



Adaptive Image Enhancement

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Abstract Currently we are living in digital era. Therefore, the image multimedia is a crucial issue in our daily life. It may be categorized the digital multimedia over still image or a video image. Digital multimedia transmission helps everyone to keep information fresh where they can access it everywhere, anytime. In this paper, an adaptive image enhancement using different enhancement technique was developed. The focus in this work is to create an adaptive program that can improve the appearance of digital images by clicking on a single button. Images might suffer from the lack of brightness, overexposed to luminance, blurriness and noise from low light exposure. The adaptive image enhancement used different types of enhancement techniques in spatial domain. The results from the simulation shows the value of peak signal to noise ratio and the mean square error that will be used to calculate the difference in both original and enhanced images.

Keywords Image enhancement; Image filtering; Image segmentation; Spatial Domain Technique, Histogram equalization, Gamma Correction.

Introduction

Nowadays, everything bit of information can be extracted through an image. Moreover, it is common to use the techniques and the systems. This study relates generally to design and improve the quality of a digital image by using the existing image enhancement techniques, adaptively. Image enhancement is important in almost work field nowadays such as medical image analysis and top view of satellite images. Throughout studies, there are lots of utilization over some work of field such as the investigation of metabolic processes of plant and animal cells mostly research by the biologist, archeologist use this techniques to go through some ancient scripts. Therefore, there are many equipment especially to maximize the image techniques so it can be assess more efficiently. Jobs are created to help this area of work field so that it allow researcher to acquire the images for investigation using varied recording accessories so that everything can be done faster and dynamically. Eventually, every images that had been taken can be fix. In this paper, MATLAB application [1] will be used to create a Graphical User Interface (GUI). A GUI can be designed so that it can combine several techniques to create an adaptive image enhancement by clicking a single button. These image enhancement techniques help image to be fix from suffering a distortion such as blurry effect due to shaking, dark images because of small depth of field, or bright images due to room conditions. Many variant of algorithms for converting, inspect, diagnose and understanding the meaning of image patterns are possible today due to the advanced research of image processing and analysis technology and also continuation efforts of experts on trying to find more ways of obtaining important information [2].



Image Enhancement Techniques

This paper focuses on the image enhancement in spatial domain. There are three types of image enhancement techniques were used; Contrast Stretching, Gamma correction and Unsharp masking / edge enhancement. These techniques were chosen based on specification. For edge enhancement, it can produce an increased over detail areas and keep it unchanged in the uniform areas. It can increase the quality of an image by sharpening a corner from a picture (by pixel) [3-4]. Histogram equalization will help an image to be modified such that it can be visible when adjusting to a certain level. Please take note that, adaptive image enhancement is another level of automation that need a proper observation on how the techniques is being implemented. There will be many outcomes to this combination of image enhancement techniques. The tools that will be used are the MATLAB. MATLAB is used by millions of engineers and scientist worldwide with their interactive environment and high-level language. Later, the discussion regarding those 3 techniques will be detailed.

Table 1: Summary on Image Enhancement Technique in Spatial Domain

Author	Technique	Strength	Limitation
Mansung Kim [10], 2014	Unsharp Masking	Enhance the edge and detail information in an image	The system is sensitive to noise
S Bedi [12], 2013	Histogram Equalization	Create a better distributed histogram	Poor sharpness and contrast
Kandasan, R [14], 2014	Image Negative	Enhancing white or gray detail	Produce different outcome from original scene
Simon, N. [13], 2014	Contrast Stretching	Produce various degrees of spread in gray level	Details in an image might be lost as the effect of stretching
Maini, R. & Aggarwal, H [1], 2010	Compression of Dynamic Range	Change narrow range of low level input gray into wider range	Noise is created when changing the gray level
R. Fisher [10], 2003	Image Averaging	Remove noise from a series of noisy images	The samples will be averaged to zero if the image have zero noise

Proposed Techniques

For the adaptive image enhancement technique, the contrast stretching method will be used. The intensity value of an image can be stretch to that it can give a desired output. With the contrast stretching, it gives a full potential to the pixel to increase or decrease the intensity value. To precise, contrast stretching method is easy compared to other type of image enhancement techniques such as histogram specification.

The upper and the lower pixel value of the image need to be analyzed before it can be stretched. By using 8-bit gray level images, there will be lower and upper limits from 0 to 255. The lower limits and the upper limits can be set as a and b . As the image is being normalized, it is sorted to find the minimum and the maximum pixel values that is currently occupied in the image. These are c and d . pixel P is scaled within the equation:

$$P_{out} = (P_{in} - c) \left(\frac{b-a}{d-c} \right) + a \quad (1)$$

Take note that the values of that is below 0 (negative) will be set to 0 and those value that is higher than 255 will be set to 255.

Contrast stretching has some weaknesses. The value of c and d can be affected when dealing with single pixel. This could cause abnormal scaling due to very high or very low enhancement.

