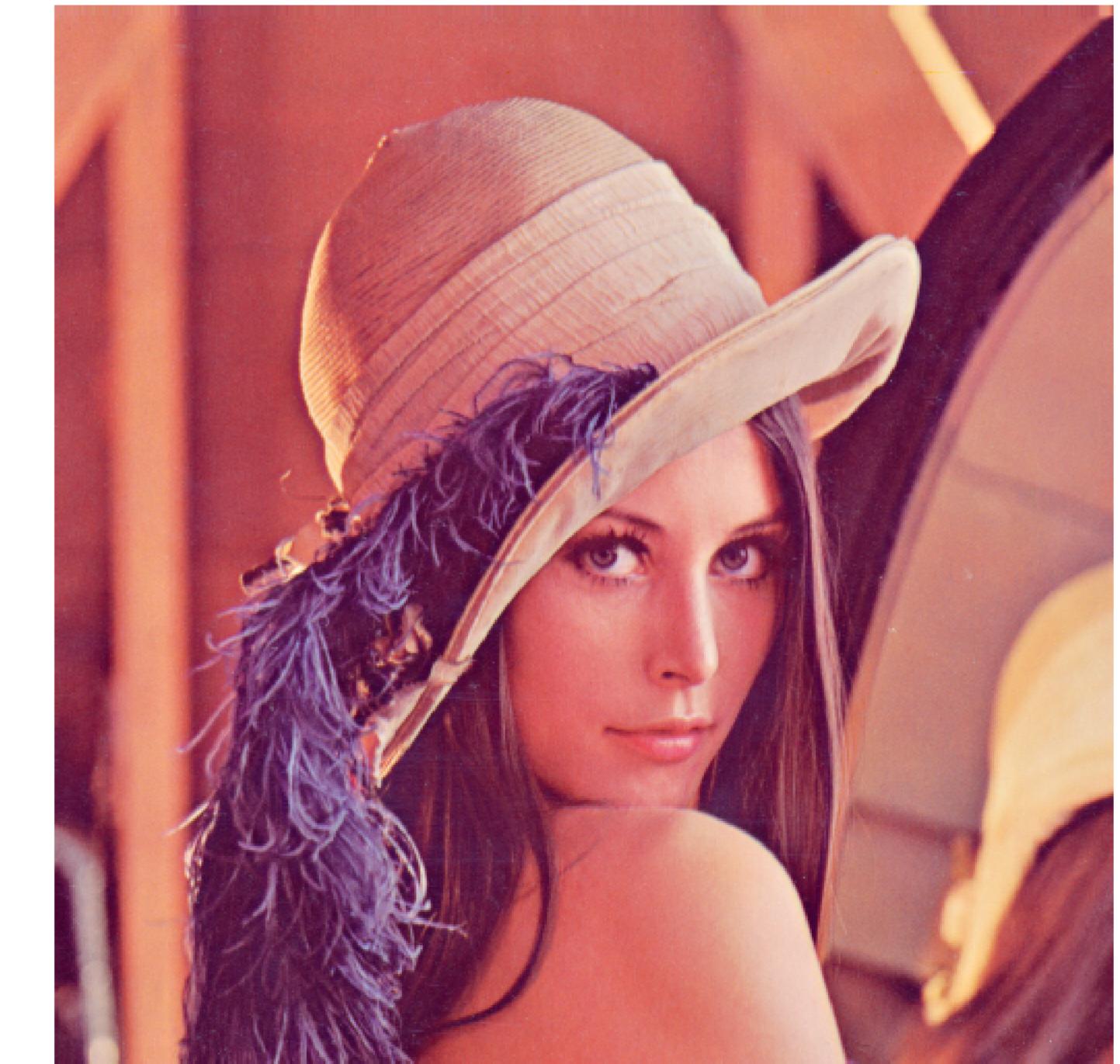
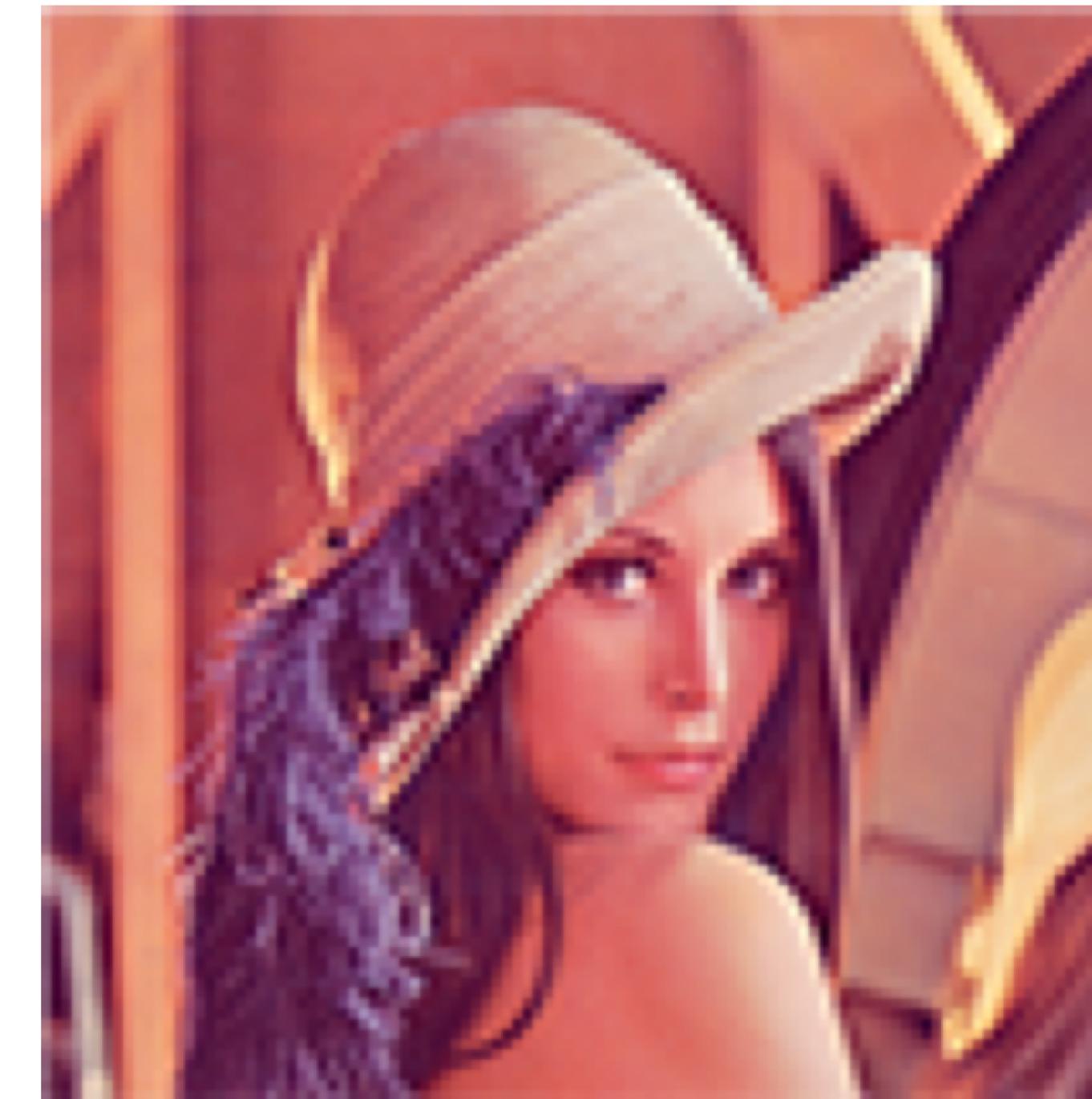
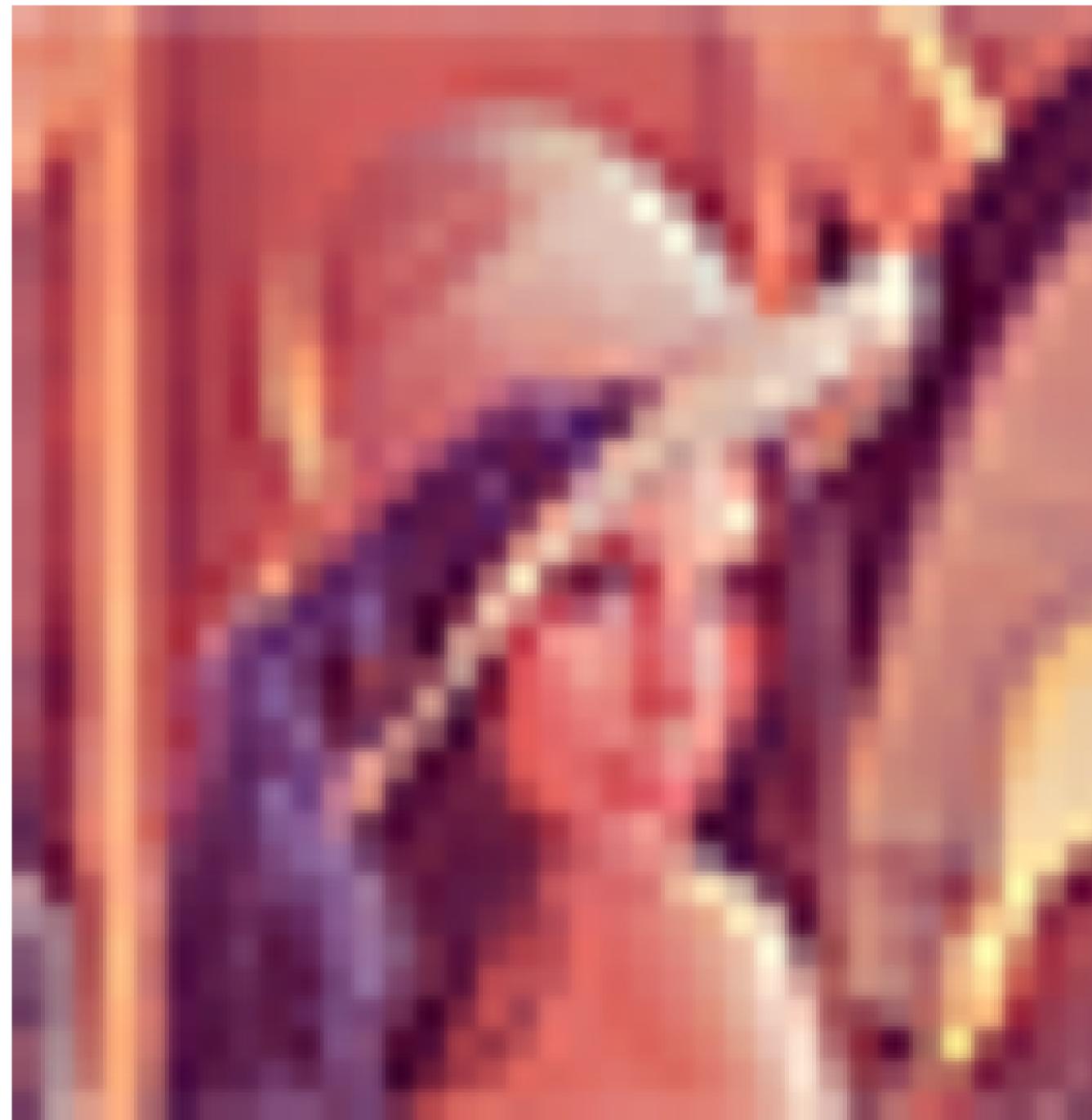


