Boston University
CAS CS 585:
Image and Video Computing

Image Formats

Slides are part of 1st Lecture by Margrit Betke
1/18/2024

Learning Objectives

Computer Science

- Understand formats of images used as inputs to computer vision models.

  Pixel values may be greyscale, color, or attenuation (medical scans)

- Know how to access a single pixel in an image
- Know how to convert color images into greyscale images
- Know about standard computer vision library: OpenCV

What is an image?

- Images are fields of colored dots
- Each dot is called a pixel = picture cell
- Standard test image with detail, shading, texture, sharp & blurry regions:

Lena Soderberg ‘72

Controversy!

Slide credit: Diane Theriault

Color Models

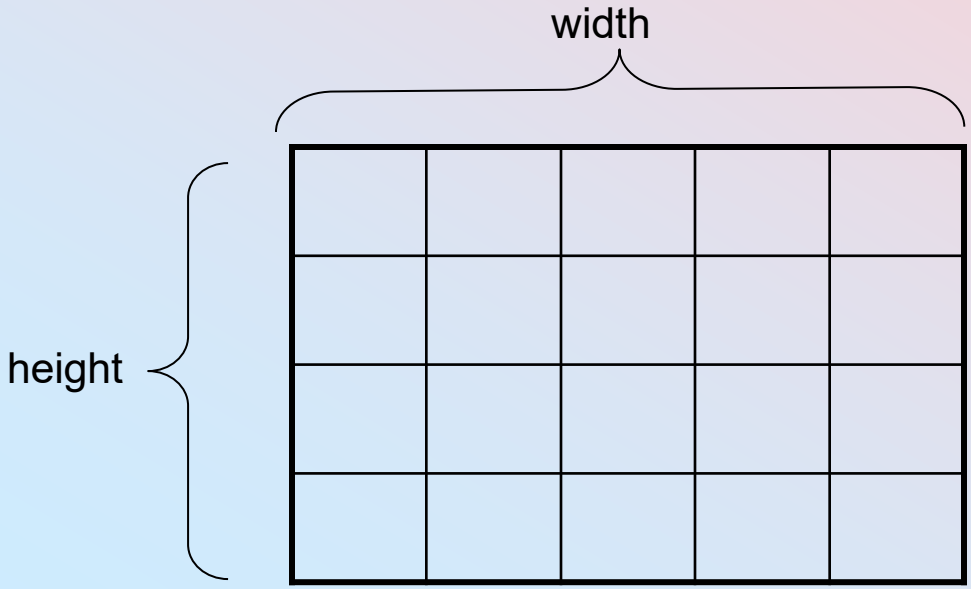
- Images can be gray scale, color, or color with an alpha (transparency) channel
- Most common color representation is RGB (Red, Green, Blue). This is the representation used to put pixels on the screen

- Other models include CMYK (used for print) and YUV (often used for input from cameras, compression, and transmission)

Slide credit: Diane Theriault

What is an image?

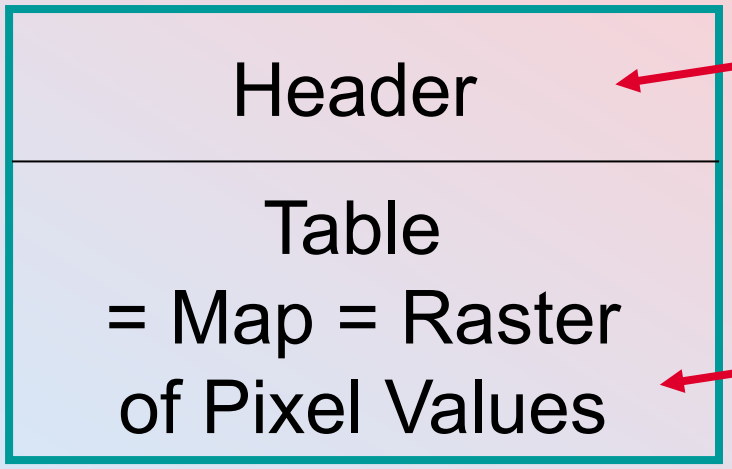
- Images are 2 dimensional arrays of data, with an associated width, height, and color depth.
- Images typically use one byte per color channel per pixel.
- Gray images have 1 color channel. RGB images have 3 color channels. RGBA images have 4 color channels.