Gamma correction is another technique of transformation. Different level of enhancement can be obtained through this type of transformation function. Different manufacturer create a different display monitor display with their own specific intensities and clarity. Therefore, display monitor play the main role over this techniques, whether it has built-in gamma ranges which can give the best output for the user.

Edge enhancement filter or unsharp masking was chosen. This is because it can improves image details and other high frequency components in edge area using the original image and subtract it over a processed image. It



can create an enhancing details in an image [15]. This method focuses on high pass filter, followed by low pass filter.

An unsharp masking filter generates a detail image $d(x,y)$ from an input image $f(x,y)$ by the following equation

$$d(x,y) = f(x,y) - f_s(x,y) \tag{2}$$

To find $f_s(x,y)$ (smoothed image of $f(x,y)$,

$$f_s(x,y) = f(x,y) * \{HPF\} \tag{3}$$

The block diagram with High Pass filter (HPF) Low Pass filter (LPF) being applied is shown in figure 1.

The following are used in coefficient for high pass filter and low pass filter.

$$HPF^V = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}, \quad HPF^H = (HPF^V)^T, \tag{4}$$

Where,

$$f_{s,2}(x,y) = f(x,y) - [\{f(x,y) * HPF\} * LPF] \tag{5}$$

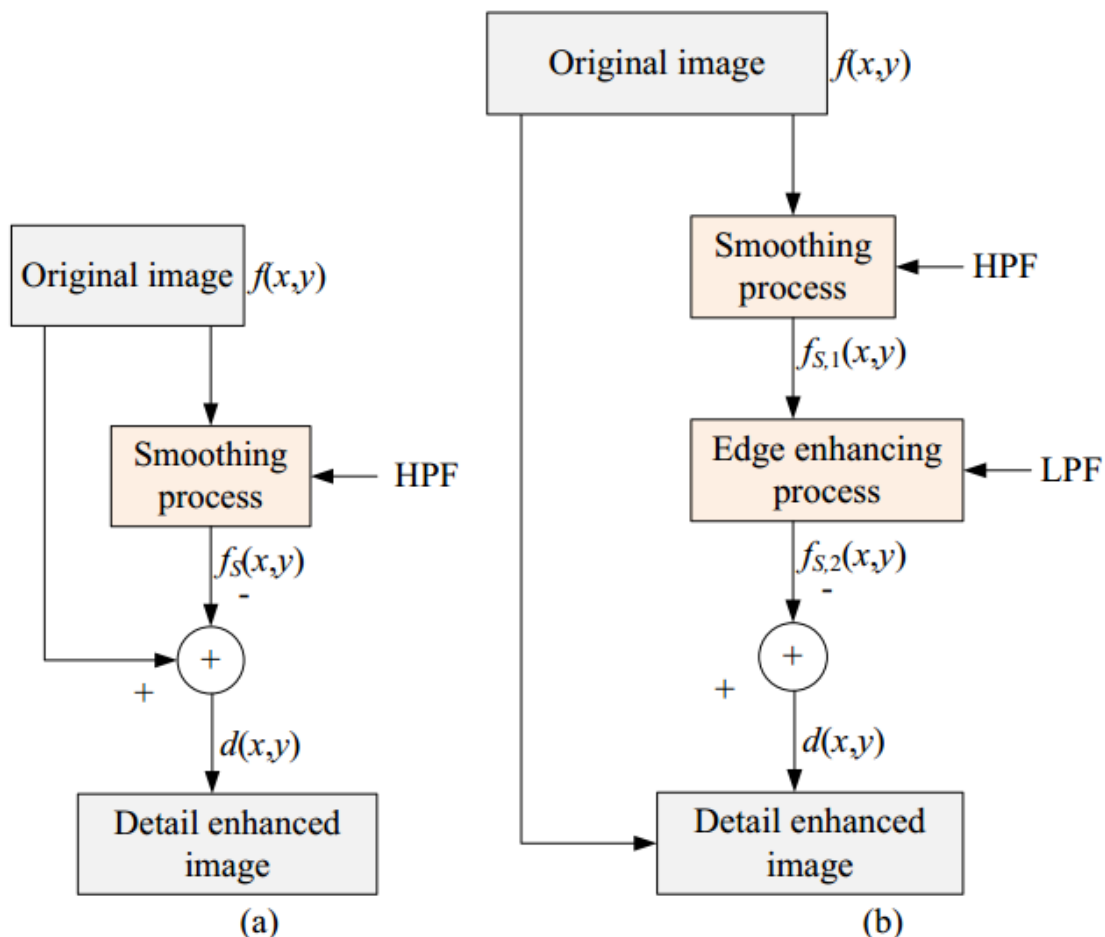


Figure 1: Block diagrams of the (a) general unsharp masking filter, (b) unsharp masking with low pass filter channel [10].

