CSC 422/522
Computer Vision and Pattern Recognition

Image Processing (Basics)

2026 Spring

SOUTH DAKOTA
STATE UNIVERSITY

Today

- What is an image?
  - Color
  - Histogram
  - Texture

- How to resize an image?

- OpenCV practice in Colab
  - Read, Show, and Write
  - Access and Modify Pixel Values
  - Access Image Properties
  - Color Space Transformation
  - Crop
  - Histogram Equalization
  - Resize

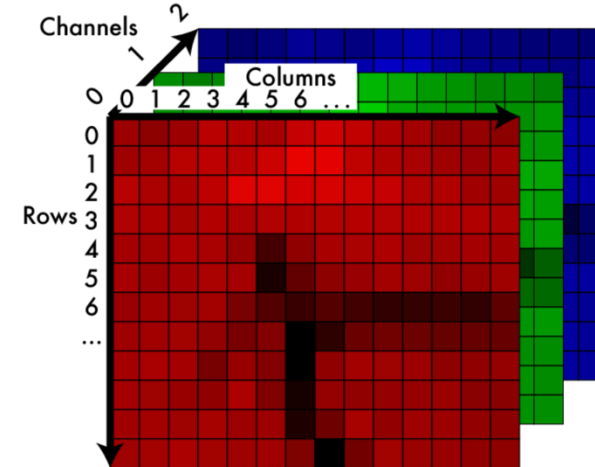Image taken at Niagara Falls during my graduation trip ☺
Hope it brings you good luck!

What is an image?

What is an image?

- We present an image as grids of pixels
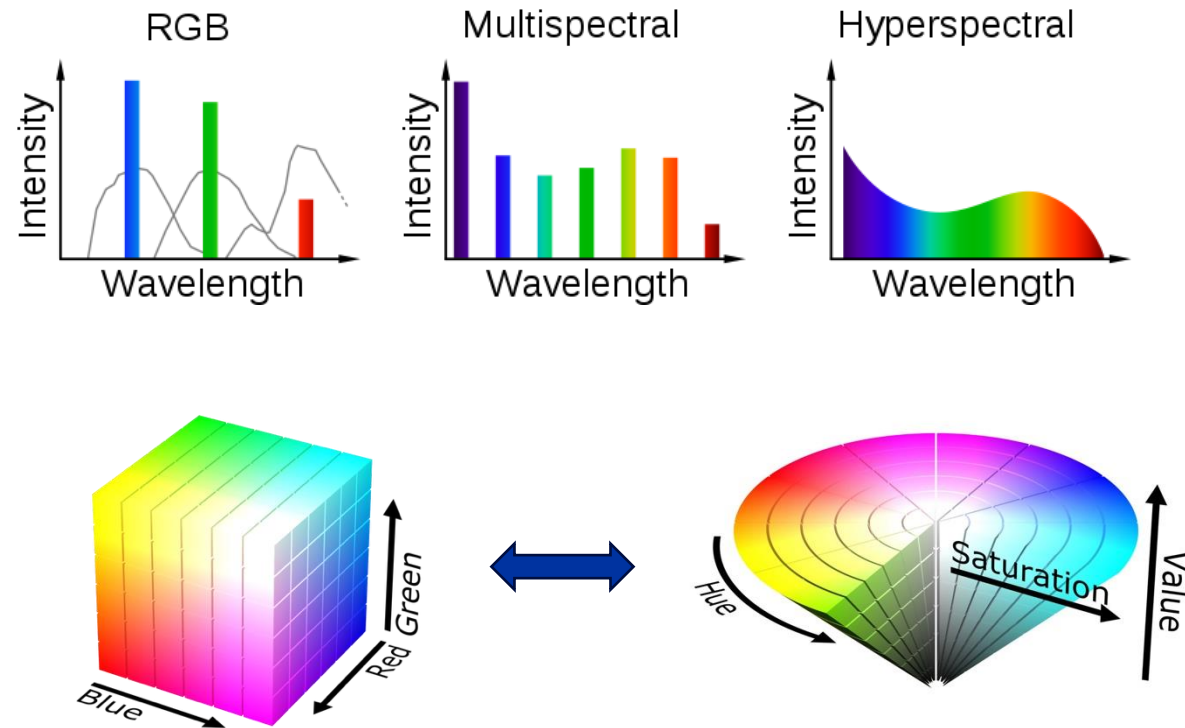
- *Resolution*: width / height

- *Channel*: color / gray

What is color?

- Image data can be saved in different color spaces

SOUTH DAKOTA
STATE UNIVERSITY
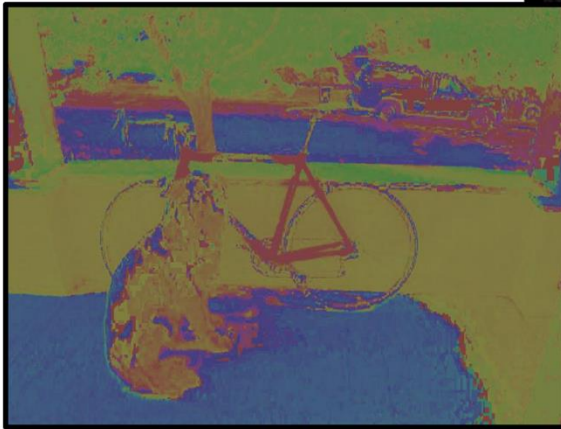
Let's Play with Image