Florida State University

Raster Images

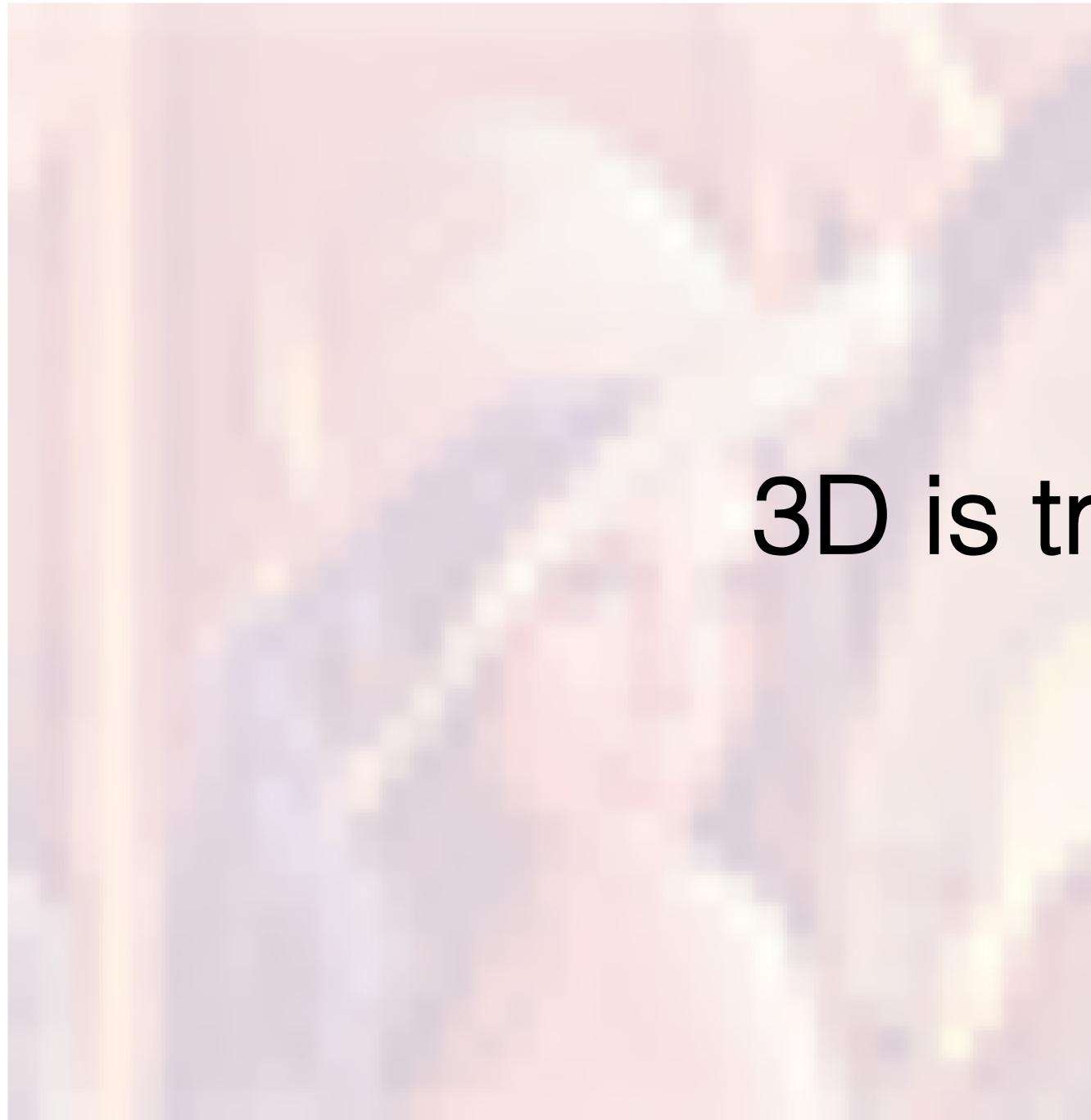


Raster Images

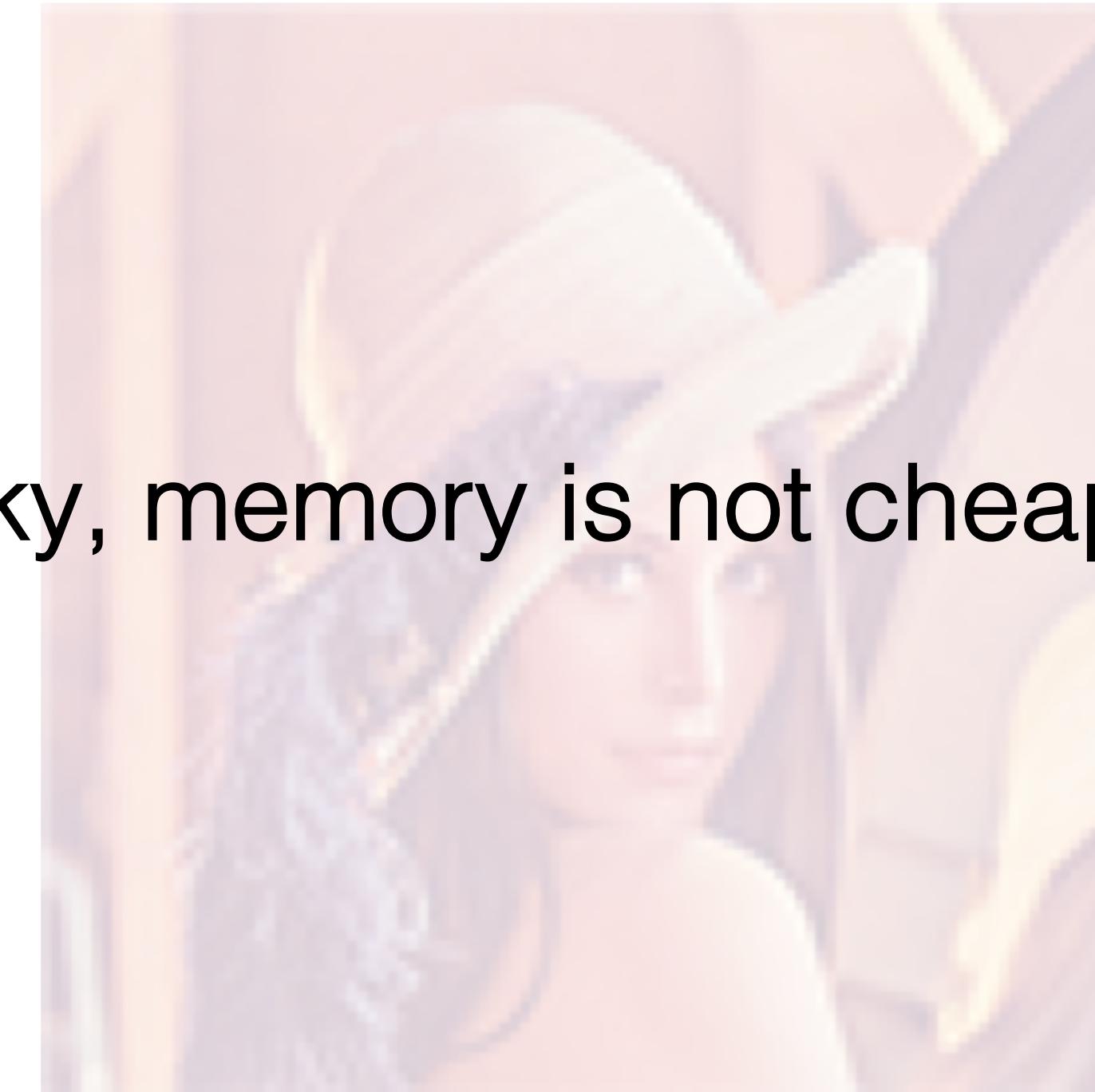


It can approximate an arbitrary function with increasing resolution

Raster Images



3D is tricky, memory is not cheap anymore!