Histogram equalization is one of the ordinary methods in image enhancement. It has the ability to enhance the edge contrast over images and also videos. It also uses stochastic probability distribution of each channel level

of color images [11]. Therefore, it always been the one with the best approaches to improve the image contrast or to conserves the luminosity of image. Over a continuous quantity, pixel value can be normalized [10].

Two additional filters are added instead unsharp filter, median filter and average filter. Median filter, like other, are used to remove noise. It also being used widely because it preserves edges while removing noise. The idea of median filter is sliding a pixel like a window so it will be sorted out. Average filter used an algorithm that change each pixel value with the mean value different spot of pixel, including the pixel itself. This will change the existing pixels value like a convolution filter. [13].

Simulation Implementation

In this paper, MATLAB was used where the step by step methodology is shown. The program consists of panels that show different selection. The selections are from auto enhancement, manual enhancement, filtering option, and noise generation option.

Here are lists of buttons including its function for the graphical user interface created:

- Load Image – Load the image. Image format consist of .jpg, .bmp, .jpeg, and .png.
- Contrast – Auto contrast to the original image.
- Gamma – Gamma correction to the original image.
- Unsharp – Filter the original image using the unsharp filter algorithm.
- Median – Apply the median filter to the original image.
- Average – Apply the average filtering to the original image.
- Salt & Pepper – Set the original image to salt & pepper noise.
- Speckle – The original image will be filled with speckle noise.
- Reset – Reset the enhanced image back to the original image.
- Save Image – Save the current applied enhanced image to hard drive.
- PSNR – Show PSNR and MSE of original and enhanced image.

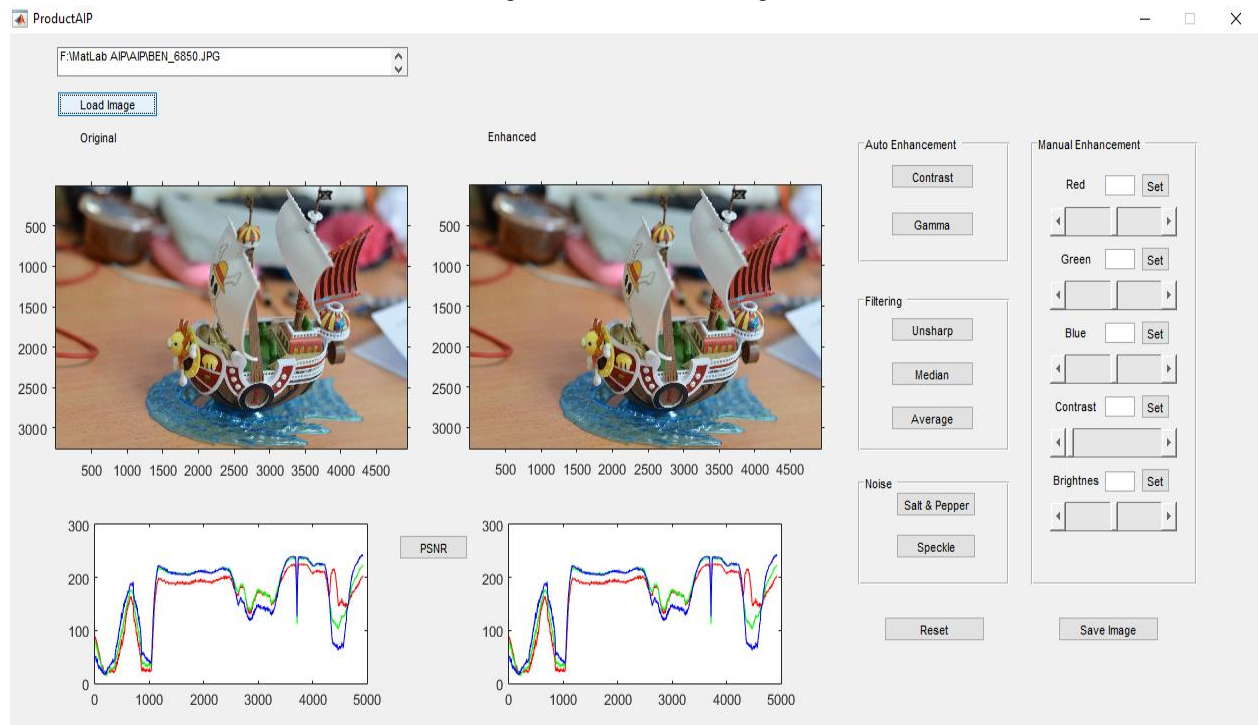


Figure 2: Selected menus after image selection for the program simulation.

Figure 2 shows the image selection, the image will have techniques to be choose on. The program will be able to change the histogram when applying any techniques even in the manual enhancement. Then, it will able to show the PSNR of the image.