- HSV (Hue, Saturation, Value) is generally considered closer to human perception than RGB.
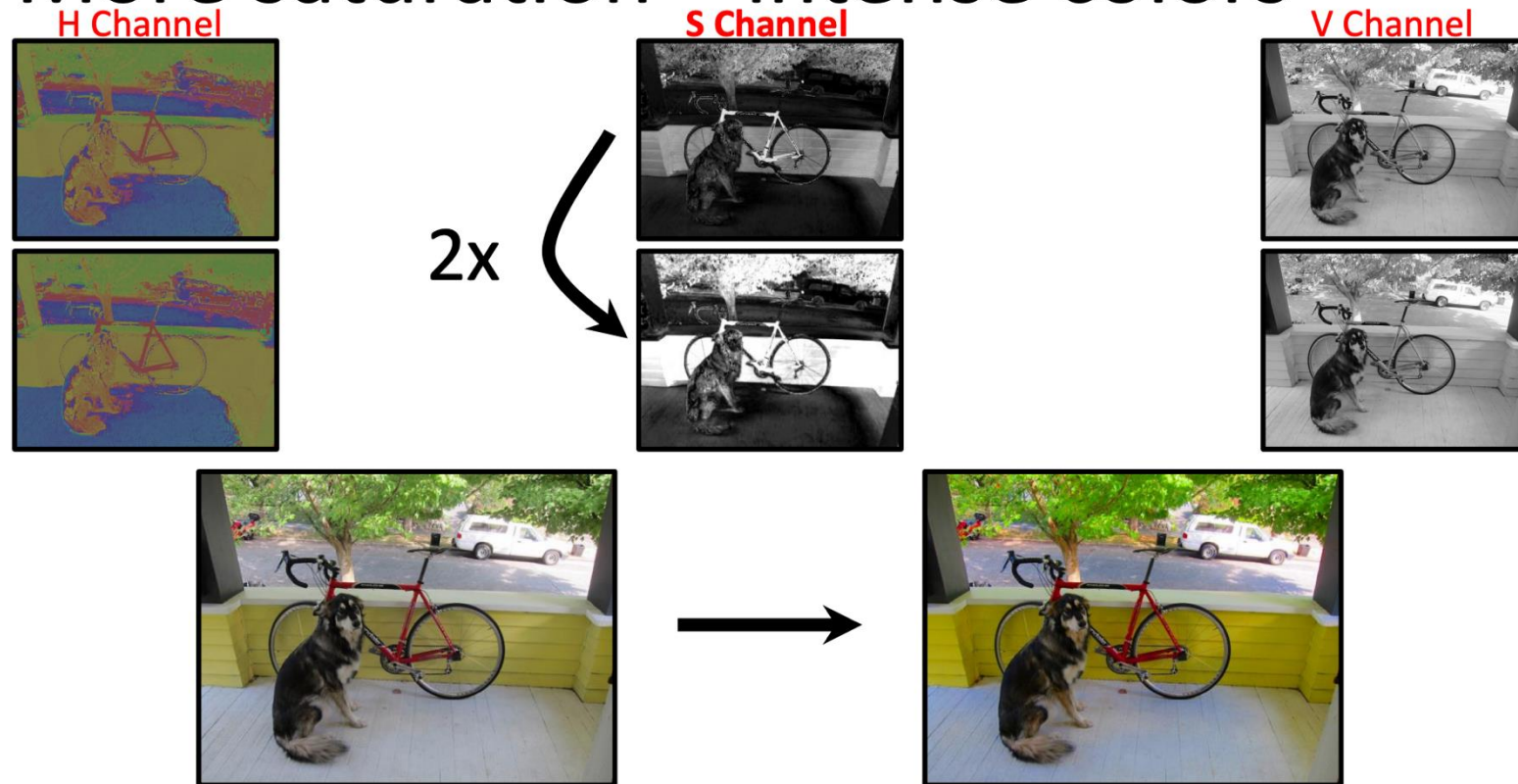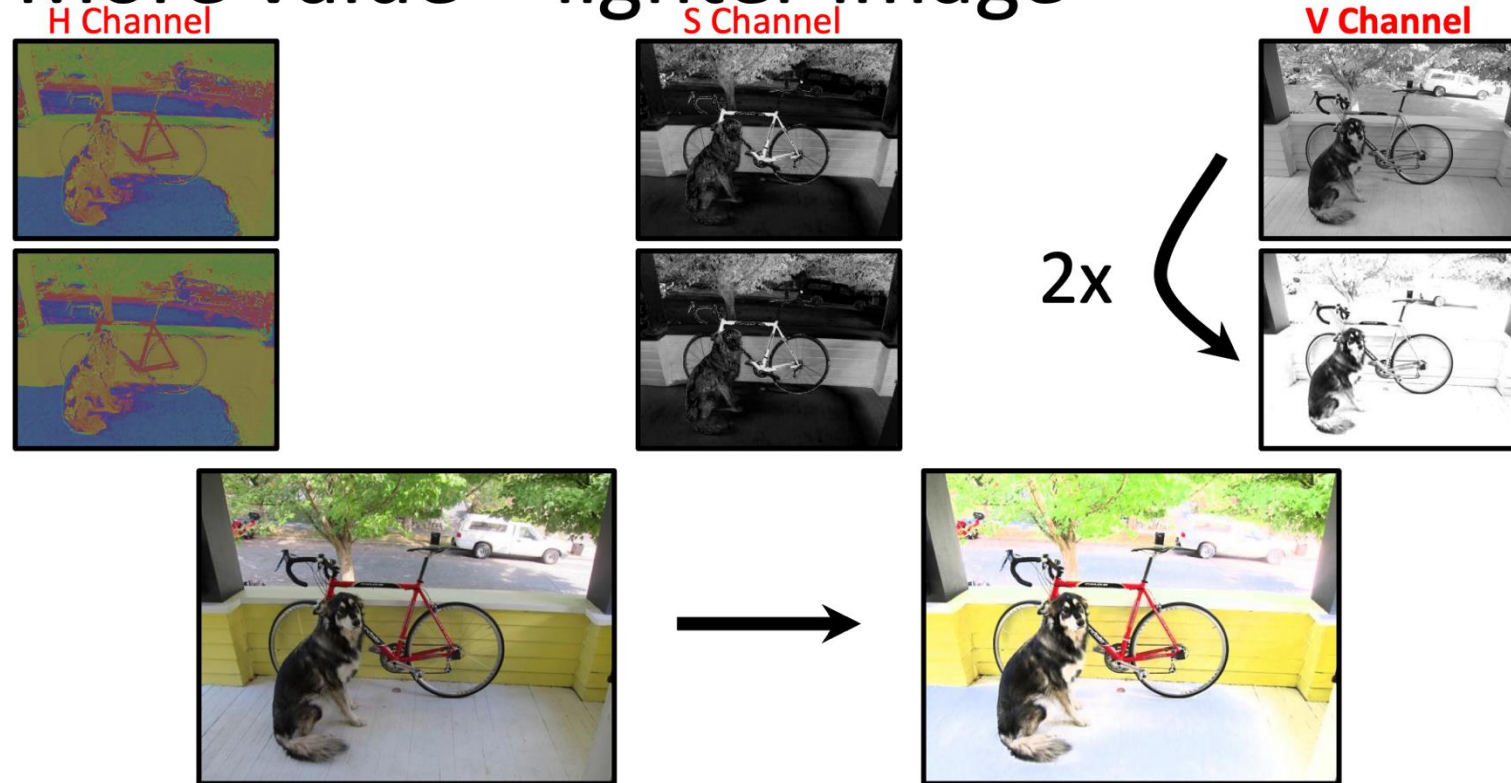
Let's Play with Image

More saturation = intense colors

Let's Play with Image

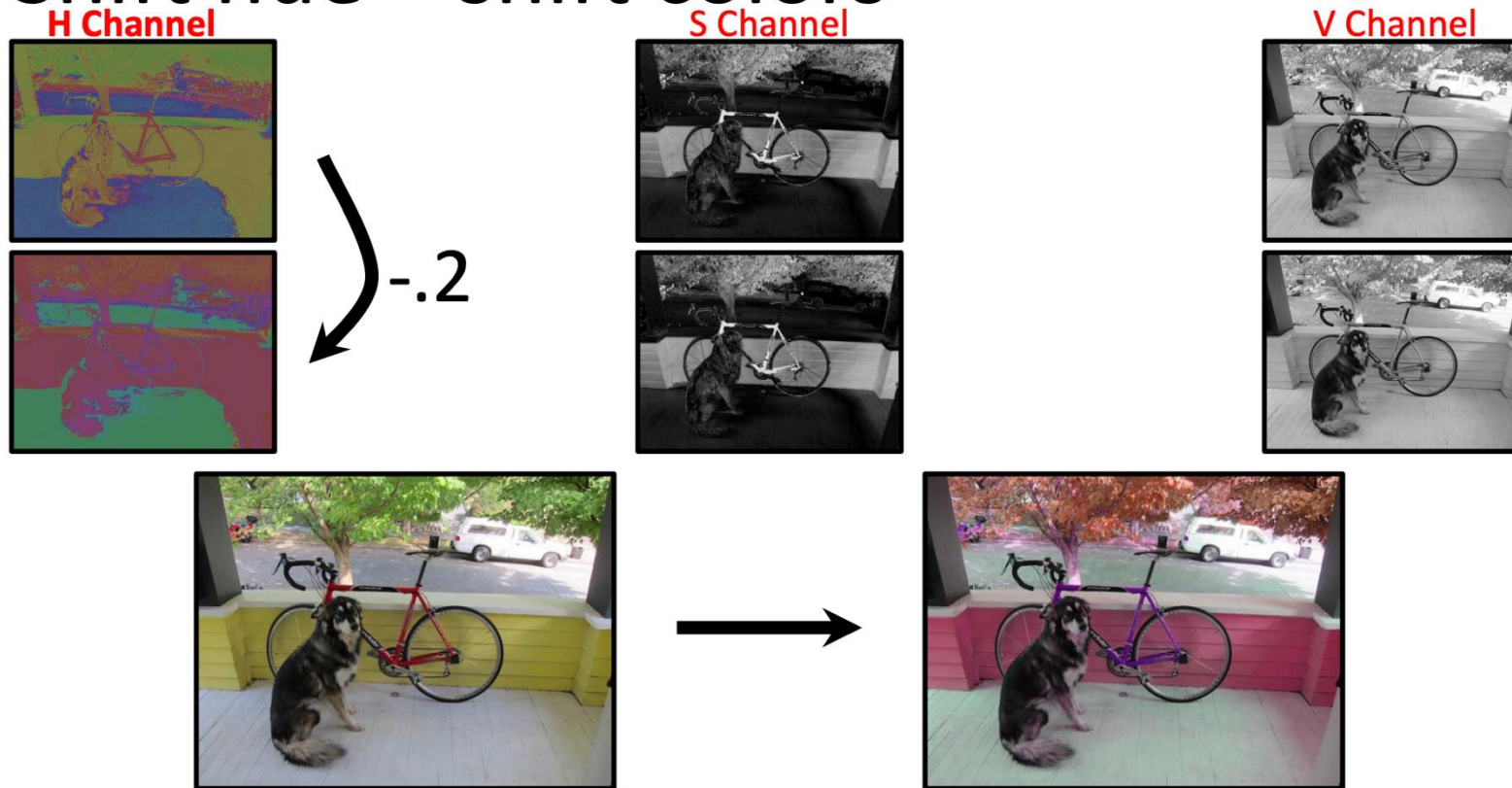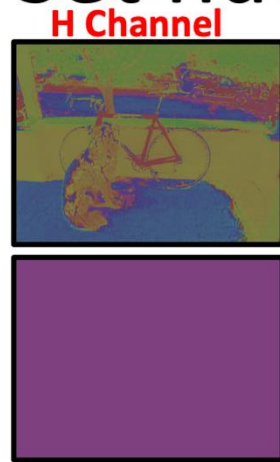More value = lighter image

H Channel
S Channel
V Channel

2x

Let's Play with Image

Shift hue = shift colors

Let's Play with Image

Set hue to your favorite color!

