Assignment 4: Artistic Stylization

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Section 4 and Section 2 (respectively)

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Introduction

The purpose of this assignment was to perform “stylization” or “non-photorealistic” effects. This application of image processing is to manipulate the image to produce a natural artistic effect, such as making an image look like an oil painting or an unnatural effect, such as changing the colour pallet of the image.The assignment consists of two sections: the eXtended Difference of Gaussians (XDoG) effect and a cartoon drawing effect.

This assignment builds off the knowledge learned in the previous assignments where it is just applying existing concepts in a new way. This assignment was conducted using MATLAB and C. MEX functions allows MATLAB to use C code to create image processing operations and MATLAB allows script files to call these MEX function in order to perform these operations on the images which results in a desired output image.

Theory

The eXtended Difference of Gaussians (XDoG) filter is a stylizing technique based on the second order derivative filtering and thresholding. The XDoG filter is defined as:

$$D_{\sigma,k,p}(x, y) = (1 + P)G_{\sigma}(x, y) - pG_{k\sigma}(x, y)$$

The second term of the equation is an image blurred with the gaussian filter multiplied by a k value; which controls how large the blurring kernel is compared to the original Gaussian filter which is the first term of the equation. The k value has a range of anything greater than zero. The value k = 1.6 is approximately a true Laplacian of Gaussian filter. The XDoG filter does not preserve the range of value in the original image since there is no restriction on the value of p which can cause the XDoG filtered image to have a large range of value.

Once the image is filtered using the XDoG filter, thresholding must be performed on the filtered image to bring the range of values in the image to a range of 0 to 1. There are two types of thresholding: hard threshold and soft threshold.

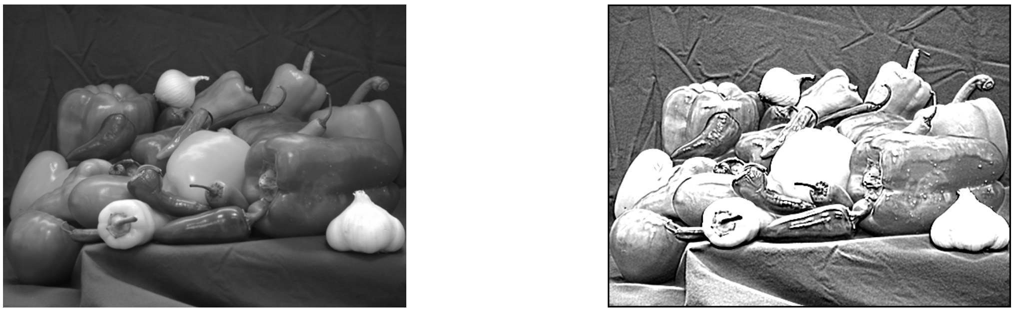
$$T_{\epsilon}(u) = \begin{cases} 1 & u > \epsilon \\ 0 & otherwise \end{cases} \qquad T_{\epsilon,\phi} = \begin{cases} 1 & u > \epsilon \\ 1 + tanh(\phi(u - \epsilon)) & otherwise \end{cases}$$

From the hard threshold equation we can see that there will be two distinct values 0 or 1 in the output image. From the soft threshold equation, we can see that the output image will have values of 1 if it’s greater than the threshold value else it would be between 0 and 1 due to the hyperbolic tangent function. The controls how sharp the transition is between 0 and 1. The cartoon filter does two operations, it first smears the colours of the original image to give “painted” image appearance, and then it overlays the edges of this “painted” image.

Results

3.1.1

Q. 1



(a) Original Image (b) Transformed Image

Figure 1: eXtended Difference of Gaussian

Q. 2

(a) Original Image (b) Transformed Image

Figure 2: Hard Threshold

(a) Original Image (b) Transformed Image

Figure 3: Soft Threshold

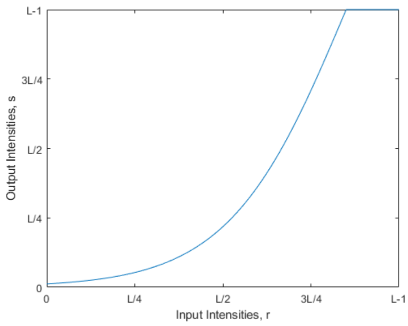


Figure 4: Soft Thresholding Image Intensity Function (Low Phi)

Q. 3

(a) Original Image

(b) Transformed Image

Figure 5: Three tone operator

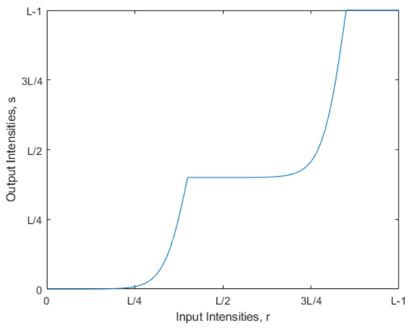


Figure 6: Three Tone Image Intensity Function

3.1.3

Q. 1

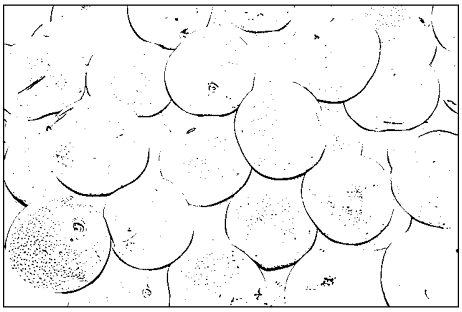
(a) Original Image

(b) Transformed Image

Figure 7: Median Smoothing

Q. 2

(a) Original Image



(b) Transformed Image

Figure 8: Edge Extraction

Q. 3

(a) Original Image

(b) Transformed Image

Figure 9: Merging Images

Analysis

Three Tone

For the three tone operator, we tried to best approximate it using this function which we based of the two tone operator.

$$T_{\epsilon,\phi} = \begin{cases} 1 & u \geq \epsilon_h \\ 1 + (tanh(\phi(u - \epsilon_h))) \cdot (1 - h_m) & \epsilon_m \leq u < \epsilon_h \\ (1 + tanh(\phi(u - \epsilon_m))) \cdot h_m & u \leq \epsilon_m \end{cases}$$

This function gave the Three tone image intensity as seen in Figure 6.

Cartoon Effect

For the cartoon effect we used the median filter to created a smoothed image. As is apparent the filtering in the y direction is much greater than that of the x direction, this was done because the effect was more pleasant.

Next, for the edge detection, we used the difference of Gaussian to extract the edges as the method described in the hint was not producing appealing edges. Afterwards the result was put through a median filter to remove outliers and then hard thresholded so that the the resultant image can be used as its own mask, similar to the masking operation in assignment 1. Finally the two images where combined and the result image is figure 9 (b). This produce a nice comic book effect as the edges are more thicker than those in the assignment example.

Conclusion

In this lab, the subjective benefits of Artistic Stylization with respect to extended difference of Gaussians and cartoon effect filters were observed. With extended difference of Gaussian, for example, varying the sigma value and k constant would produce subjective effects depending on the input image. This resulted in a lot of tinkering to produce an effect that was visually appealing. This exact same process was used even more so in the cartoon effect portion of the lab. varying the median filter, the edge detection was critical to producing a pleasant effect.

References

1. “Assignment 4 – Artistic Stylization.” Assignment 4 – Artistic Stylization, 2016.

2. Gonzalez, Rafael C., and Richard E. Woods. Digital Image Processing. 4th ed. New York, NY: Pearson, 2008.