Results and Analysis

Currently, the focus is to create a suitable algorithm that can improve the image quality. The effectiveness of the algorithm and its efficiency play the critical role in this part. Therefore, it is crucial to understand the definition of each method correctly. First, the program is tested using an image that have low aperture value (too dark). From the test, using the contrast button give the above image. All the pixel intensity in the image above are stretched so that it achieve a desired output. In histogram equalizer, the enhanced image get a high noise effect. Average PSNR shows that low value of ratio which explained the contrast method affect a high percent of the image quality

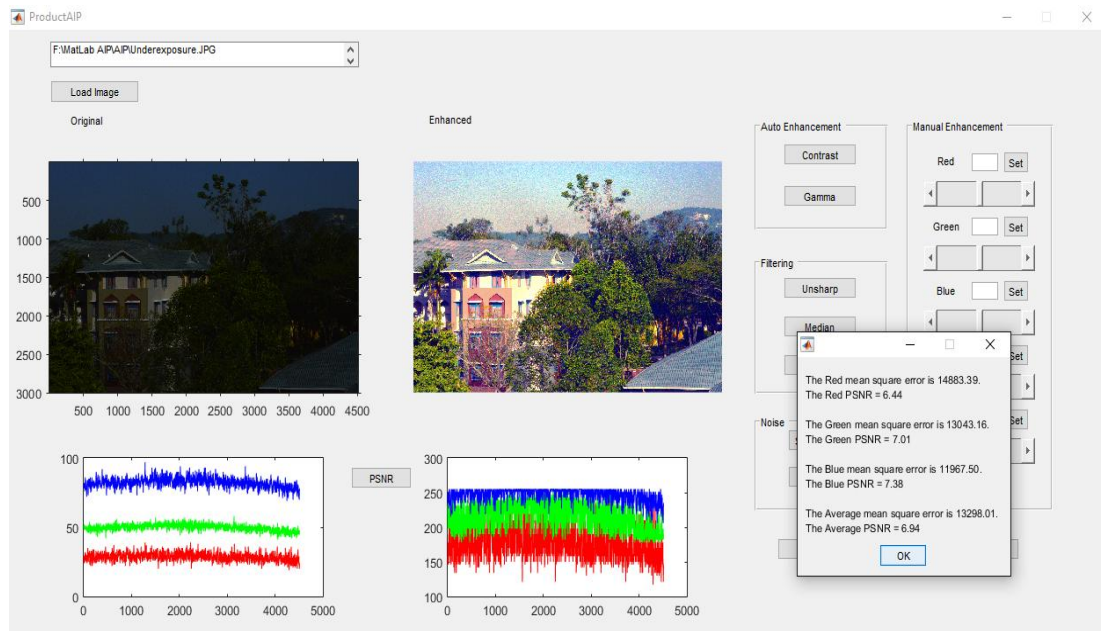


Figure 3: Underexposed image corrected using contrast adjustment.

Next, an image that have a high exposure image which brighten the image were used.

The analysis showed that the contrast enhancement that had been done to this image reduced most of the pixel intensity. In the histogram equalization graph, the value cannot be seen as most of the pixel have high value (maximum of 255). The average PSNR also show low value due to many changes to each pixel in this image. Gamma correction is used to optimize every pixel in a still image. It provide quality boost to picture that have good shots.

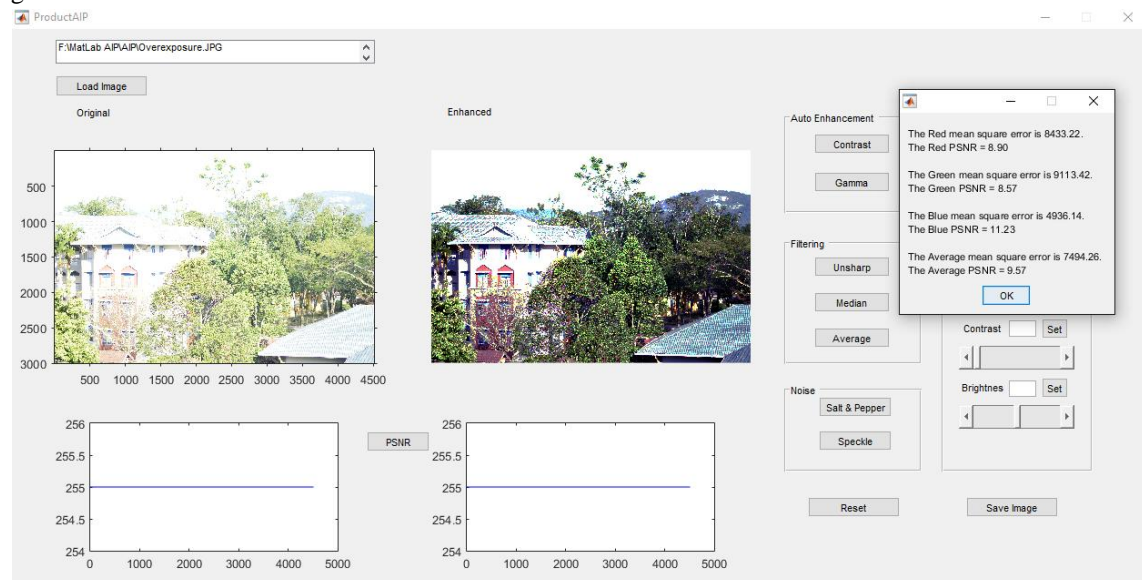


Figure 4: Overexposed image corrected using contrast adjustment.