Let's Play with Image

Or pattern…

H Channel

S Channel

V Channel
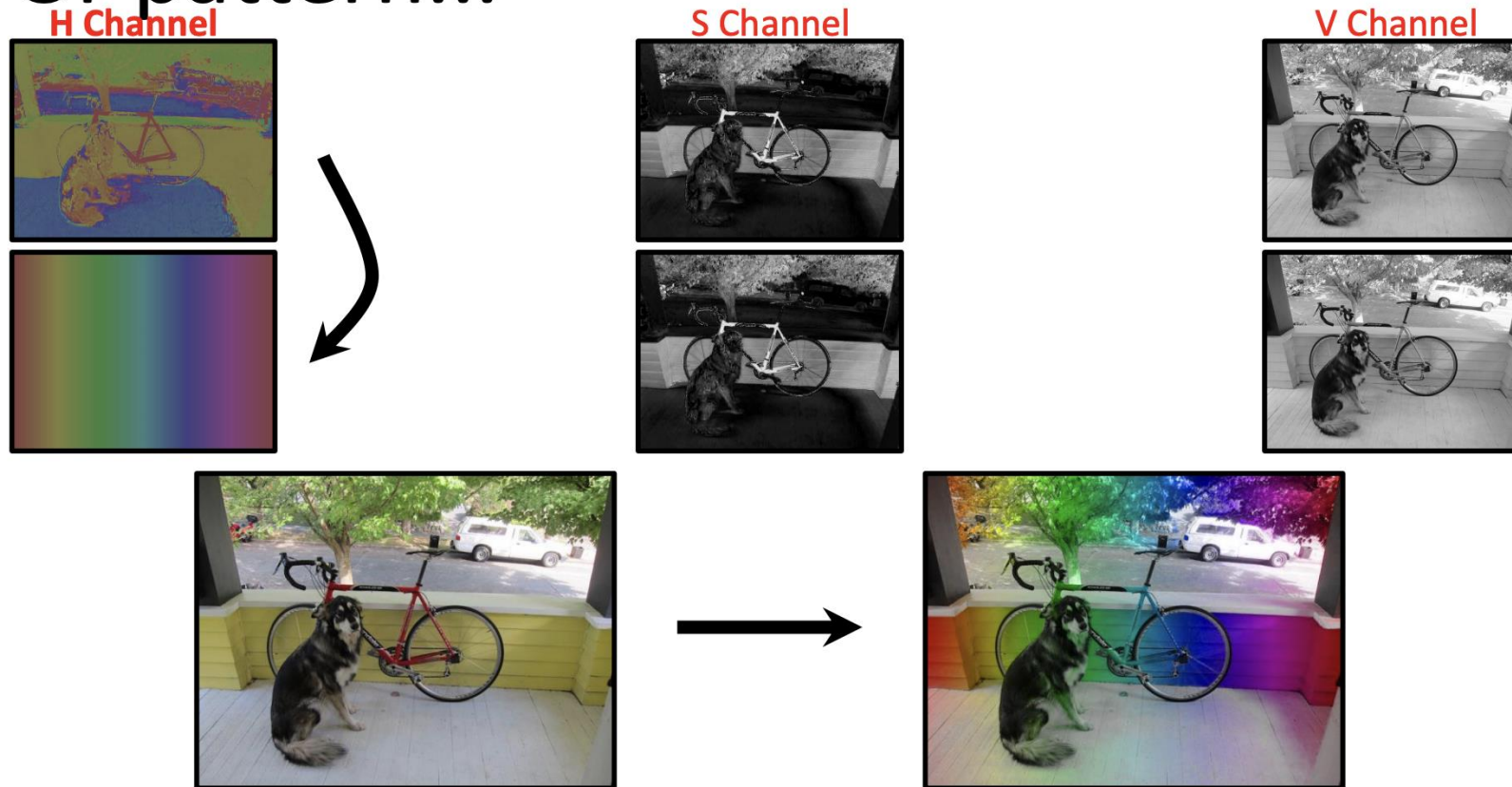
Color: Histograms

- A histogram of a grayscale image is an array $H[*]$ of bins, one for each gray tone

- $H[i]$ gives the count of how many pixels of an image have gray tone i

- $P[i]$ (the normalized histogram) gives the percentage of pixels that have gray one i

```
// traverse all pixels and accumulate the count of same intensity values
for ( i = 0; i < pixelCount; ++i )
{
    histogram[image[i]]++;
}
```
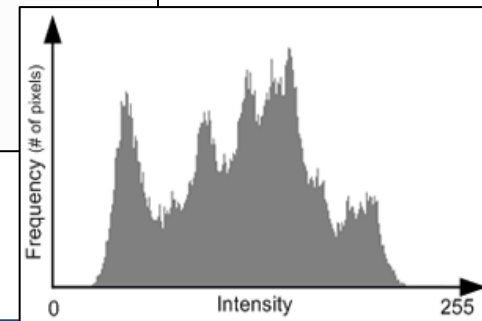
Color: Histograms
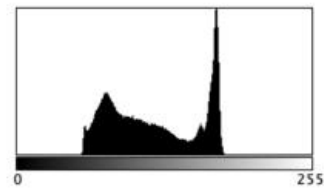
low contrast

normal contrast

high contrast

SOUTH DAKOTA
STATE UNIVERSITY

What is a Texture?

- Image texture is a set of metrics to quantify the perceived texture of an image

What is a Texture?
Local Binary Pattern (LBP)

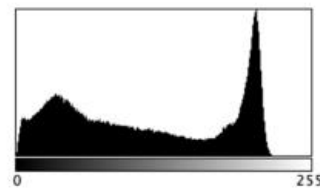- For each pixel p, create an 8-bit number $b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8$, where $b_i = 0$ if neighbor i has value less than or equal to p's value and 1 otherwise.

- Represent the texture in the image (or a region) by the histogram of these numbers.

100	101	103
40	50	80
50	60	90

$\longrightarrow$ **1 1 1 1 1 1 0 0**
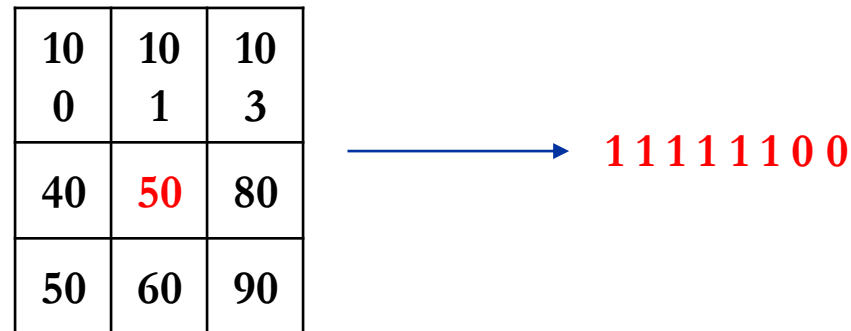
What is a Texture?
Local Binary Pattern (LBP)

