IT5437 Assignment 1 on Intensity Transformations and Neighborhood Filtering

Ranga Rodrigo

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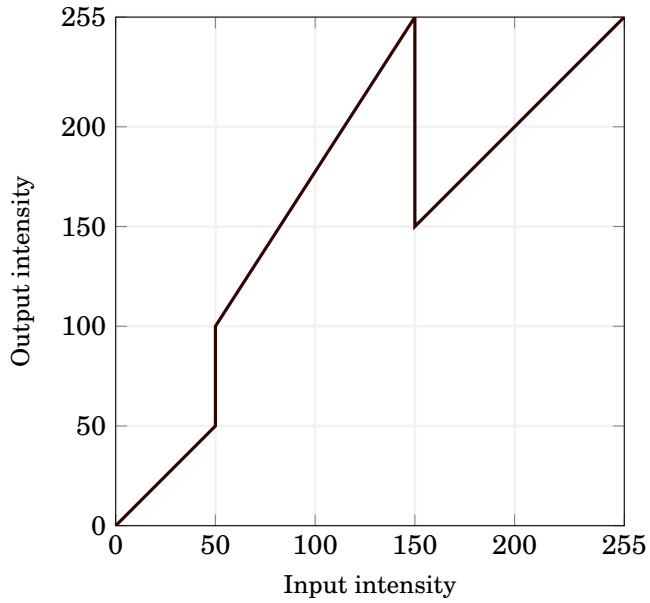
1. Implement the intensity transformation depicted in Fig. 1a on the image shown in Fig. 1b. **[10]**



(a) Intensity transformation.

(b) Image for intensity transformation.

2. Apply a similar operation as above (question 1) to accentuate

   (a) white matter

   (b) gray matter

   in the brain proton density image shown in Fig. 2. Show the intensity transformations as a plots. **[10]**

Figure 2: A brain proton density slice.

3. Consider the image shown in Fig. 3[1]. **[10]**

   (a) Apply gamma correction to the L plane in the $L^*a^*b^*$ color space and state the γ value.

   (b) Show the histograms of the original and corrected images.

Figure 3: Image for gamma correction.

4. Increasing the vibrance of a photograph is probably achieved by applying an intensity transformation such as

$$f(x) = \min\left(x + a \times 128 e^{-\frac{(x-128)^2}{2\sigma^2}}, 255\right),$$

   to the saturation plane, where x is the input intensity, $a \in [0,1]$ and $\sigma = 70$. **[10]**

   (a) Split the image shown in Fig. 4 into hue, saturation, and value planes.

   (b) Apply the aforementioned intensity transformation to the saturation plane.

   (c) Adjust a to get a visually pleasing output. Report the value of a.

   (d) Recombine the three planes.

   (e) Display the original image, vibrance-enhanced image, and the intensity transformation.

Figure 4: Image for enhancing the vibrance.

5. In this question, we will apply histogram equalization only to the foreground of an image to produce an image with a histogram equalized foreground. **[10]**

   (a) Open the image in Fig. 5, split it into hue, saturation, and values and display these planes in grayscale.

   (b) Select the appropriate plane to threshold in extract the foreground mask. A mask is a binary image.

   (c) Now obtain the foreground only using cv.bitwise_and and compute the histogram.

   (d) Obtain the cumulative sum of the histogram using np.cumsum.

   (e) Use the formulas in slides to histogram-equalize the foreground.

   (f) Extract the background and add with the histogram equalized foreground.

   Show the hue, saturation, and value plane, the mask, the original image, and the result with the histogram-equalized foreground.

6. Filtering with the Sobel operator can compute the gradient. Consider the image shown in Fig. 6 **[10]**

   (a) Using the existing filter2D to Sobel filter the image.

[1] https://www.adobe.com/creativecloud/photography/discover/highlights-and-shadows.html

Figure 5: Image for histogram equalizing the foreground.

(b) Write your own code to Sobel filter the image.

(c) Using the property

$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & -1 \end{bmatrix},$$

carry out Sobel filtering.

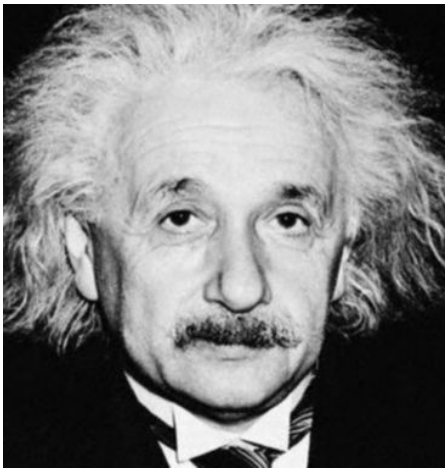


Figure 6: Image for Sobel filtering.