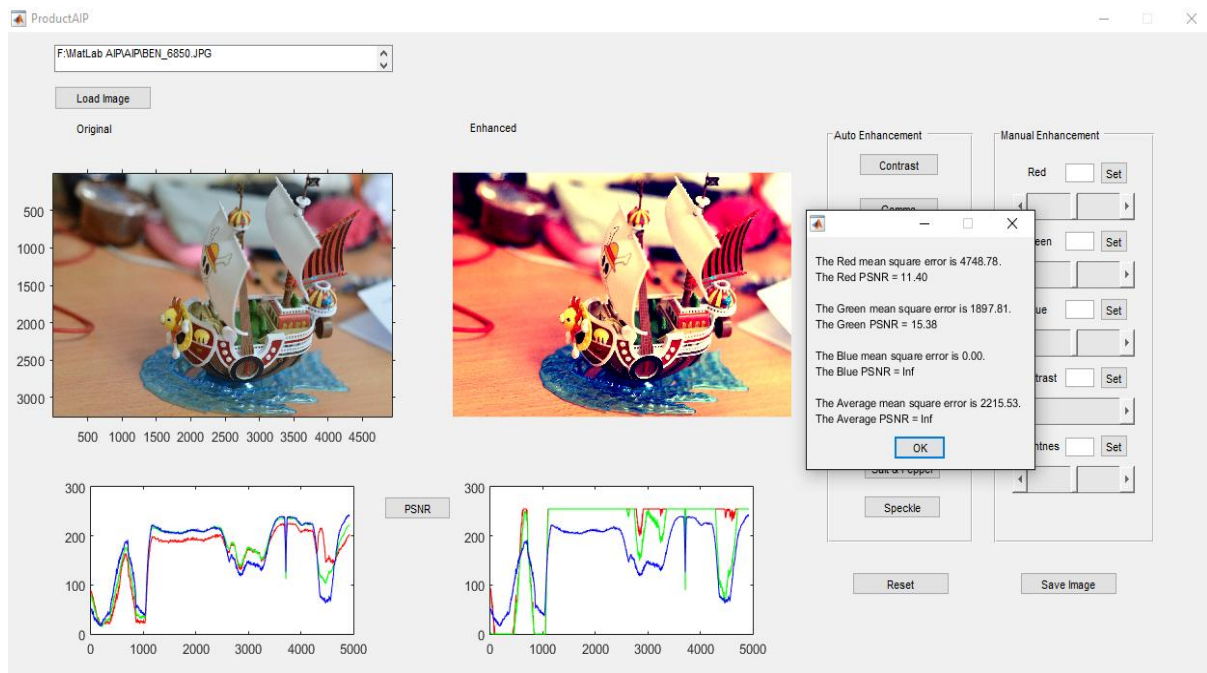


Figure 5: Enhanced image using gamma correcting.

In this observation, the Blue MSE and PSNR doesn't not change because of gamma correction properties. The gamma value only comprise the bright color pixel so it can enhance it for human viewing.