- Example:
  - Image database system retrieves images similar to the query image using LBP texture
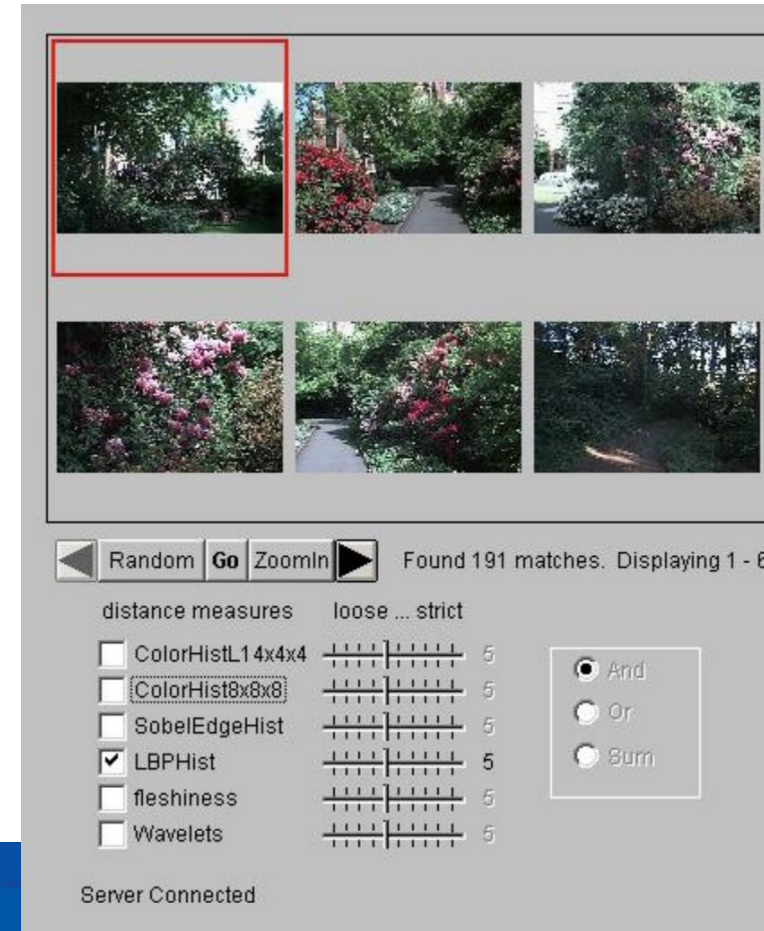
What is a Texture?
Local Binary Pattern (LBP)

- Not always semantically similar images

- But, effective for low-level semantic information

- What if we need more high-level semantics?
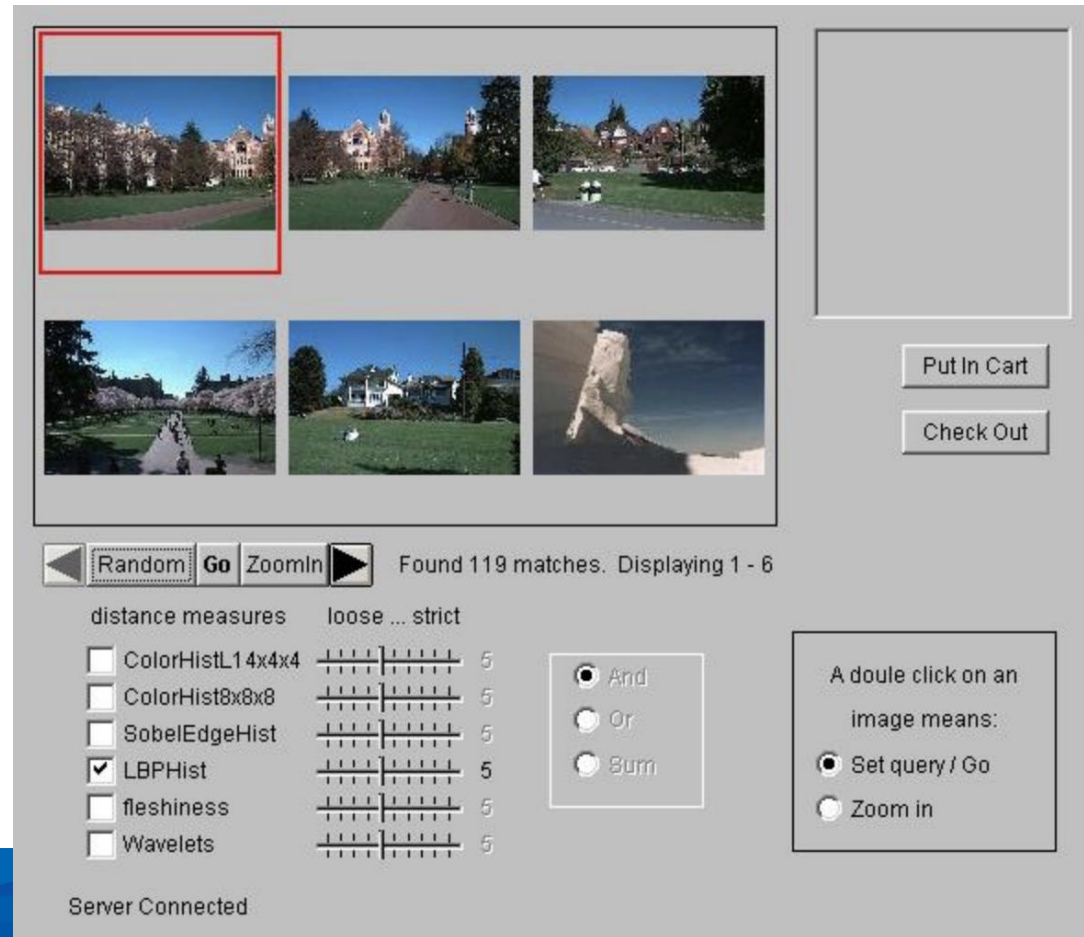
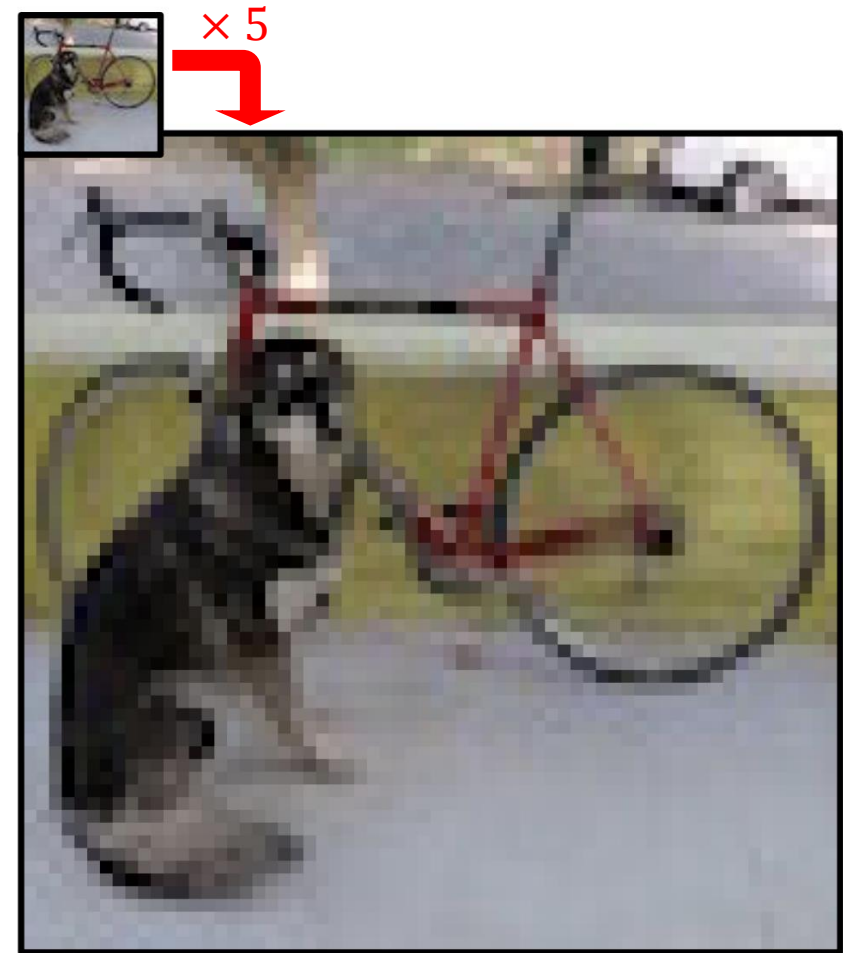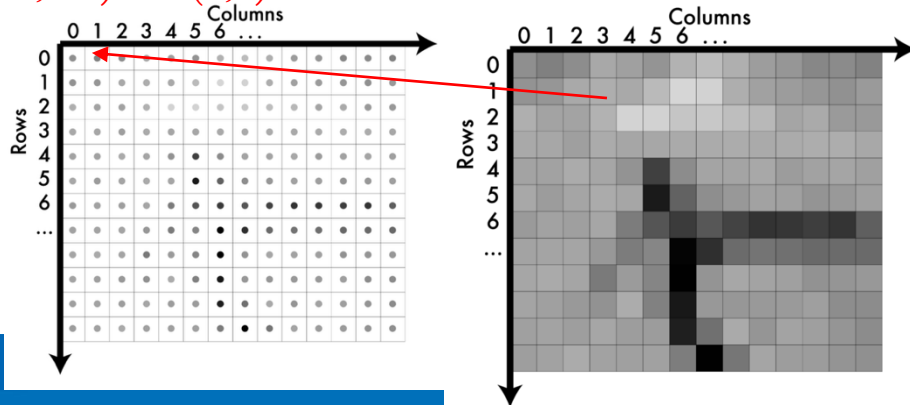Image taken at Niagara Falls during my graduation trip ☺

How to Resize an Image?