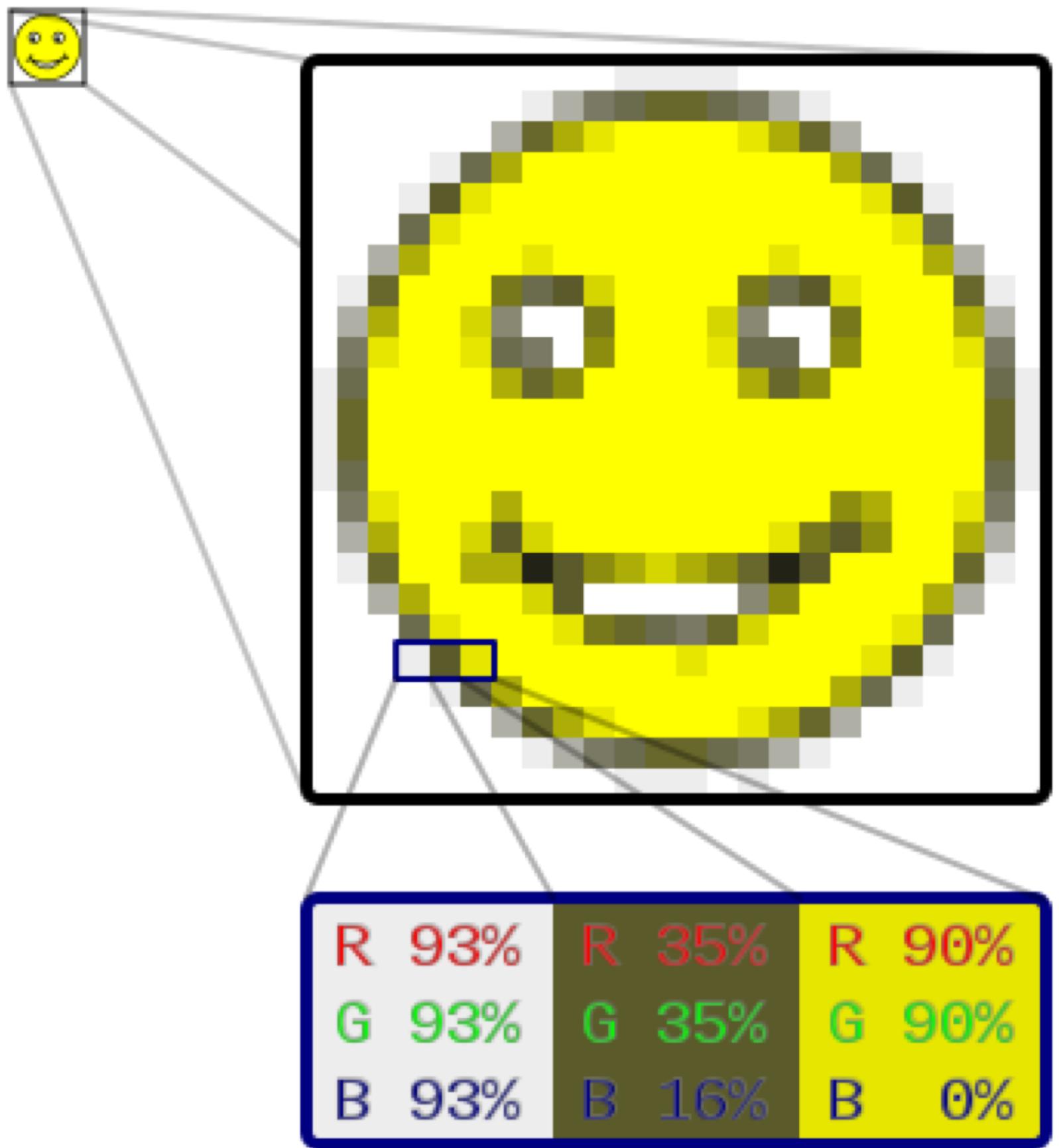
It can approximate an arbitrary function with increasing resolution



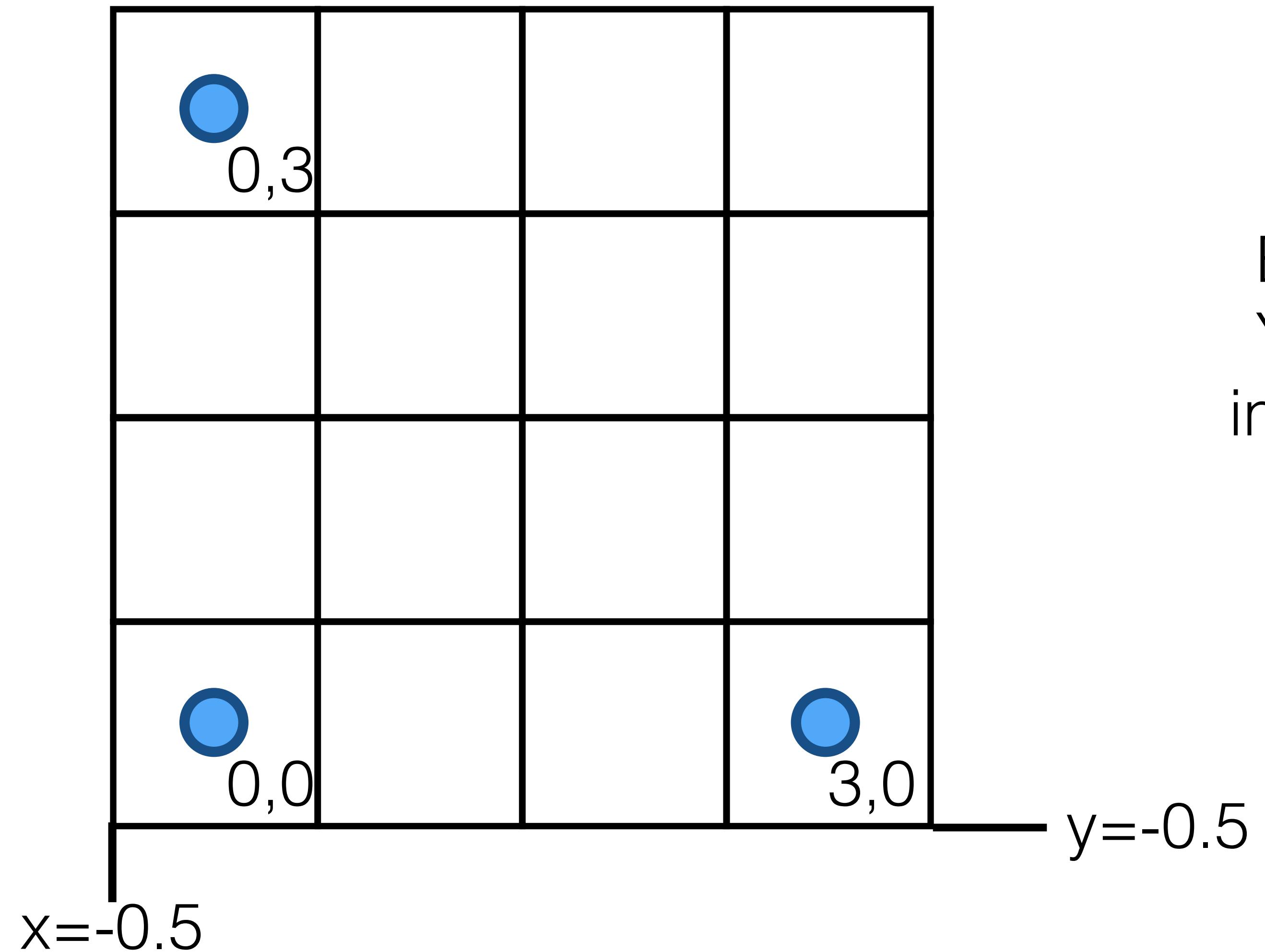
Florida State University

Raster Images

- A discretization of a function in 2D
- An array of values = the resolution of a display?
 - The resolution of a screen is fixed, but, we don't have just one output device
 - want to define images we can't display
- A pixel is not a little square: “this is the intensity around here”



Pixel Coordinates - Raster Image



Be Careful:
Y is flipped
in some APIs



Florida State University

Pixel Values (Framebuffer format)

- 1-bit/8-bit – text
 - black and white, grey
- 8-bit RGB (24 bits) - web and email
 - full range of displayable color; e.g. color print
- 8-bit RGBA (32 bits) - alpha channel, see next slide
- 16/24/32bits - high accuracy for photography and high dynamic range (HDR)
 - represent real scenes independent of display



Florida State University

Storage Sizes

1024x1024 image (1 megapixel)

- bitmap: 128KB
- grayscale 8bpp: 1MB
- grayscale 16bpp: 2MB
- color 24bpp: 3MB
- floating-point HDR color: 12MB



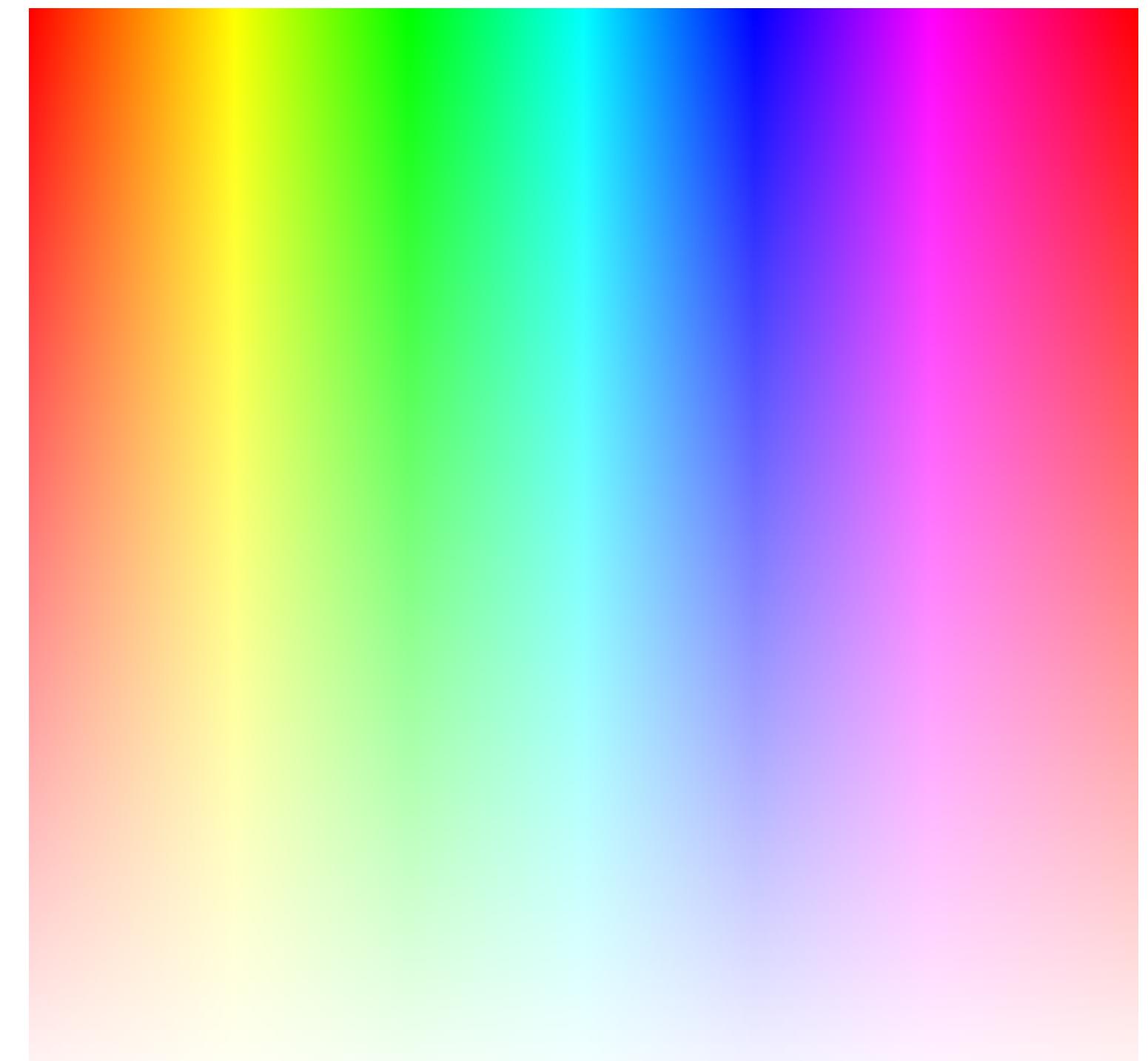
Florida State University

Alpha Compositing

- A way to represent transparency
- The pixels of an image are blended linearly with the image below