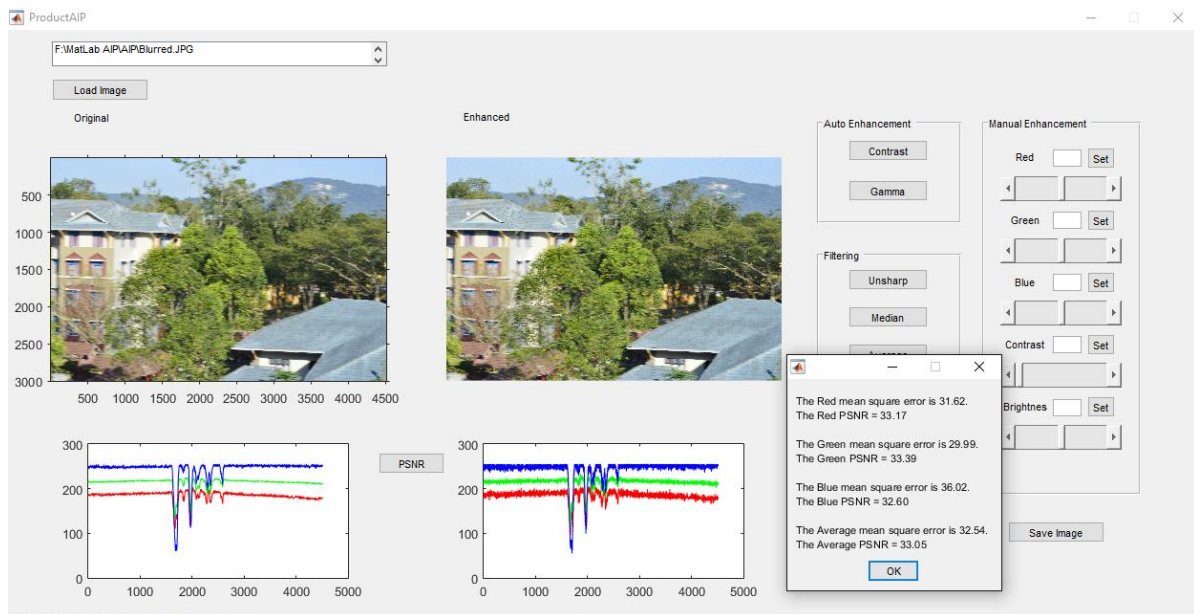


Figure 6: Blurred images sharpen using unsharp filter.

Low shutter speed causes an image to have blurred. Using unsharp filtering, they image was analyzed. It seem that pixels intensity are distorted so it can enhanced the edge of the original image. The image from figure 6 is then being filtered by using median filter.

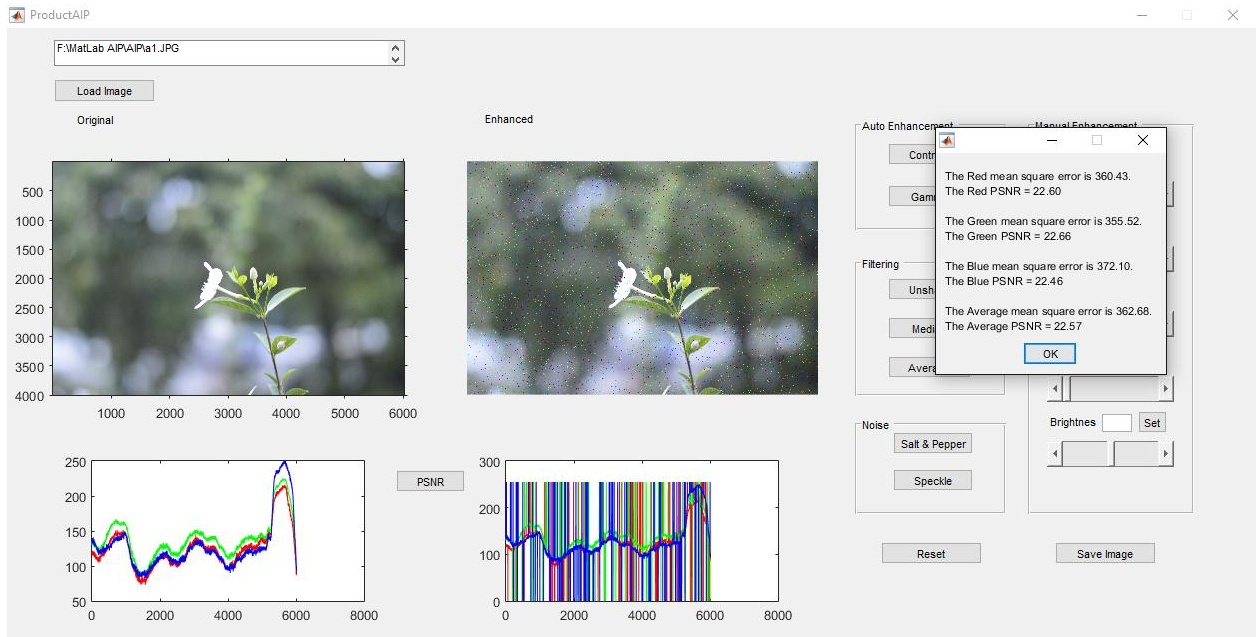


Figure 7: Salt & Pepper noise being added to the original image.

The noise generated by using salt & pepper noise create a distort value to the histogram equalizer. The average PSNR shows the quality of image that worsen when applying noise.