Credits: some slides of this section are adapted from CSC 492/592 (Spring 2024)
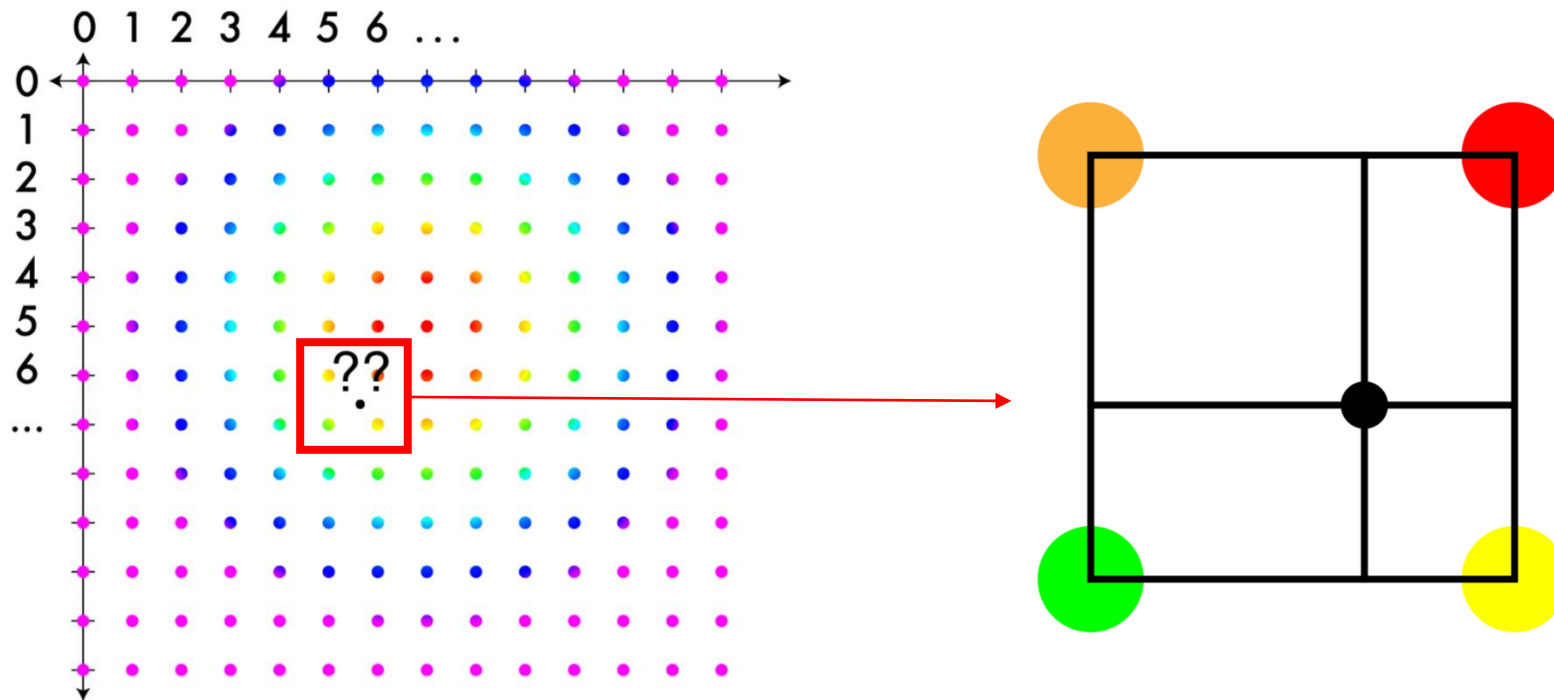
Method 1: Nearest-Neighbor Interpolation

- $f(x, y) = Im(round\left(\frac{x}{s}\right), round\left(\frac{y}{s}\right))$

× 5

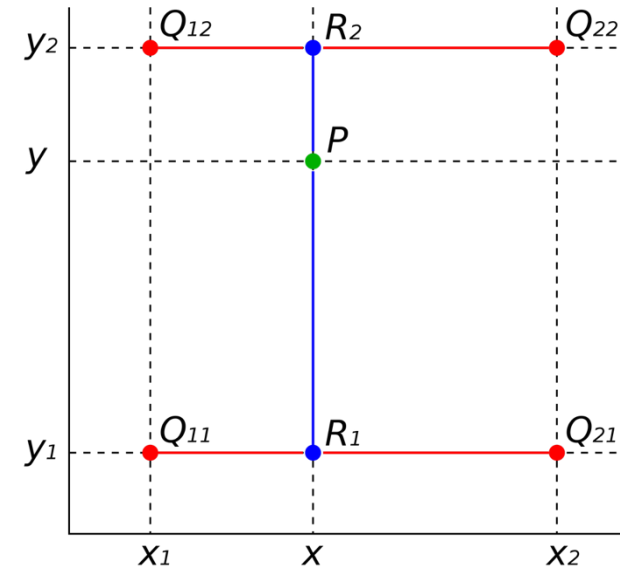(0.6, 0.2) → (1,0)

Method 2: Bilinear Interpolation

Method 2: Bilinear Interpolation

$$R_1: f(x, y_1) = \frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21})$$

$$R_2: f(x, y_2) = \frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22})$$

$$P: f(x, y) = \frac{y_2 - y}{y_2 - y} f(x, y_1) + \frac{y - y_1}{y_2 - y_1} f(x, y_2)$$