$$\mathbf{c} = \alpha \mathbf{c}_{\text{new}} + (1 - \alpha) \mathbf{c}_{\text{old}}$$

$$\alpha = 1$$



More info: https://en.wikipedia.org/wiki/Alpha_compositing



Florida State University

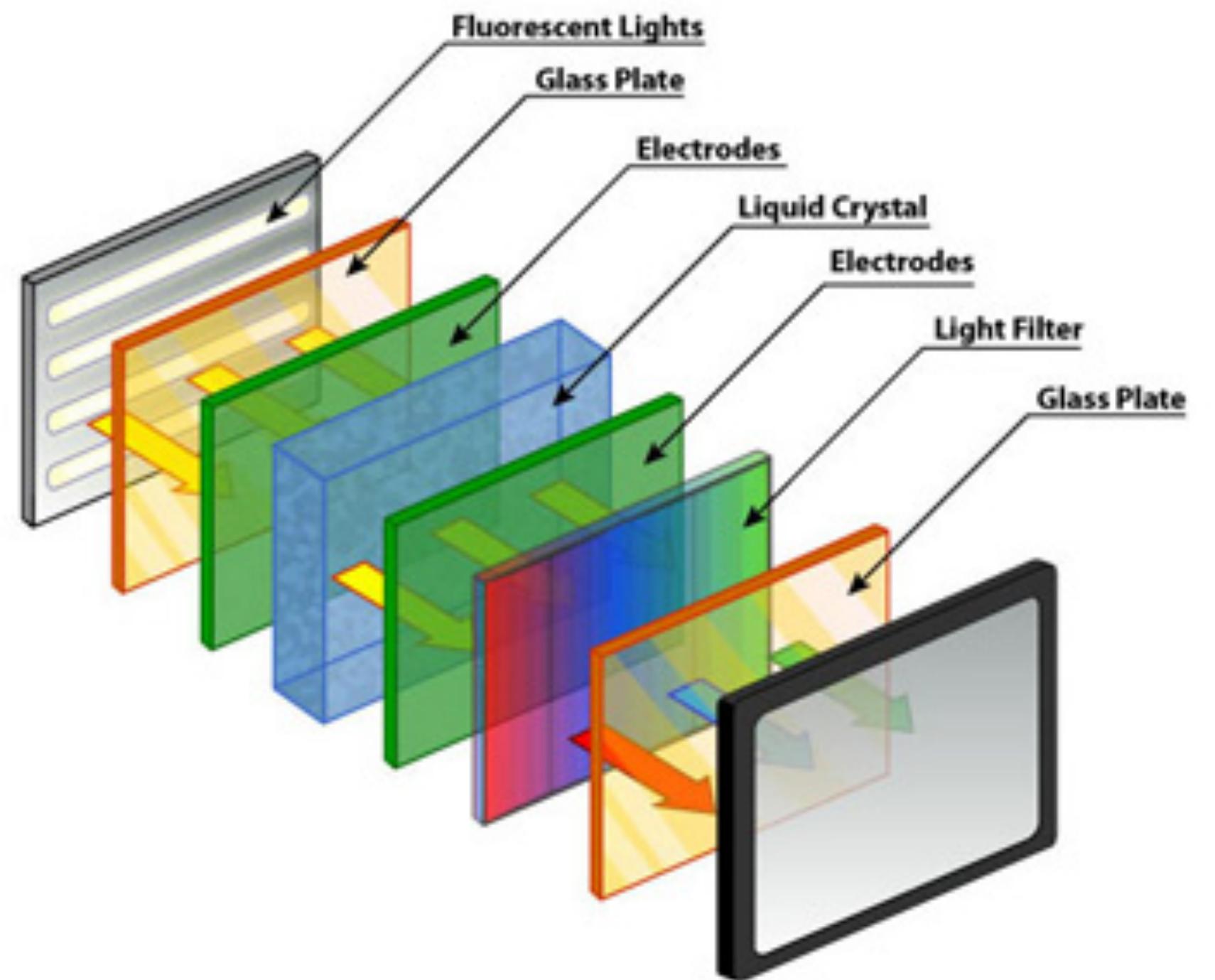
Image Formats

- Lossy:
 - **jpeg** - compact, introduces artifacts, works well for natural images
- Lossless:
 - **png** - common for web applications
 - **ppm** - very simple, not compressed
 - **tiff** - mostly scientific use