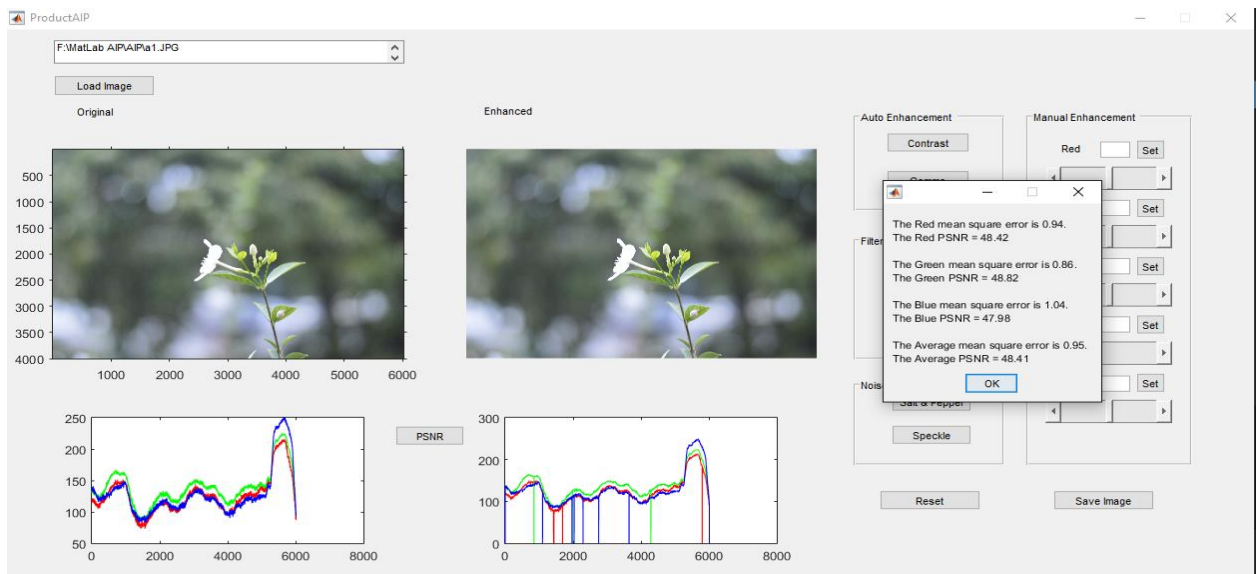


Figure 8: Salt & pepper noise removed by using median filter.

Applying Median filter almost completely removes the salt & pepper noise. Even though, it still could not generate a similar output from the original image. The histogram equalizer also shows some spike due to noise that were generated.

Lastly, the original image is then being added with speckle noise.

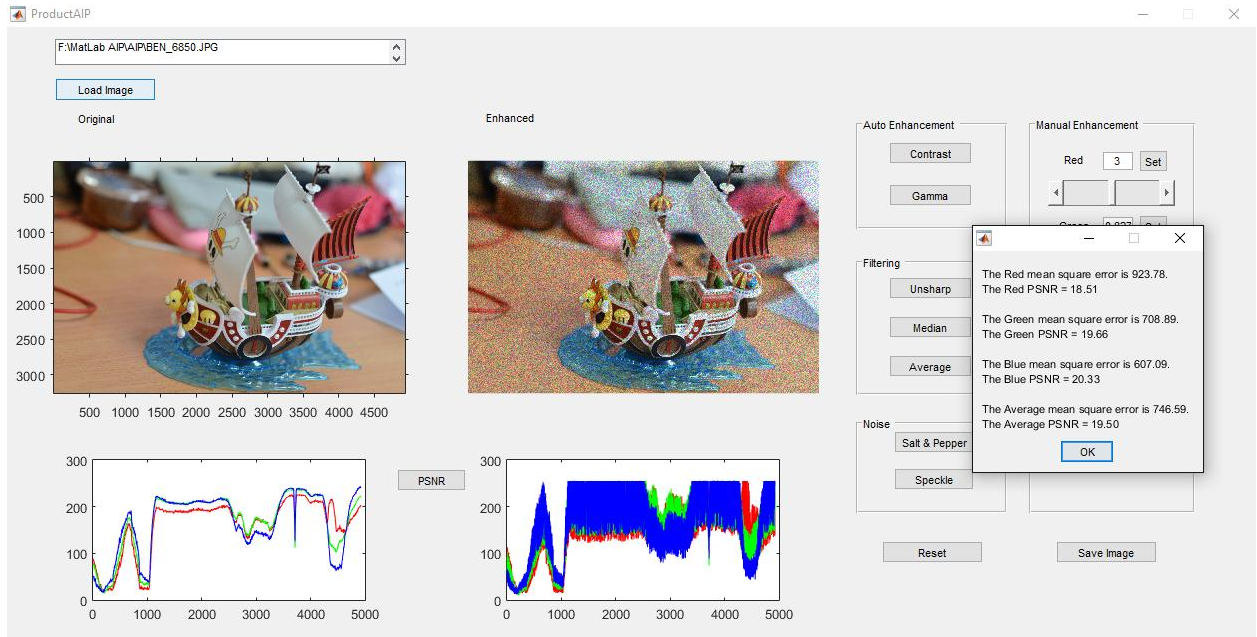


Figure 9: Image with speckle noise.

Then, applying the average filter from the image from figure 10.