Slide credit: Diane Theriault

Digital Image File Formats

Image:



Size of table, color, compression scheme

Gray-scale images: generally 1 byte per pixel

Color images: 3 numbers (each 1 byte) per pixel

Medical images, e.g., CT, MRI:
typically 2 bytes per voxel

Example: PGM Image

Image file

Image ??

```
P2
3  3  255

0   255   0
220   0   20
0   130   0
```

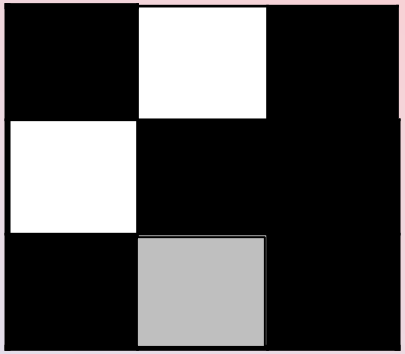
Example: PGM Image

Image file

```
P2
3  3  255

0   255   0
220   0   20
0   130   0
```

Image



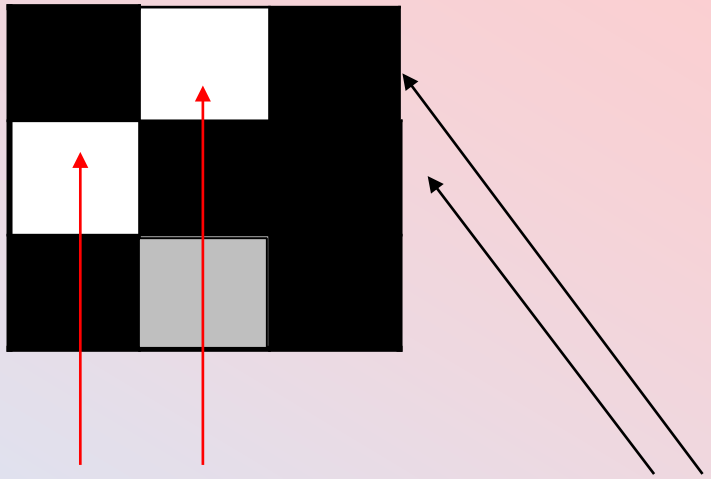
Example: PGM Image

Image file

```
P2
3  3  255

0   255   0
220   0   20
0   130   0
```

Image



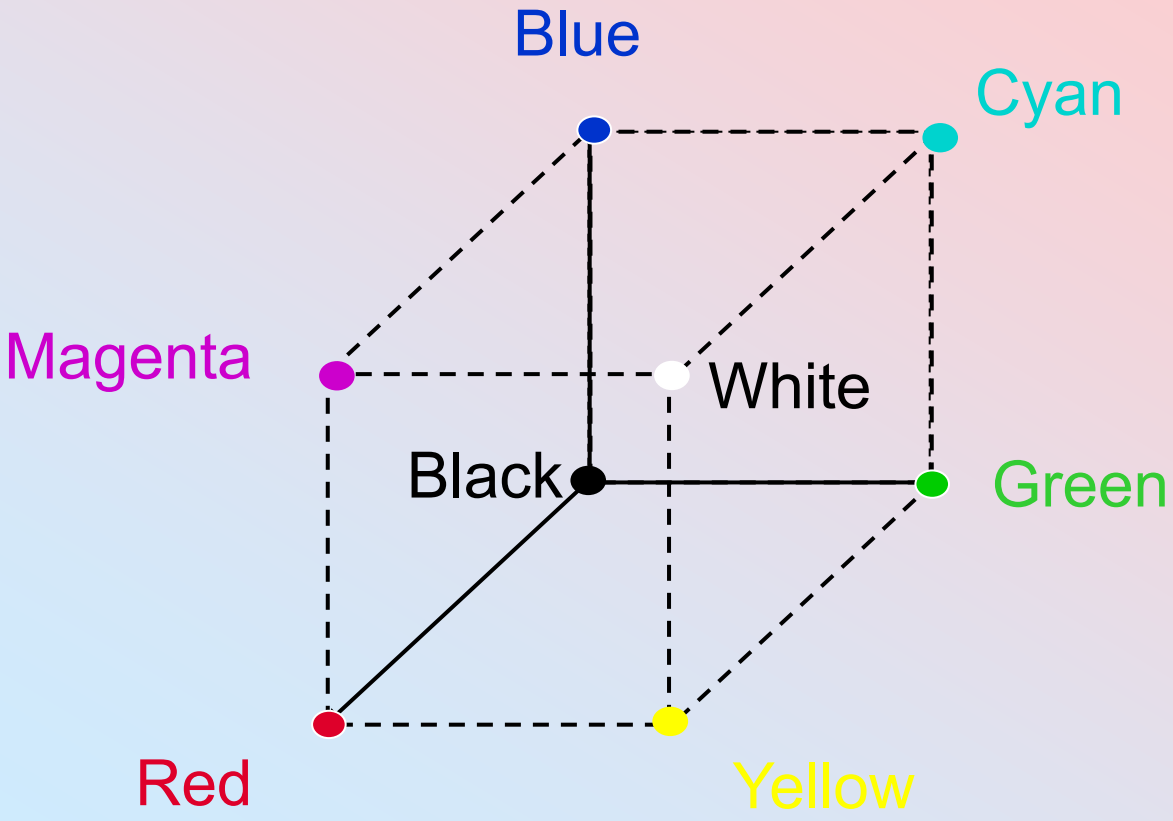
Note how indistinguishable

Light: Electromagnetic Waves

Wavelength λ

RGB Color Space

Additive Space



Example: PPM Image

Computer Science

Image file

```
P3
3  3  255

0   0   0   255 0   0   0   0   0