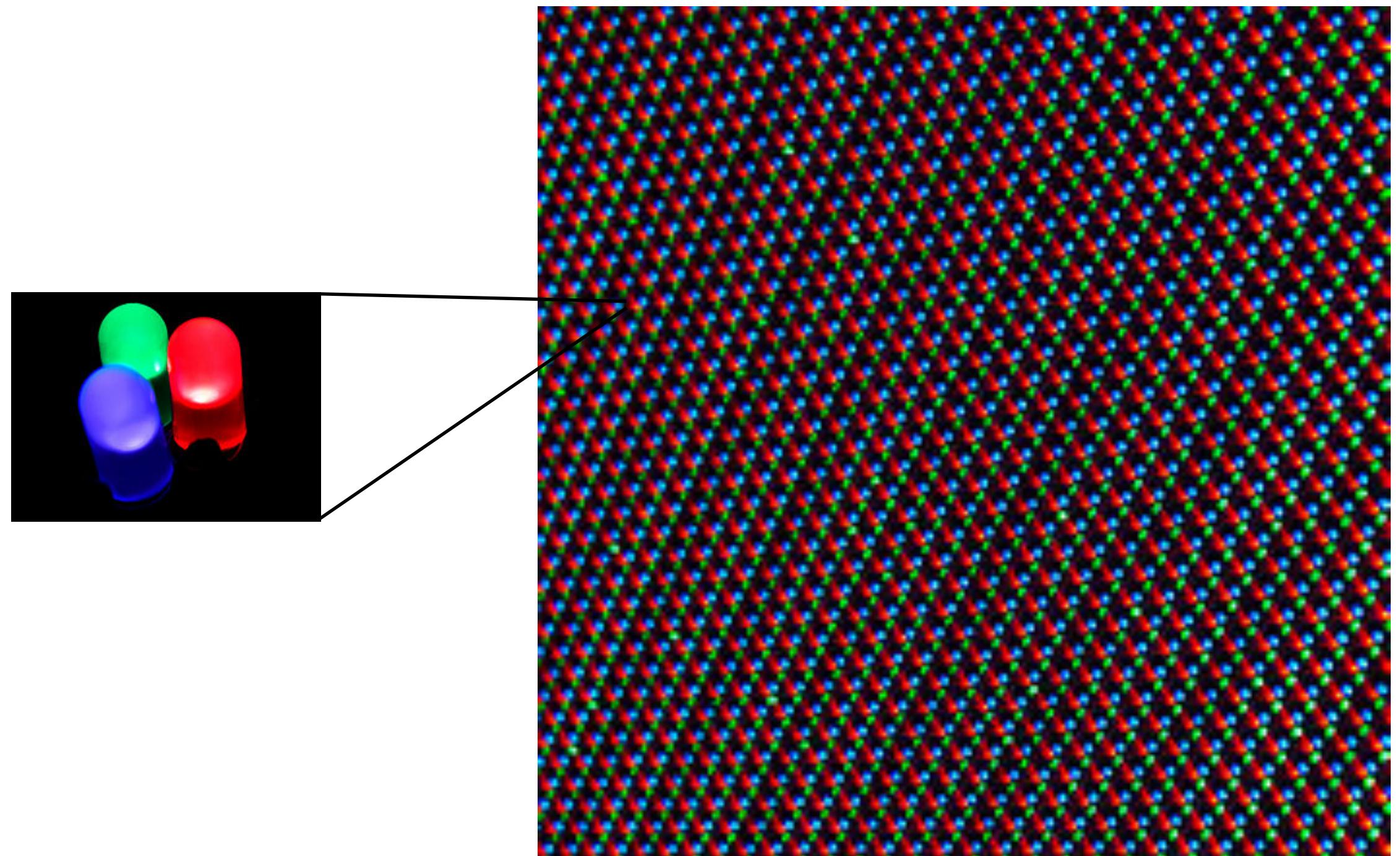


Florida State University

Raster Output Devices: Display



**Transmissive
Liquid Crystal display (LCD)**



**Emissive
Light-emitting Diode (LED) display**

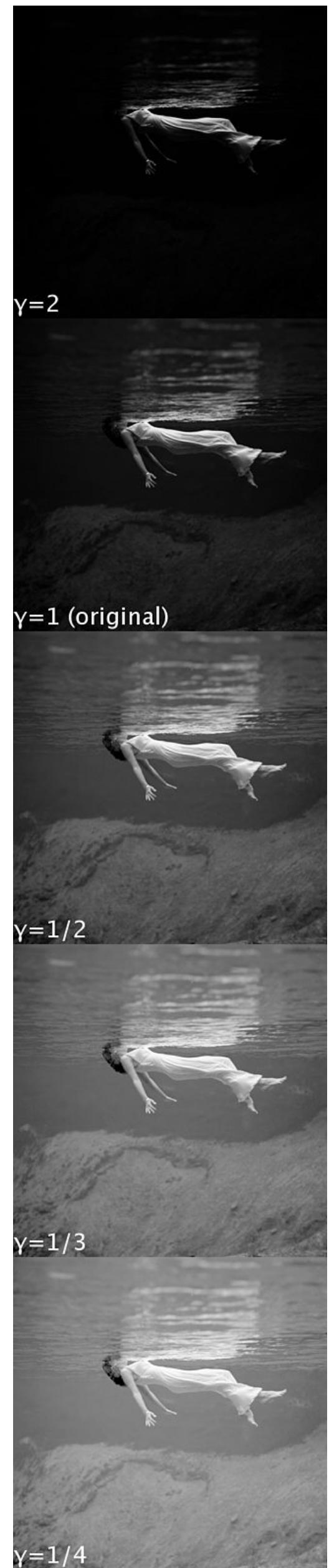
Monitors Intensity, Gamma Correction

- What is the minimal and maximal light intensity?
- The intermediate intensities are different for each person, and it is non-linear
- Monitors needs to be calibrated for a certain viewer, using a procedure called “Gamma Correction”
- The rule is simple: displayed intensity = (max intensity) * a^γ

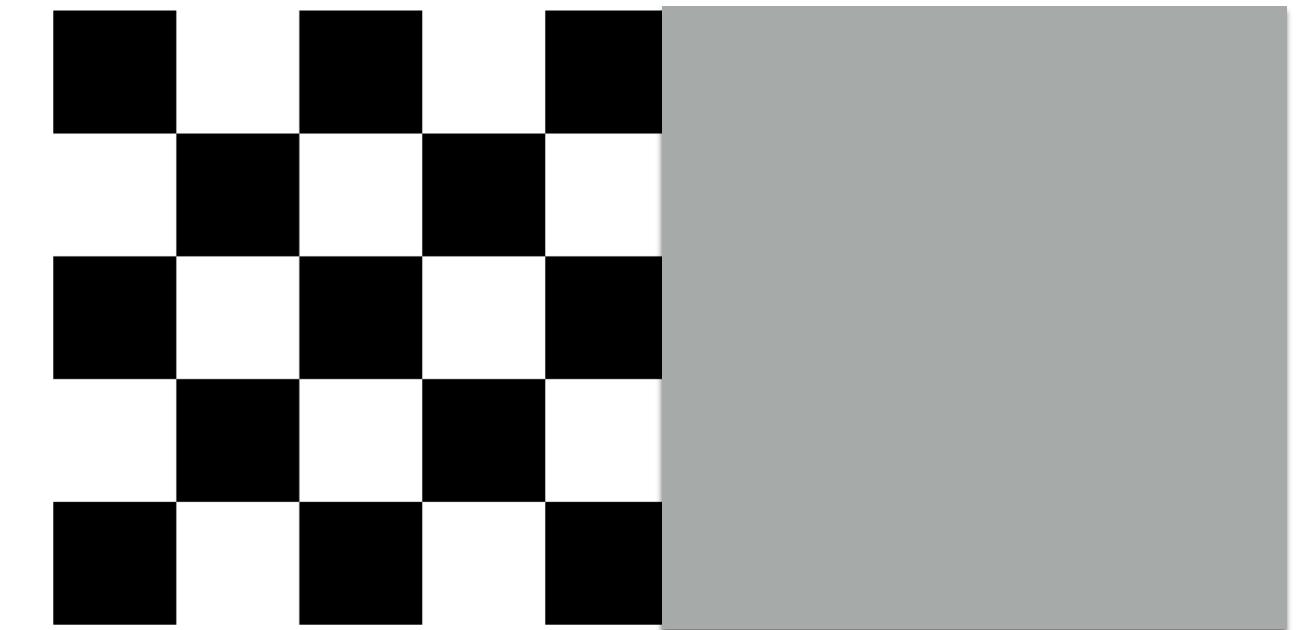




Gamma Correction



- Find the neutral gray: $0.5 = a^\gamma$
- Compute
$$\gamma = \frac{\ln 0.5}{\ln a}$$
- Gamma correct
$$a' = a^{\frac{1}{\gamma}}$$
- The colors will not be uniform on normal screens, one of the major factor affecting the cost of screens is their ability to be consistent on all pixels!

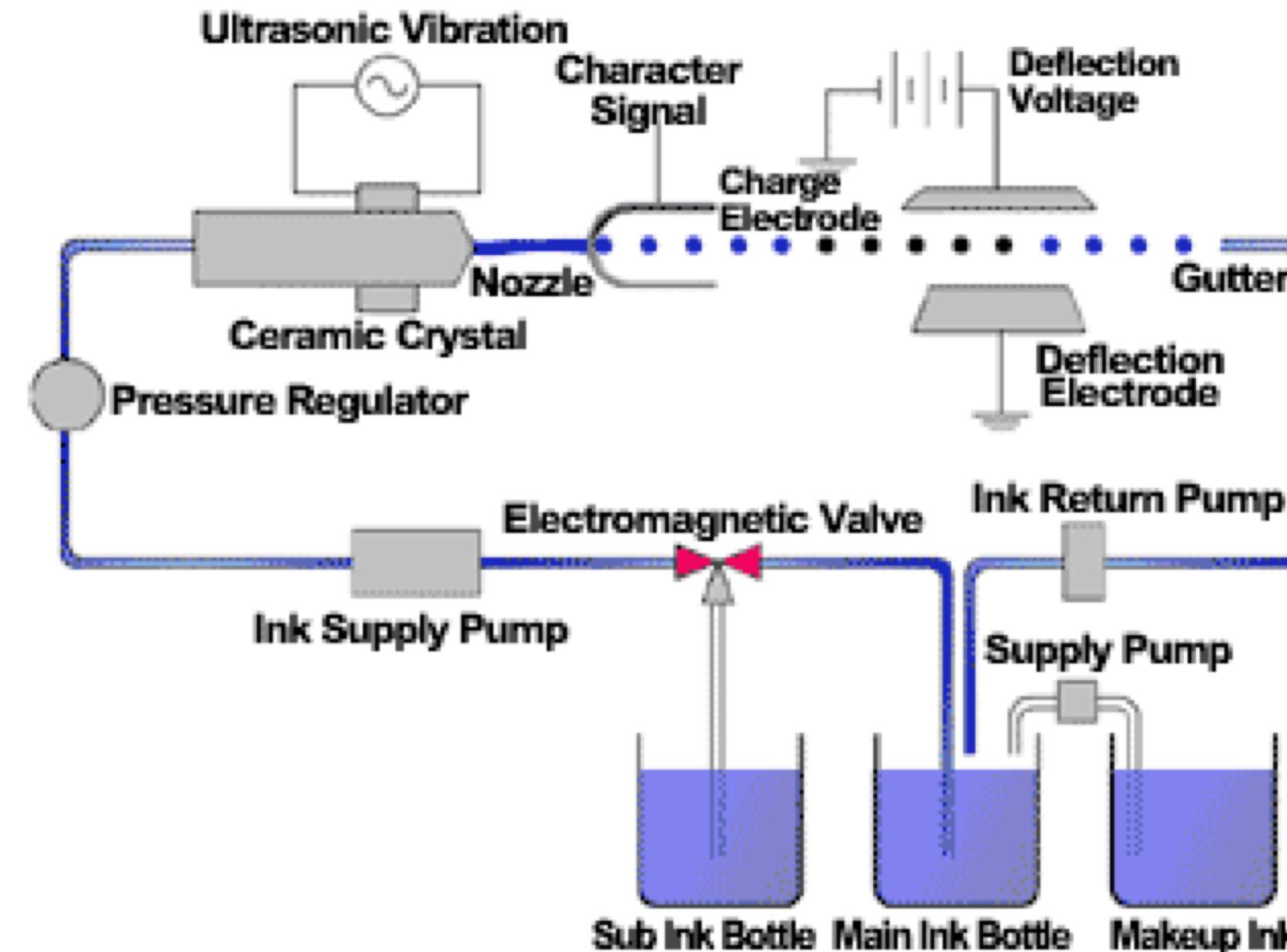


By X-romix 10:00, 7 June 2008 (UTC), Updated by --Rubybrian (talk) 14:25, 14 September 2010 (UTC); Photographer: Toni Frissell - This file was derived from: Weeki Wachee spring 10079u.jpg, GFDL, <https://commons.wikimedia.org/w/index.php?curid=4176109>