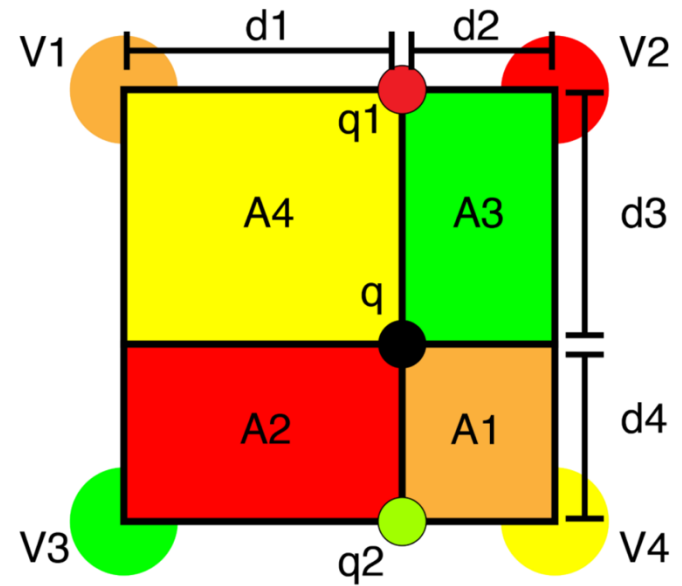# Method 2: Bilinear Interpolation

$$q = V1 * A1 + V2 * A2 + V3 * A3 + V4 * A4$$
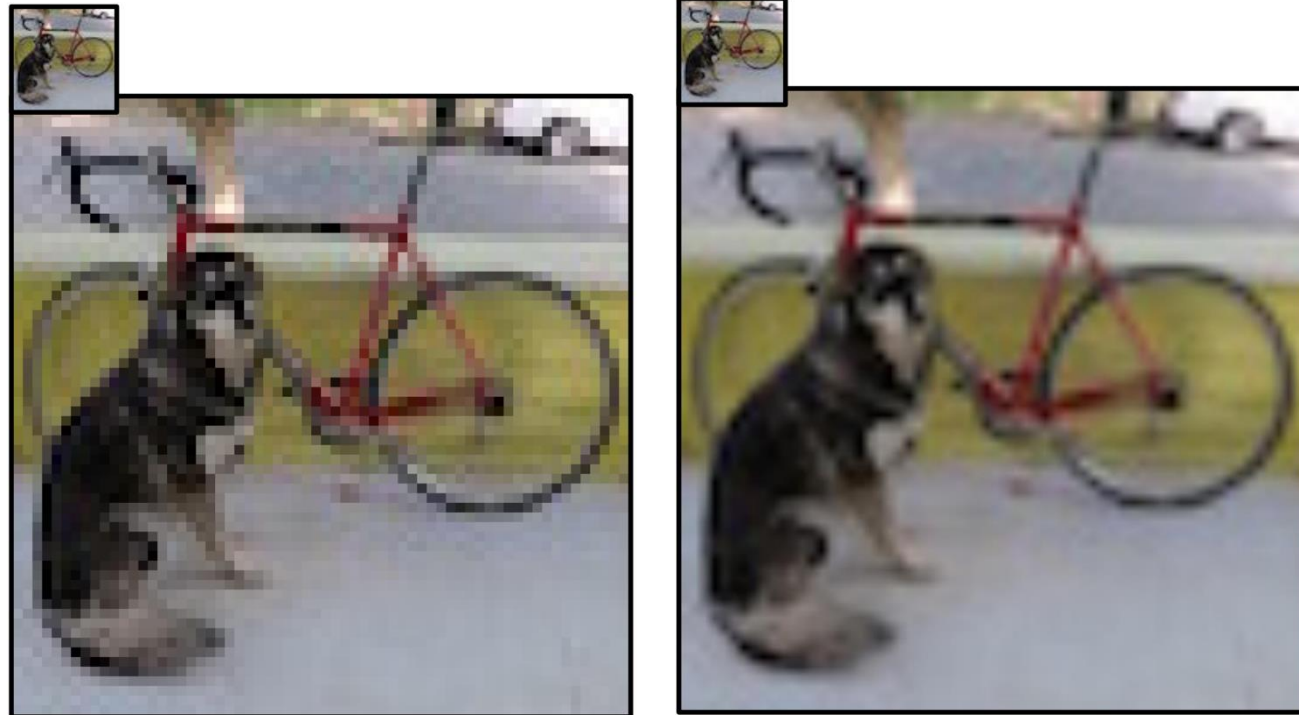
$$A1 = d2 * d4$$
$$A2 = d1 * d4$$
$$A3 = d2 * d3$$
$$A4 = d1 * d3$$
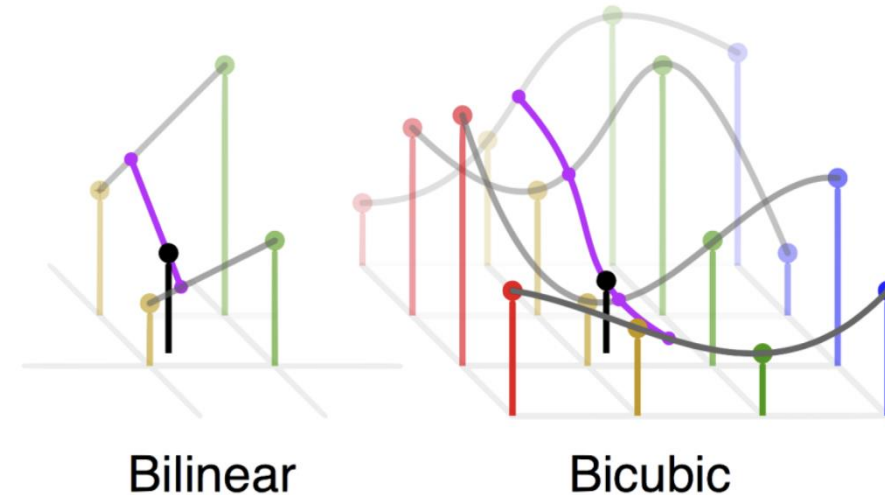
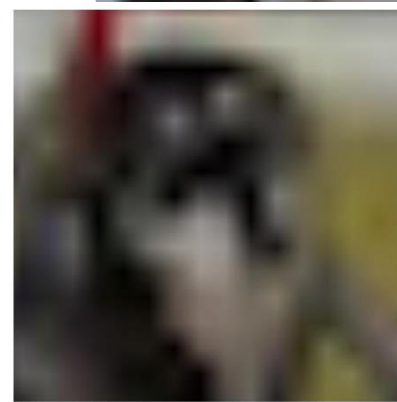# Nearest-Neighbor vs. Bilinear