0 255 0   0   0   0 255 255 0
0   0   0   0   0 255 0   0   0
```

Image ??

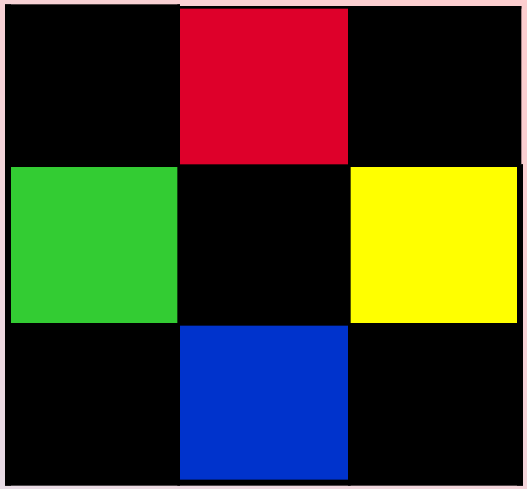
Example: PPM Image

Image file

```
P3
3  3  255

0   0   0   255 0   0   0   0   0
0 255 0   0   0   0 255 255 0
0   0   0   0   0 255 0   0   0
```

Image



How do I get at the data?

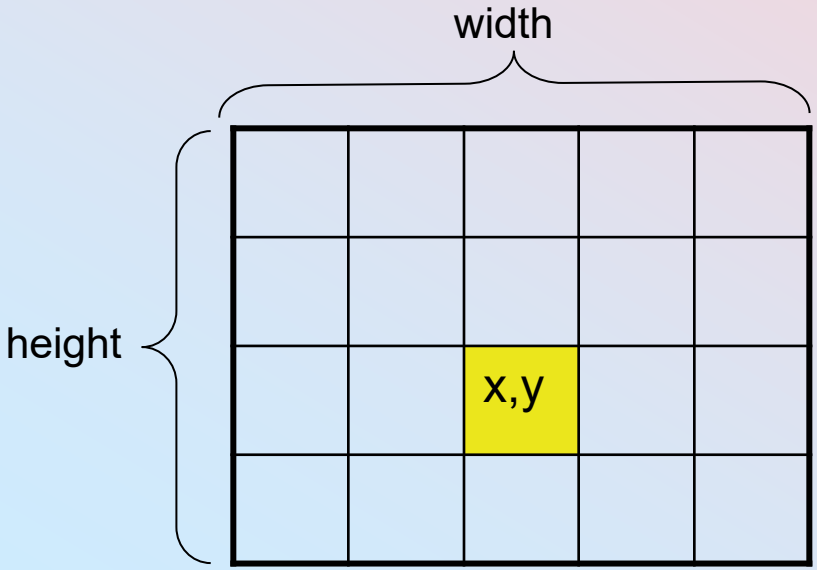
Computer Science

- Some image-handling APIs have nice interfaces, but speed can be a problem.
- You will probably have to handle the bytes of data directly at some point

Slide credit: Diane Theriault

How do I get at the data?

- X = desired row
- Y = desired column
- C = color channel (red, green, blue, …).
- Bpp = Bytes per pixel (color channels)
- Image data is normally stored in row major order
- Note that there may be multiple values associated with each (x,y) pixel
- $Data(x,y,c) = y \cdot (width \cdot Bpp) + x \cdot Bpp + c$