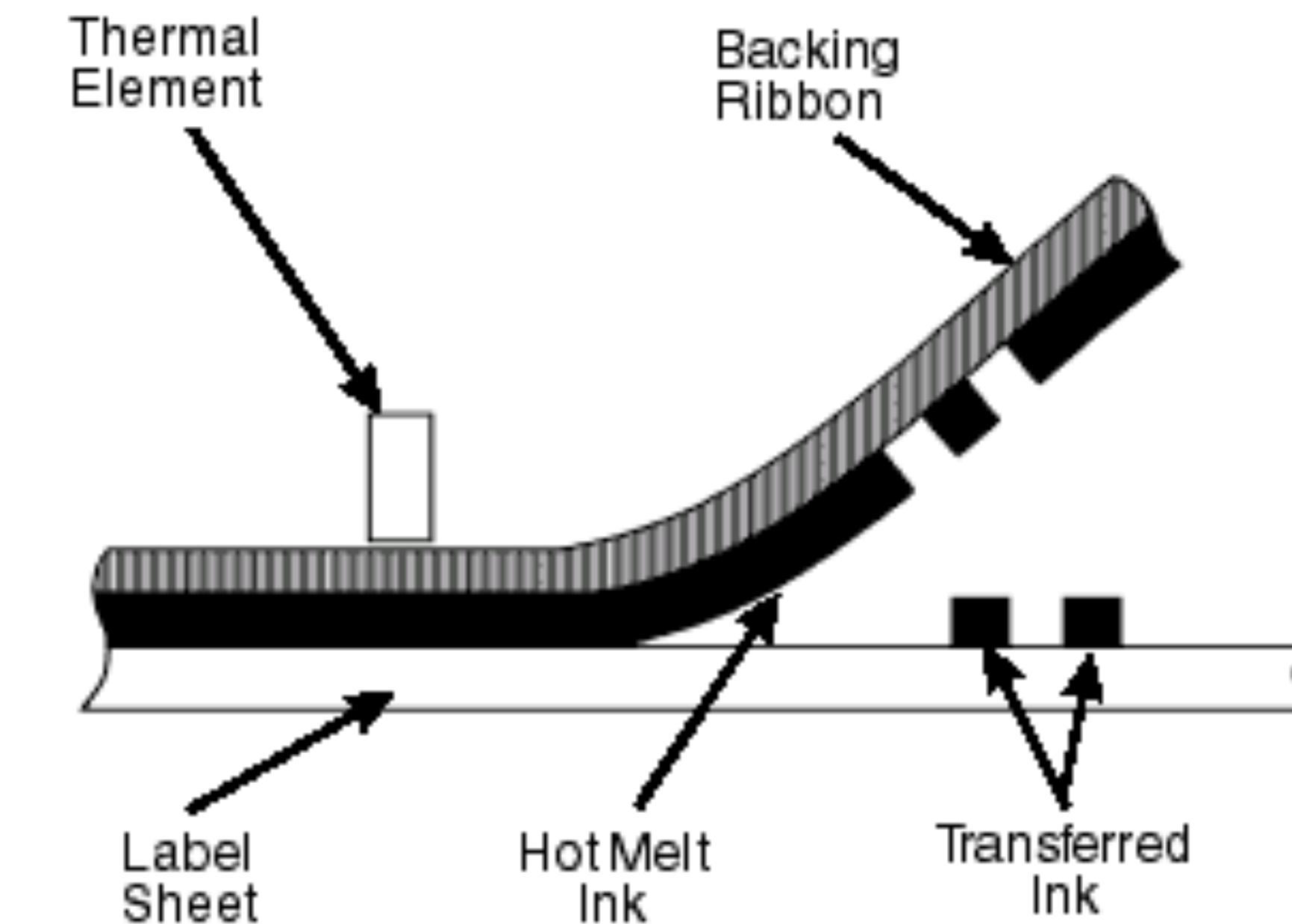
Florida State University

Raster Output Devices: Printer



<https://www.hitachi-ies.co.jp/english/products/ijp/outline/principle.htm>

Ink-Jet Printer



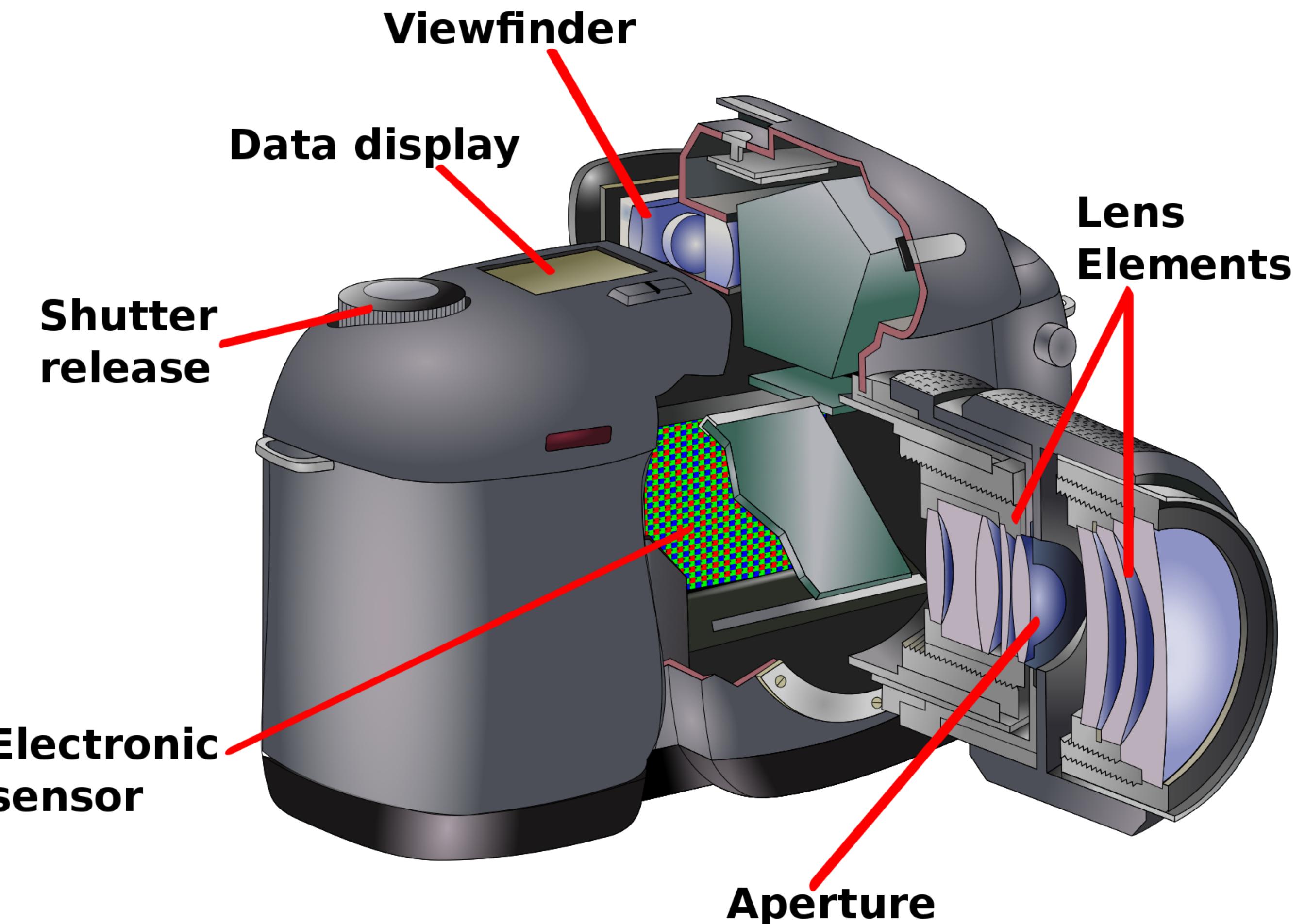
https://en.wikipedia.org/wiki/Thermal-transfer_printing

Thermal Dye Transfer Printer

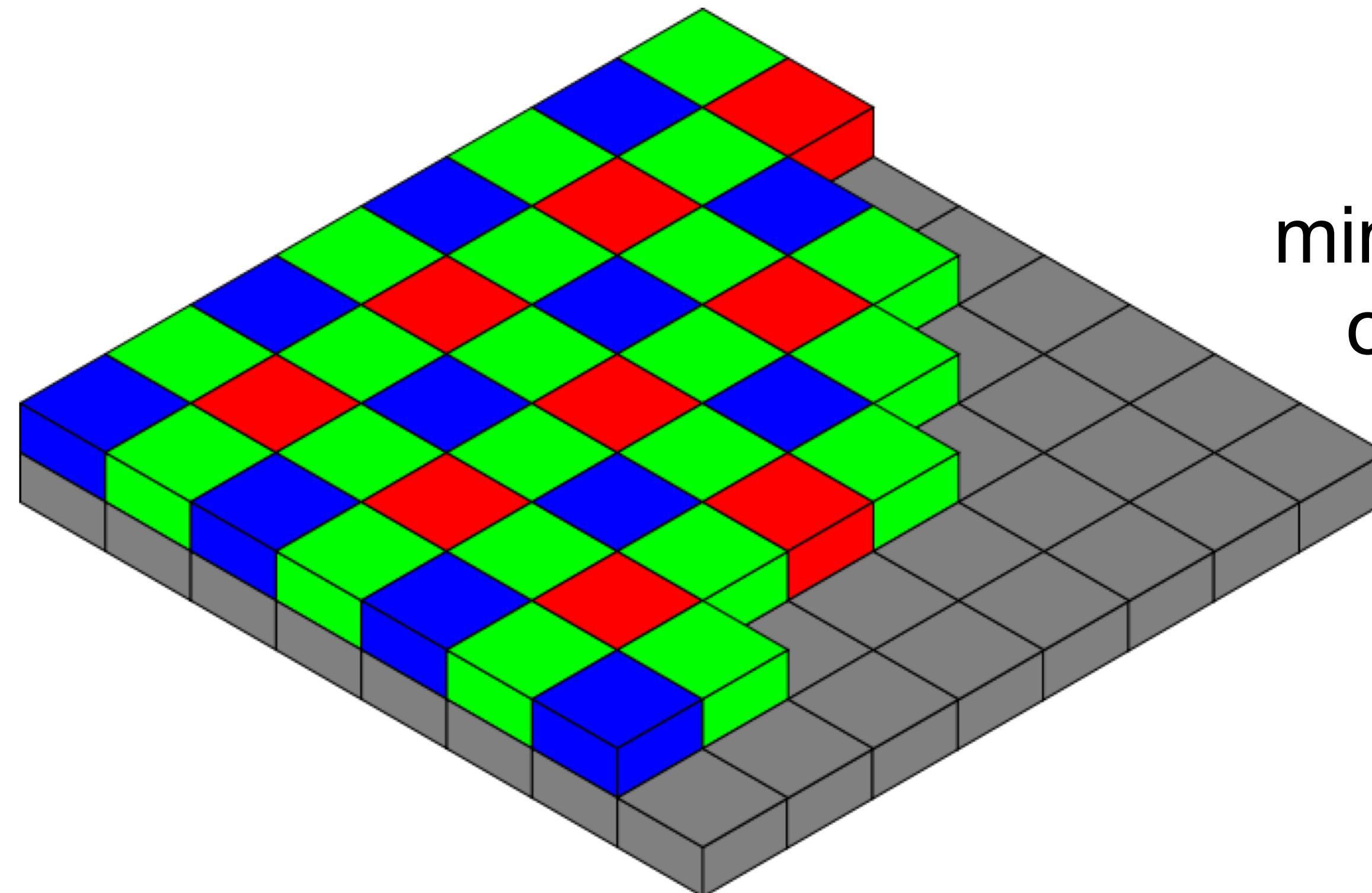


Florida State University

Raster Input Devices: Camera



Bayer Color-Filter



mimic the physiology
of the human eye

By en:User:Cburnett - Own workThis vector image was created with Inkscape., CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=1496858>



