Project 1
CSC 613 - Machine Learning
Grading: 100 points
Due Date: March. 16, 2020

Description: As the digital world is rapidly expanding, image processing is becoming more prevalent and important. For example, Instagram was acquired for $725 million dollars using only the basic techniques that you will be performing in the project. You will be programming several image processing algorithms to enhance images using Python. This lab is meant to reinforce the basic data structures, variables, and methods that you have learned thus far.

There are many built in commands in Pillow that perform these operations for you. However, you will not be using these built-in commands, but rather writing the algorithms from scratch.

Part 1 - Grayscale (20 points)

(a) Original image. (b) Grayscale result.

Figure 1: Ggrayscale sample result for Part 1.

Grayscale is an image processing technique that takes a 3 channel RGB image and turns it into a single channel of gray values. The color image can be represented in vector form as $< R, G, B >$. The range of values that a pixel may take is 0-255. To properly convert a color image into a grayscale image, one must use the following formula:

$$Y = 0.2989R + 0.5870G + 0.1140B \tag{1}$$

where R,G,B represent the intensity values of the red, green, and blue channel respectively, and Y represents the grayscale value. Use numpy to obtain the 3 channels into separate variables and perform matrix-scalar multiplication to get the final result.

Part 2 - Contrast stretch (20 points)

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by "stretching" the range of intensity values it contains

(a) Original image. (b) Contrast result.

Figure 2: Contrast stretch with the values $c = 0$ and $d = 180$

to span a desired range of values, e.g. the the full range of pixel values that the image type concerned allows. Contrast stretching takes the following form,

$$< \hat{R}, \hat{G}, \hat{B} >= (< R, G, B > -c)\frac{(b-a)}{(d-c)} + a \tag{2}$$

where a and b are the lower and upper limits of the image, respectively. In our case, these limits will be normally be set to 0 and 255. c and d represent the mapped range such that a maps to c and b maps to d. For this, we can use $a = 0$, $b = 255$, $c = 0$ and d=180.

Part 3 - Gaussian blur (20 points)

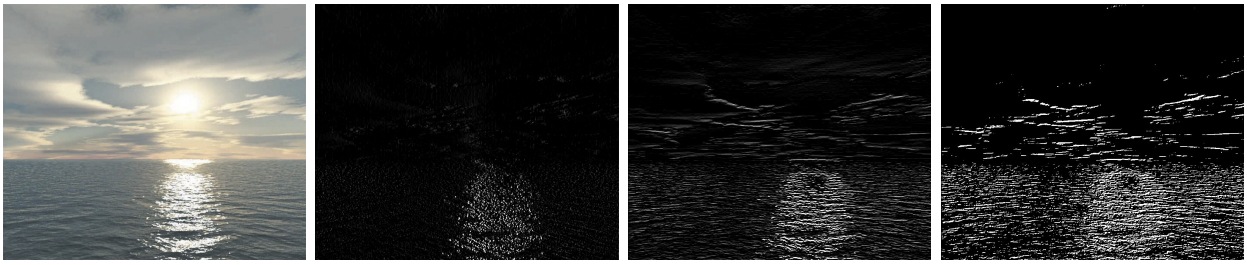
(a) Original image. (b) Blurred result.

Figure 3: Gaussian blur with $\sigma = 1$ and 5x5 kernel.

A Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. The Gaussian function is defined as,

$$G(x, y) = \frac{1}{2\pi\sigma^2} \exp^{-\frac{x^2+y^2}{2\sigma^2}} \tag{3}$$

You will create a 5x5 Gaussian kernel and convolve the kernel with the image to produce a blurred result. You can assume that $\sigma = 1$ for all cases.



(a) Original image. (b) G_x. (c) G_y. (d) G_{thresh}.

Figure 4: Edge detection using the Sobel filter. G_{thresh} is computed at threshold = 50.

Part 4 - Sobel edge detection (20 points)

The Sobel operator, sometimes called Sobel Filter, is used in image processing and computer vision, particularly within edge detection algorithms, and creates an image which emphasizes edges and transitions. The Sobel filter is defined as the following 3x3 matrix,

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}, G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \tag{4}$$

You may implement the Sobel edge operator either through a straight correlation of the 3x3 matrix, or you may use seperable filters to accomplish this task (which are slightly more efficient), or through the use of a dot product between stacked vectors. Use a threshold of 50.

Part 5 - Color transfer (40 points)

(a) Original image. (b) Target image. (c) Color transfer result.

Figure 5: Color transfer result borrowing the colors from the target image and applying it to the source image.

The article, "Color Transfer between Images" describes a method for a more general form of color correction that borrows one image's color characteristics from another image. You will be converting the image to LAB space which minimizes correlation between channels for many natural scenes. This space is based on data-driven human perception research that assumes the human

visual system is ideally suited for processing natural scenes. Follow the procedure carefully in that article.

Part 6 - PDF write up (20 points) Create a 2 page write up that summarizes the interesting parts of your program and includes results. Include any problems or insights that you encountered.

Deliverables: Email to me PDF and iPython Notebook.