Slide credit: Diane Theriault

Color-to-Grayscale Conversion

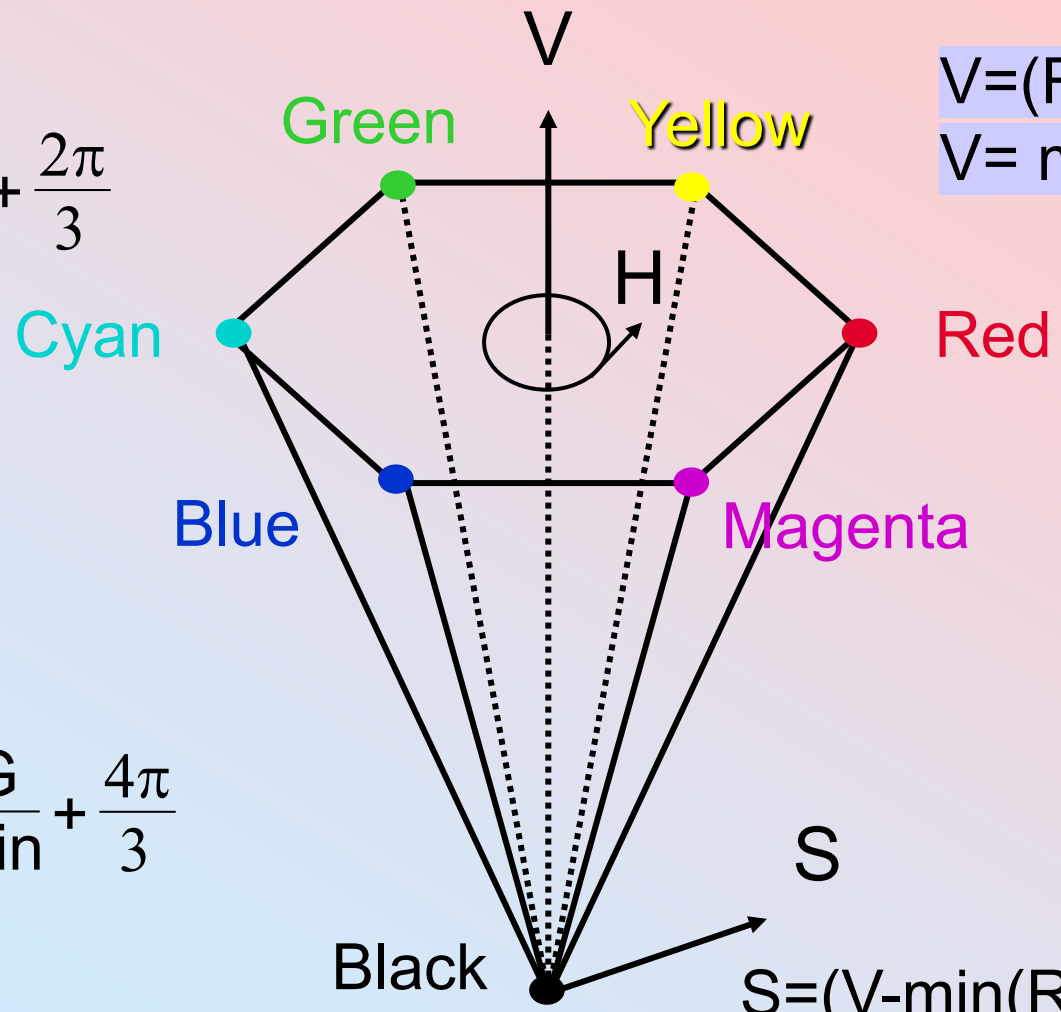
- "Quick and dirty" conversion: Grab the Green Channel
- Average R, G, B: (R+G+B)/3
- Max(R, G, B)
- Weigh them: 0.3*R + 0.6*G + 0.1*B

Slide credit: Diane Theriault

Hue-Saturation-Value (HSV) Color Space

near G:

$$H = \frac{\pi}{3}\,\frac{B-R}{V-min} + \frac{2\pi}{3}$$



V=(R+B+G)/3 or
V= max(R,G,B)

near R:

$$H = \frac{\pi}{3}\,\frac{G-B}{V-min}$$

near B:

$$H = \frac{\pi}{3}\,\frac{R-G}{V-min} + \frac{4\pi}{3}$$

S=(V-min(R,G,B))/V

Image File Formats

- PPM / PGM is maybe simplest file format ever, but not supported by Photoshop or MS Image Viewer. Uncompressed. ASII mode lets you open the image in a text editor.
- BMP: Microsoft's uncompressed image format
- GIF: Images are compressed using run-length encoding to reduce the number of colors used. Previously licensed, now open
- JPEG: Images are compressed by removing high frequency information (also uncompressed version)

Tools of the Trade

Computer Science

- OpenCV is a widely used open-source computer vision library started by Intel
- Provides libraries for image I/O, video I/O and camera capture
- Industrial strength computer vision and image processing implementations
- “Quick and dirty” GUI toolkit

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