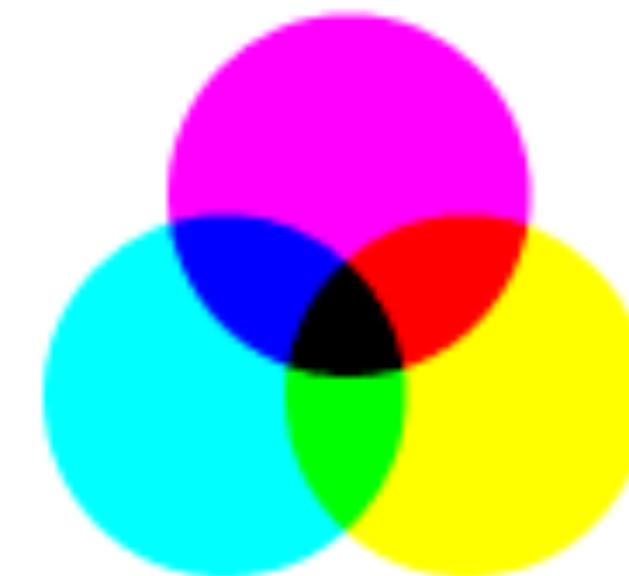
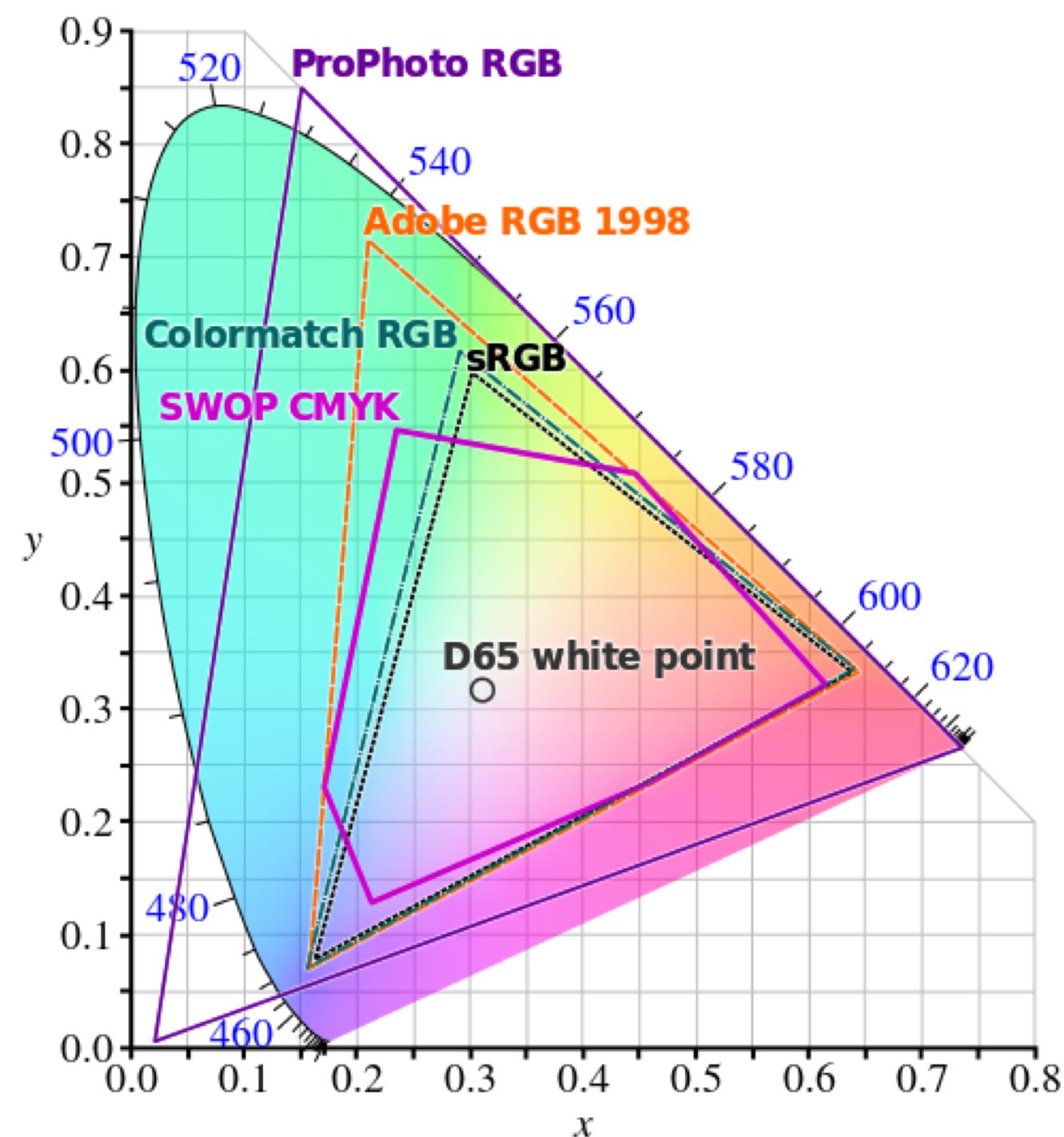
Florida State University

Raster Input Devices: Scanner



RGB vs CMYK colors

- RGB is additive
- CMYK is subtractive

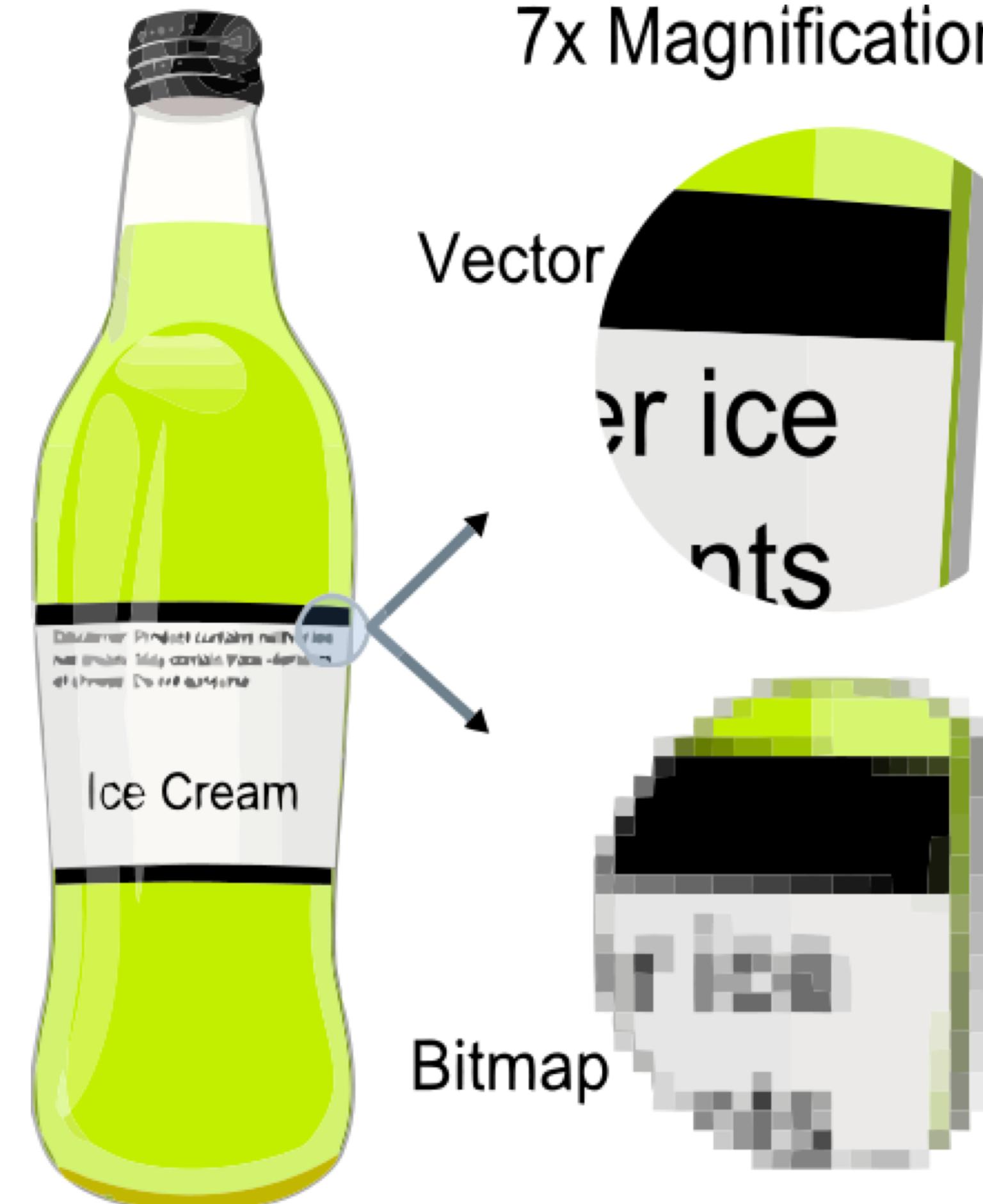


By BenRG and cmglee - http://commons.wikimedia.org/wiki/File:CIE1931xy_blank.svg, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=32158329>



Florida State University

Vector Image



<https://commons.wikimedia.org/w/index.php?curid=15789788>



Florida State University

Vector Vs Raster

Advantages

- Small storage: the size of representation does not depend on the dimensions of the object
- Infinite precision: one can infinitely zoom in the image, and it remains smooth
- The parameters of objects are stored and can be later modified
- From a 3-D perspective, rendering shadows is also much more realistic with vector graphics