- Smoother than NN

- More complex

- Tradeoff: speed vs. quality

Method 3: Bicubic Interpolation

- Smoother than bilinear

- 16 nearest neighbors

- Fit 3rd order poly:
  - $f(x) = a_0 x^0 + a_1 x^1 + a_2 x^2$

- Interpolate along axis

- Fit another poly to another axis

Bilinear   Bicubic

Bicubic vs. Bilinear
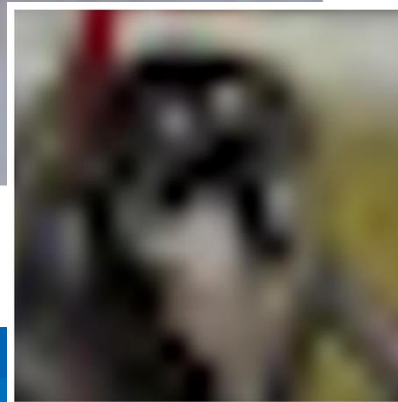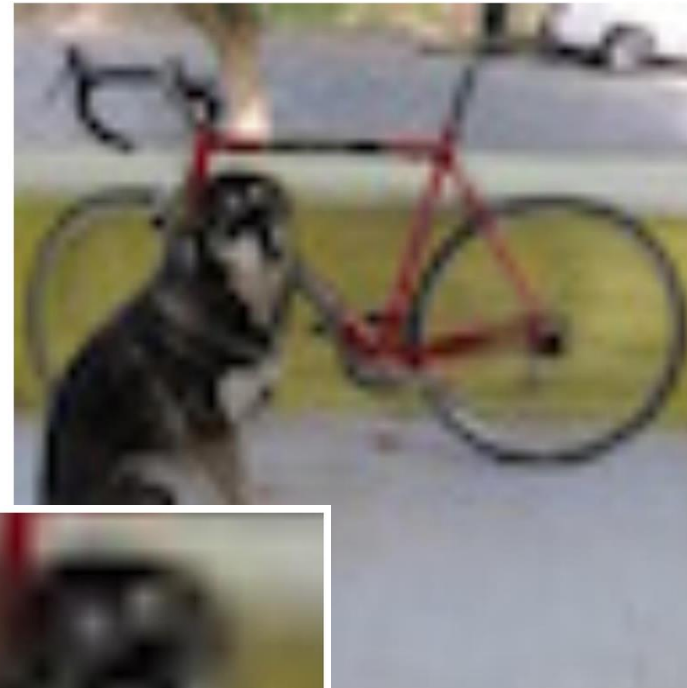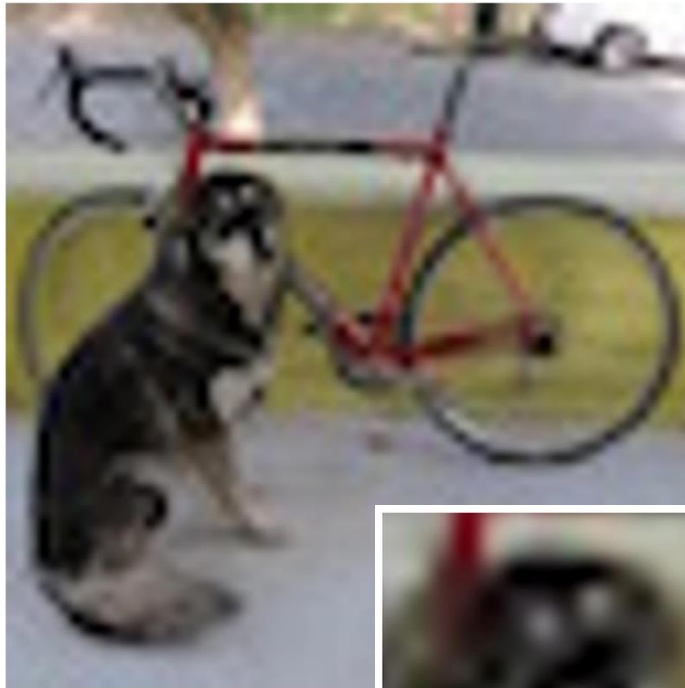
Comparison of bicubic interpolation with some 1- and 2-dimensional interpolations
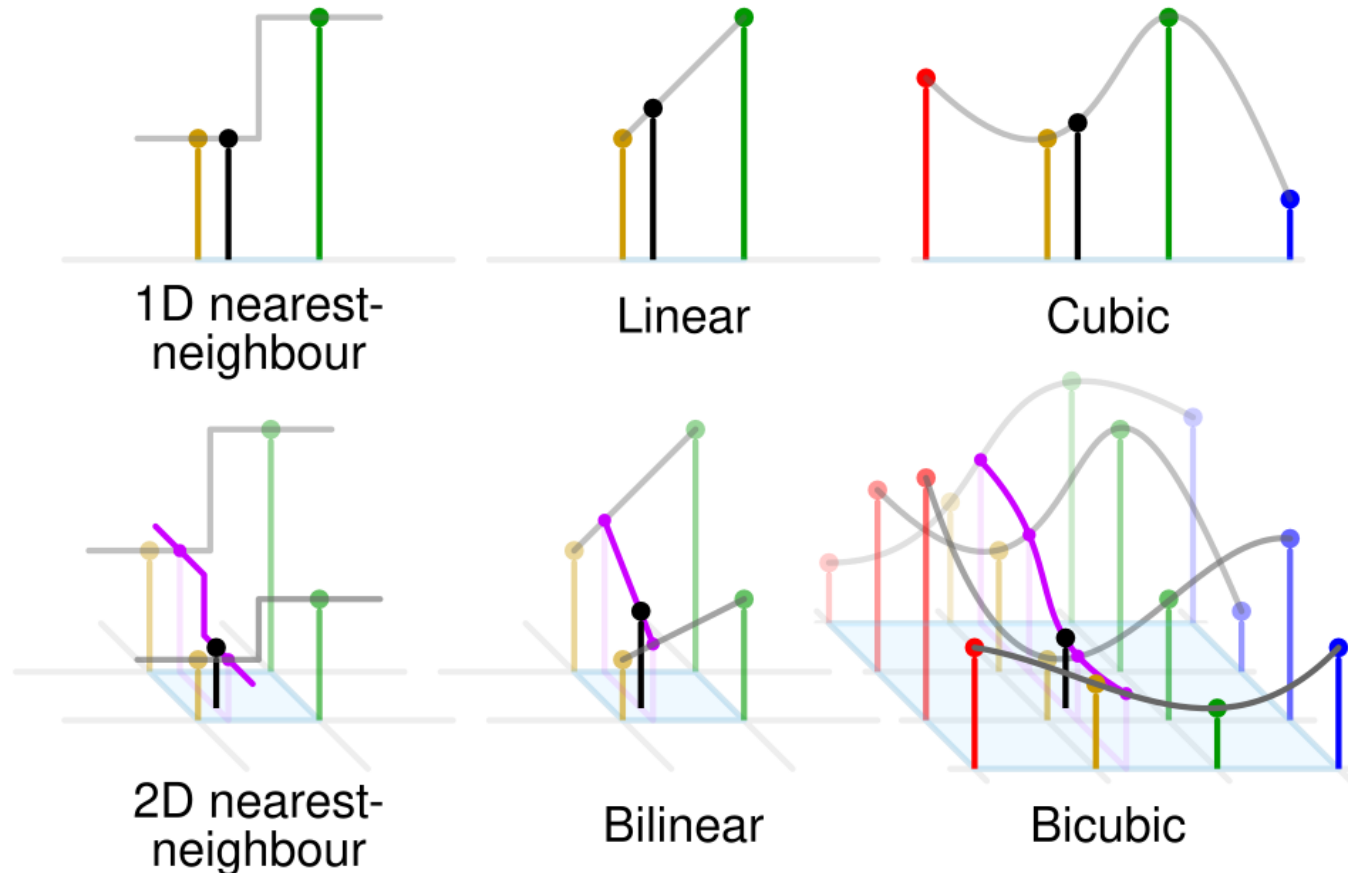
Source:
https://en.wikipedia.org/wiki/File:Comparison_of_1D_and_2D_interpolation.svg

South Dakota State University

Nearest-Neighbor vs. Bilinear vs. Bicubic
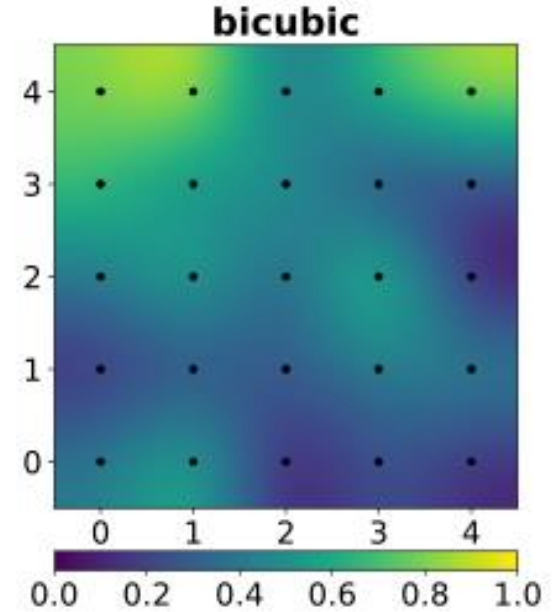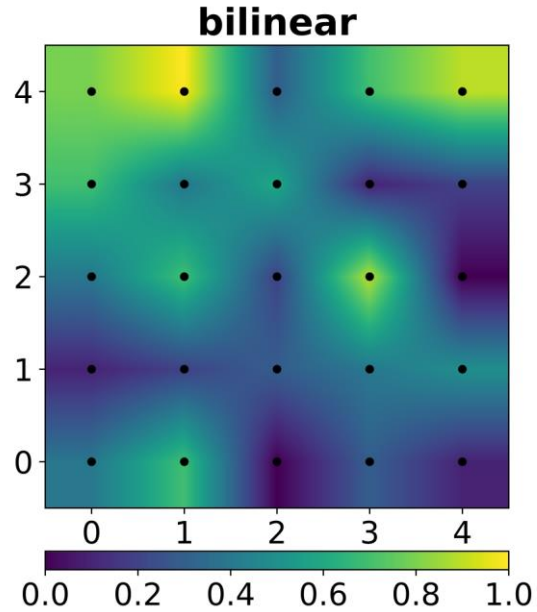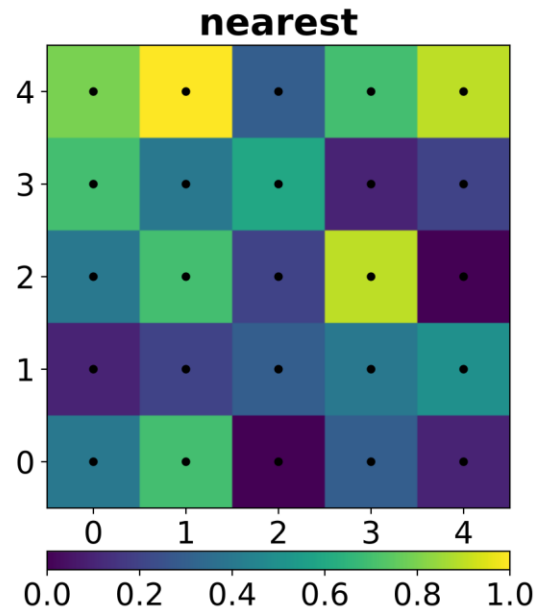
Source: https://en.wikipedia.org/wiki/Bicubic_interpolation

Image from: https://opencv.org/blog/read-display-and-write-an-image-using-opencv/