7. Write a program to zoom images by a given factor $s \in (0, 10]$. You must use a function to zoom the image, which can handle

   (a) nearest-neighbor, and

   (b) bilinear interpolation.

   I have included four images, two large originals, and there zoomed-out versions. Test you algorithm by computing the normalized sum of squared difference (SSD) when you scale-up the given small images by a factor of 4 by comparing with the original images. **[10]**

8. Fig. 7[2] shows a flower image with both the foreground and background are in focus. **[10]**

   (a) Use grabCut to segment the image. Show the final segmentation mask, foreground image, and background image.

   (b) Produce an enhanced image with a substantially blurred background. Display the original image alongside the enhanced image.

   (c) Why is the background just beyond the edge of the flower quite dark in the enhanced image?

9. Consider the rice image shown in Fig. 8. **[10]**

   (a) Preprocess the image 8a to remove noise.

   (b) Preprocess the image 8b to remove noise.

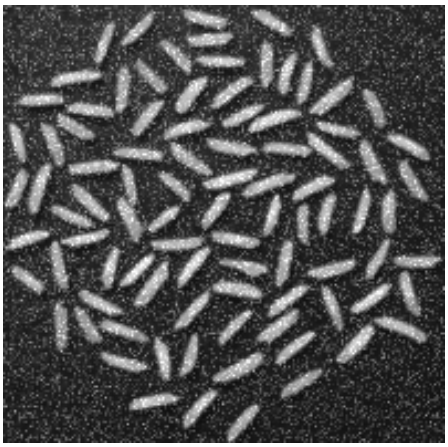
[2] https://steemit.com/marguerite/ctrl-alt-nwo/marguerite-daisy

Figure 7: Image enhancing.

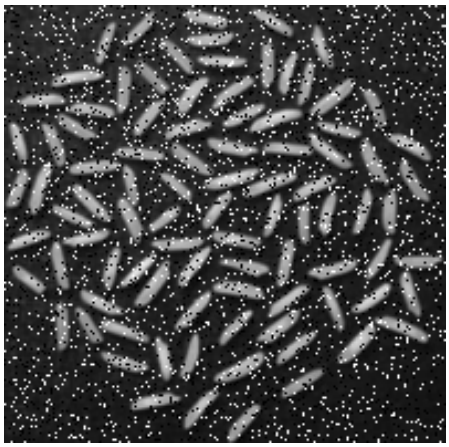
(c) Apply Otsu's method to segment the image.

(d) Apply morphological operations to remove the small objects and fill holes.

(e) Use connected components to count the number of rice grains.



(a) Gaussian noise corrupted.



(b) Salt-and-pepper noise corrected.

Figure 8: Images for rice grain counting.

10. Fig. 9 shows a an image of two sapphires placed on a table. The optical axis is perpendicular to the surface of the table. **[10]**

    (a) Apply a segmentation algorithm to obtain a binary mask for the sapphires.

    (b) Apply a morphological operation to fill the holes.

    (c) Run connectedComponentsWithStats to obtain the areas in pixels.

    (d) If $f = 8$ mm and the camera lens is 480 mm away from the table surface, compute the actual areas of the sapphires.

GitHub Profile

You must include the link to your GitHub (or some other SVN) profile, so that I can see that you have worked on this assignment over a reasonable duration. Therefore, make commits regularly. However, I will use only the pdf for grading to save time.

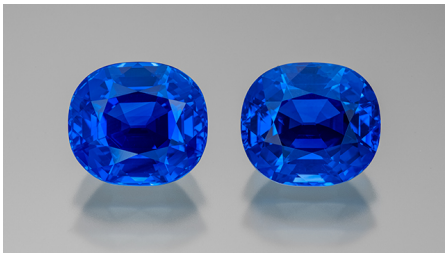


Figure 9: Image of sapphires.

Submission

Upload a report (eight pages or less) named as your_index_a1.pdf. Include the index number and the name *within the pdf* as well. The report must include important parts of code, image results, and comparison of results. The interpretation of results and the discussion are important in the report. Extra-page penalty is 20 marks per page.