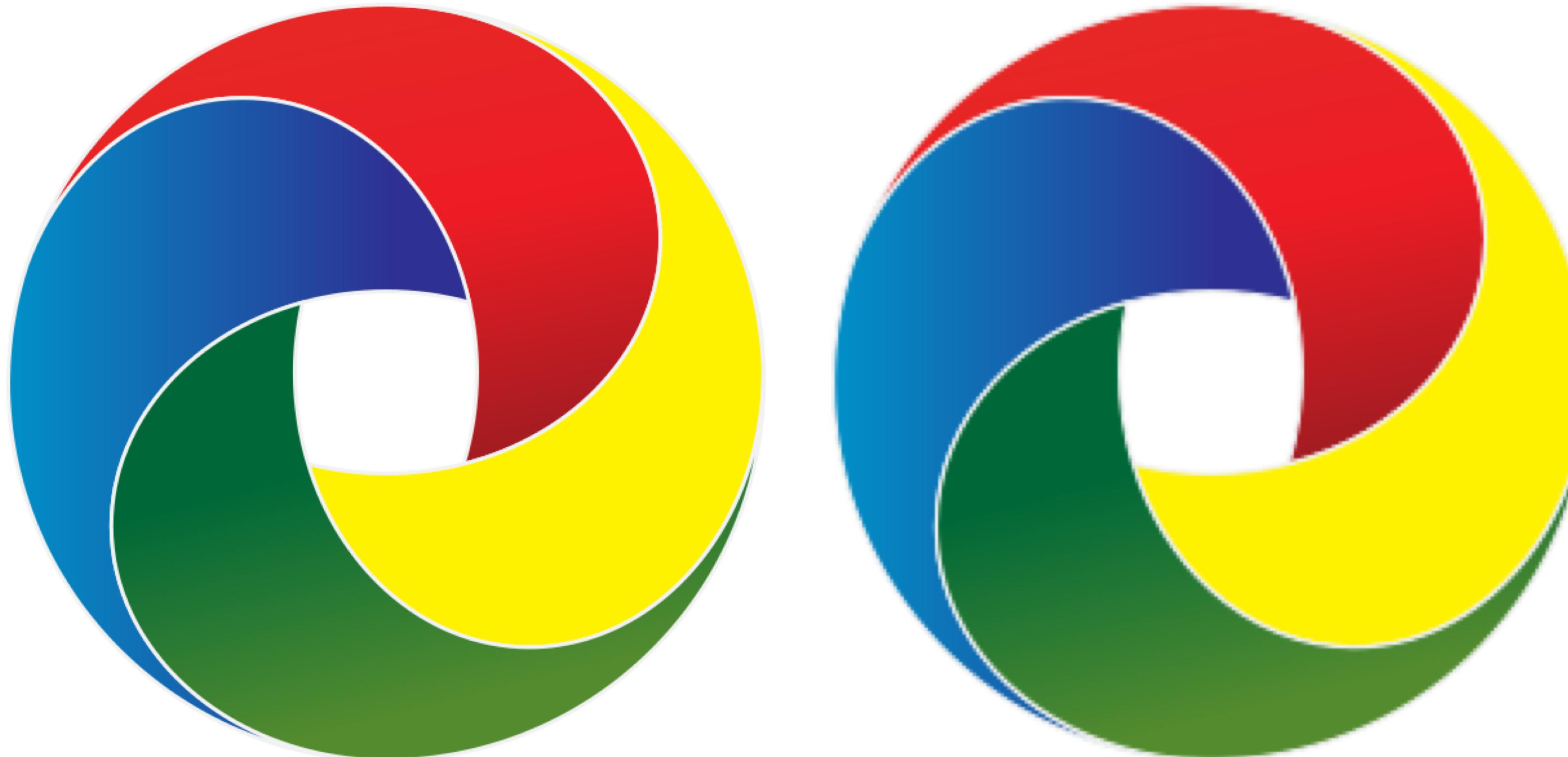
Disadvantages

- Incompatible with most imaging devices, such as camera and scanners
- Image editor software operates on the pixels rather than on drawing objects defined by mathematical expressions
- Hard to describe complicated scenes and shading



Florida State University

Vector Image

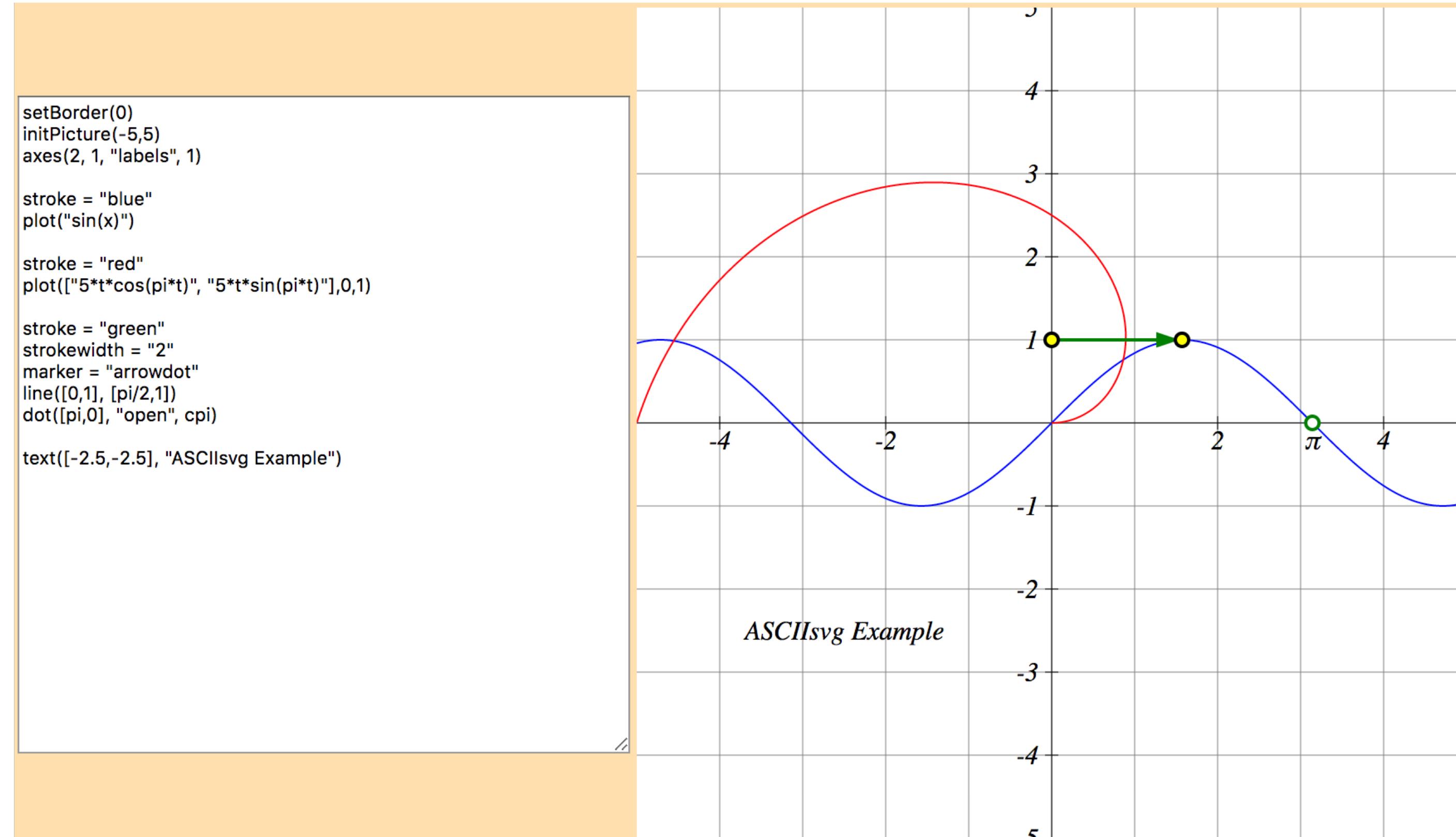


By Tonchino - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=23776193>



Florida State University

Vector Image



<http://www1.chapman.edu/~jipsen/svg/asciisvgeditor.html>



Florida State University

Vector Image

Typical primitives

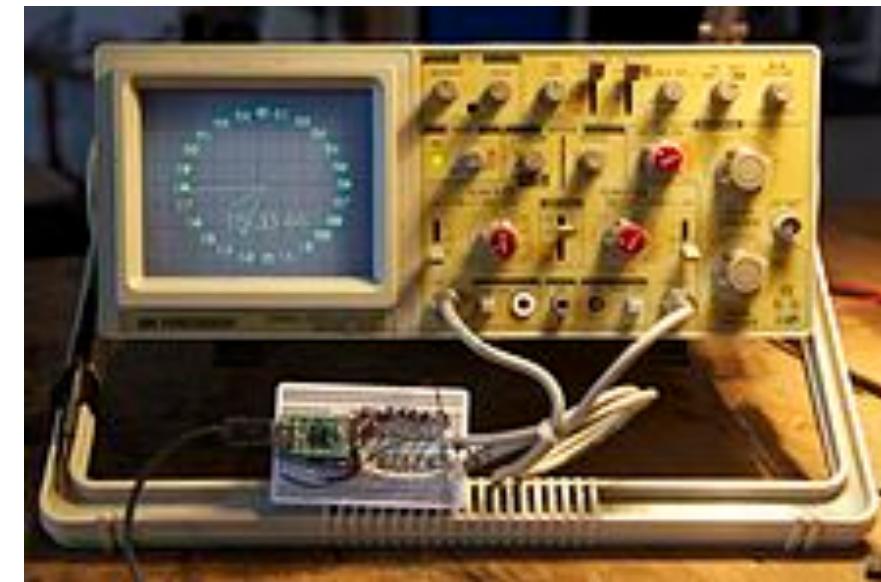
- Lines, polylines and polygons
- Bézier curves and bezigos
- Circles and ellipses



Florida State University

Vector Devices

- A 24-hour clock displayed on an [oscilloscope](#) configured as a vector monitor
- A free software [Asteroids](#)-like video game played on an [oscilloscope](#) configured in X-Y mode



https://en.wikipedia.org/wiki/Vector_monitor



Florida State University

References

Fundamentals of Computer Graphics, Fourth Edition
4th Edition by Steve Marschner, Peter Shirley

Chapters 2, 3, 19

