**Project Title:  Image Processing Fundamentals**

**Project Number**: Project 3

**Course Number**: CEG 7850-01

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**Declaration Statement:**

I hereby declare that this Report and the Matlab codes were written/prepared entirely by me based on my own work, and I have not used any material from another Project at another department/ university/college anywhere else, including Wright State. I also declare that I did not seek or receive assistance from any other person and I did not help any other person to prepare their reports or code.  The report mentions explicitly all sources of information in the reference list. I am aware of the fact that violation of these clauses is regarded as cheating and can result in invalidation of the paper with zero grade. Cheating or attempted cheating or assistance in cheating is reportable to the appropriate authority and may result in the expulsion of the student, in accordance with the University and College Policies.

**Abstract:**

This project shows various applications of effective filtering and image enhancements. The efficacy of median filtering over filtering using averaging is shown. Image improvements are shown with the application of Laplacian filters. The Laplacian is used to sharpen image features both in a series of sequential improvements and as a standalone enhancement. Unsharp masking and high boost filtering are replicated to show the effects of lowpass filtering in combination with feature amplification to sharpen image features. Finally, the series of image enhancements from the text are replicated and shown to improve the quality of the image and its features.

**Technical Discussion:**

All of the processing techniques implemented in this project were done so with the function nlfilter. Additionally, the entire project source code has been implemented in a single file, with main.m making calls to the relevant subfunctions. These subfunctions are found at the end of the file in the order that they are utilized.

Problem 1 makes use of the built-in mean and median MatLab functions. These functions are applied to the subject image with a sliding kernel of dimensions 3x3, as are all windows in this project unless otherwise specified.

Problem 2 relies on the definition of a gaussian filter defined in equation (3-45) and the corresponding approximation of the gaussian kernel (defined in Figure 3.35 from the text) as follows:

(1/4.8976).\*[ 0.3679 , 0.6065 , 0.3679 ;

0.6065 , 1.0000 , 0.6065 ;

0.3679 , 0.6065 , 0.3679 ];

Problem 3 also relies on equation (3-45) which is defined as follows:

G(x,y) = Ke^(-1\*(x^2+y^2)/(2\*sigma^2))

We use the approximated transformation from problem two to create a blurred – or unsharpened – image. The image is then used as an unsharp mask in the highBoostGaussianTransform function, which is just a Gaussian transformation with values of k = 4 and sigma = 1. The output of this image is then added to the output to enhance the sharpness of the image.

Problem 4 consists of several enhancements techniques being applied sequentially to recreate the same enhancements found in Figure 3.57 from the textbook. This process consists of application of a Laplacian transform and using the resultant mask to enhance the original through addition. The Sobol Gradient was also applied to the image along with an averaging filter of size 5x5. The resultants of these processes were than multiplied together, scaled to the original value range, and added to the original image. The final step was to apply a power-law transform to the new image. The power-law transform was derived from equation (3-5) in the text and is as follows:

S = c\*r^(gamma)

The values c = 25 and gamma = 0.4 were used to achieve the best outcome, as determined through experimentation.

**Results Discussion:**

Problem 1 shows that Salt-Pepper noise reduction is more successful with the application of a median filter than that of a mean filter. The results were quite dramatic and can be seen below, in Fig. 1 (a-c).

Problem 2 makes use of both the Laplacian and Gaussian transformations in the recreation of images from the textbook. The Laplacian approximation kernel is used to emphasize edges in the image and is then combined with the blurring induced by the unsharpened Gaussian transform to recreate an image noticeably higher in quality than the original, which can be seen in Fig. 2 (a-d).

Problem 3 shows that the combination of initially reducing the quality of the image through blurring will result in an overall enhancement in image quality with the application of a high boost enhancement to the unsharpened image and adding the results to the original image. This works because the processing of dulling and sharpening the image accentuates the areas of changing intensity in the image, similar to the Laplacian filter. Image quality improvements are easily seen in Fig 3. (a-c).

Problem 4 starts with an initially low quality image and applies the Laplacian transform to it. This mask is most easily seen after grayscale values are adjusted, thus as in the textbook, my results show the Lacplacian filter scaled in this way. The addition of the Laplacian mask to the original image results in some minor improvements in image sharpness. The Sobol Gradient is applied to the original image to better see the low intensity and low pixel density details in the image and is then smoothed using a mean transform to reduce the width of edges in the image, giving a better visual of the muscle tissues. This image is then multiplied with the Laplacian sharpened image to get the best of both transformations. Finally, the power-law transformation is applied to this product image to gain some minor non-linear detail enhancements. This process results in a dramatic improvement over the original image, and the entire process of images is seen in Fig. 4 (a-h).

**Results:**

A picture containing timeline

Description automatically generated

Figure 1: Resultant images from problem 1

A picture containing text

Description automatically generated

Figure 2: Resultant images from problem 2

A picture containing text

Description automatically generated

Figure 3: Resultant images from problem 3

A picture containing text

Description automatically generated

Figure 4: Resultant images from problem 4

**Appendix:**

**Written Programs:**

* Main.m
* meanTransform
* medianTransform
* laplacianTransform
* gaussianTransform
* highBoostGaussianTransform
* sobolTransform
* smoothTransform
* scalePixelValues
* powerTransform

**Utilized Programs:**

* subplot
* imshow
* imread
* pwd
* cast
* mat2grat
* nlfilter
* mean
* median
* sum
* max
* min
* abs
* zeros
* size