OpenCV practice in Colab

Reading an Image in OpenCV
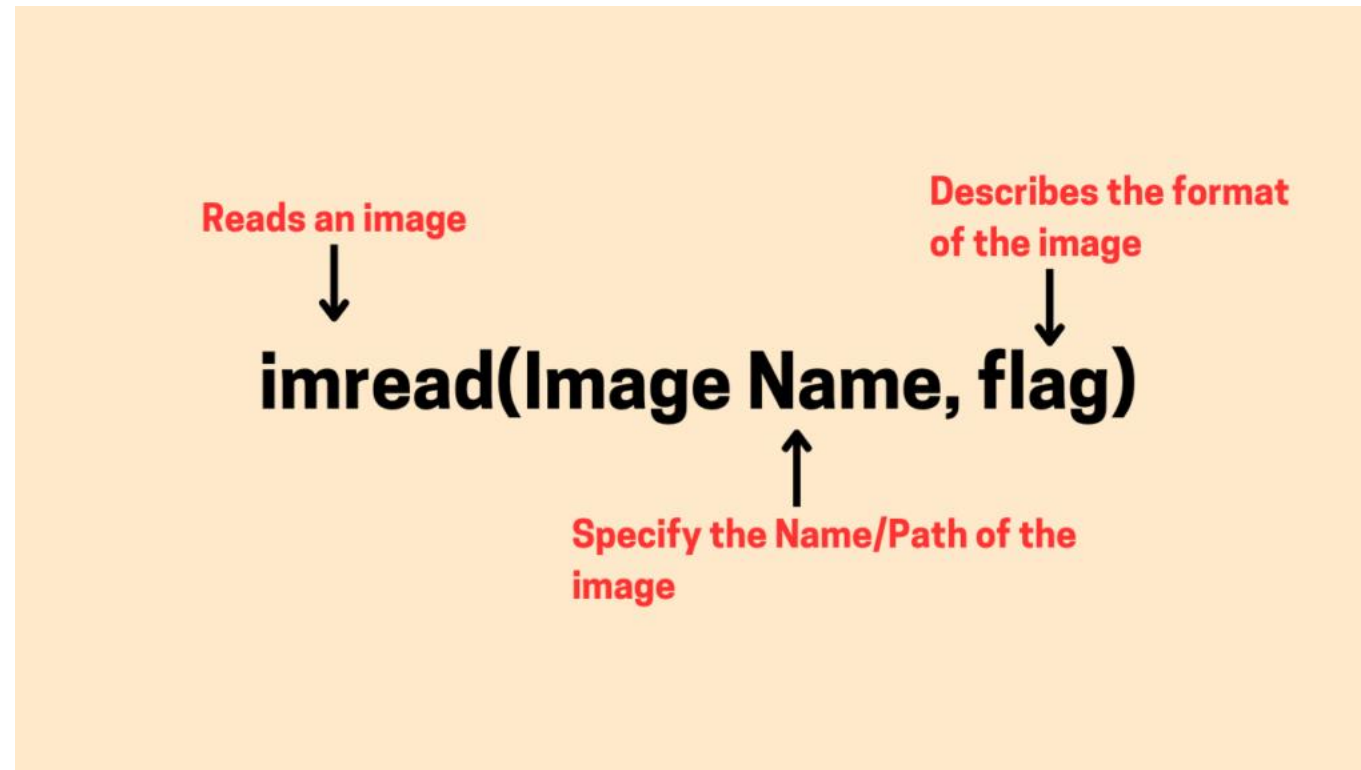
Reading an Image in OpenCV

Flags	Alternative Value	Description
IMREAD_UNCHANGED	-1	Loads the image as is, including the alpha channel (if present). Total of 4 channels – (3-BGR & 1-Alpha)
IMREAD_GRAYSCALE	0	Loads the image in grayscale mode (single channel).
IMREAD_COLOR	1	Loads the image in full color (default mode, 3-BGR) ignores alpha channel

https://opencv.org/blog/read-display-and-write-an-image-using-opencv/

Resize an Image in OpenCV

SOUTH DAKOTA
STATE UNIVERSITY
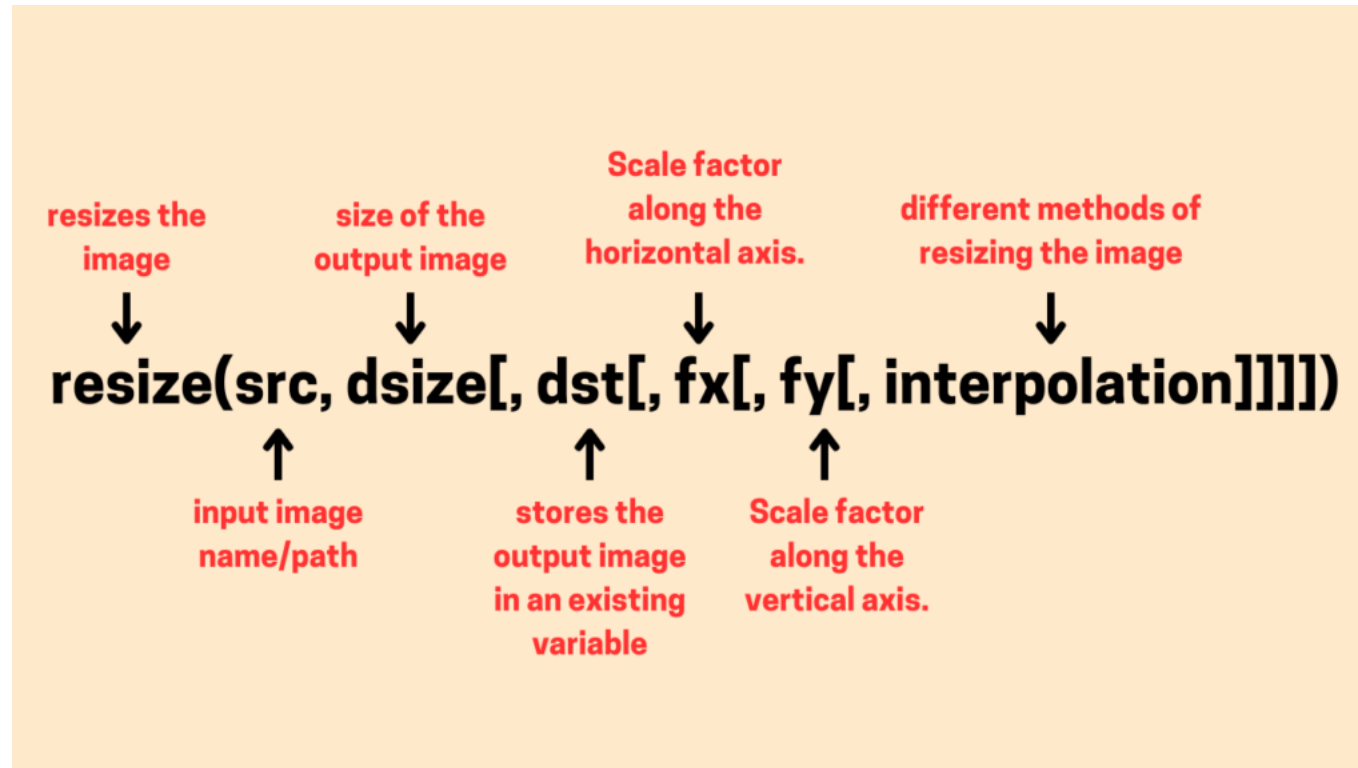
Resize an Image in OpenCV

Method	Description	Best Used For
INTER_NEAREST	Nearest-neighbor interpolation (fastest, but low quality)	Simple, fast resizing (e.g., pixel art, binary images)
INTER_LINEAR	Bilinear interpolation (default method)	General-purpose resizing (good balance of speed & quality)
INTER_CUBIC	Bicubic interpolation (uses 4×4 pixel neighborhood)	High-quality upscaling, smoother results
INTER_AREA	Resampling using pixel area relation	Best for **shrinking** images (avoids aliasing)
INTER_LANCZOS4	Lanczos interpolation using 8×8 pixel neighborhood	High-quality **upscaling & downscaling** (preserves fine details)

https://opencv.org/blog/resizing-and-rescaling-images-with-opencv/#h-opencv-function-to-resize-images

Let's Practice More Operations in Colab!

- Link: https://colab.research.google.com/drive/1wZt00QnxYgMVjlih16RI73IS_99UlHQt?usp=sharing

Takeaway

- Image properties: color, histogram, texture

- Different interpolation methods to resize an image

- Use OpenCV to perform basic image processing
  - Color space transformation
  - Crop and resize
  - Histogram Equalization

Questions?