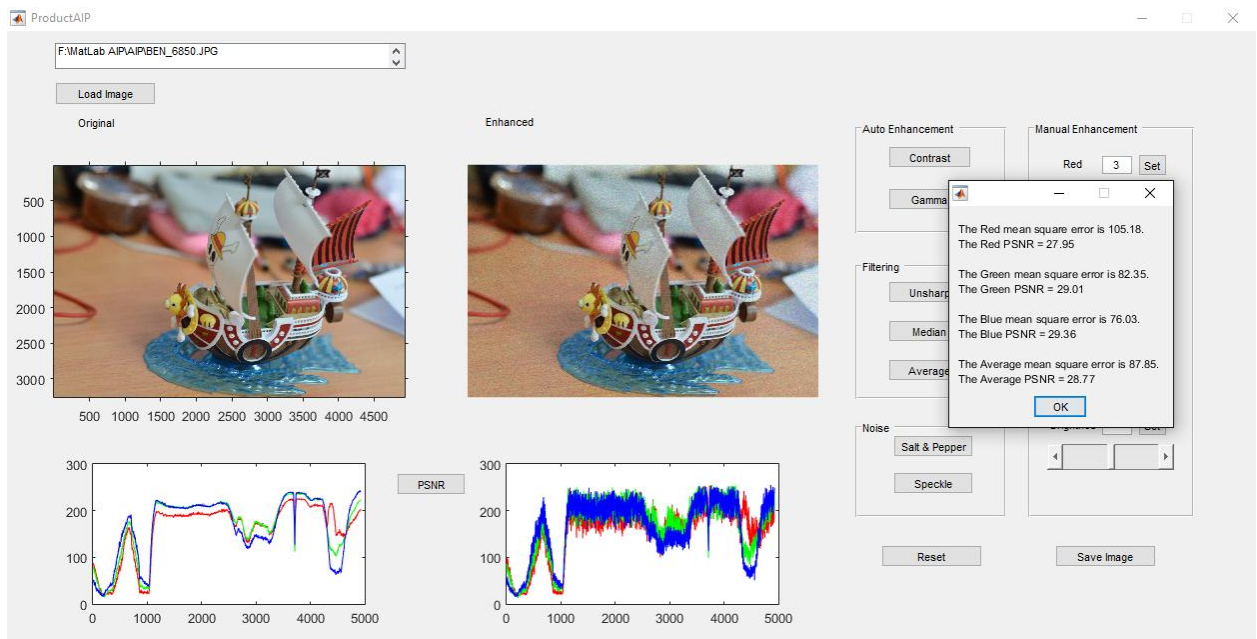


Figure 10: Average filter being applied to the distorted image.

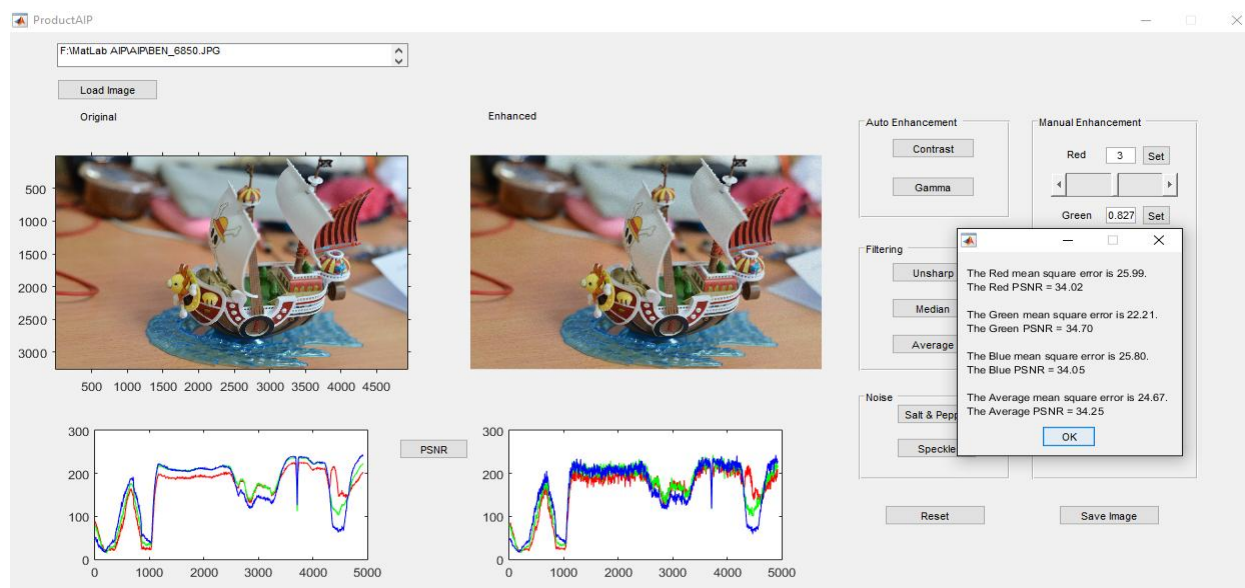


Figure 11 Average filter being applied five times (5x) to the image from figure 11.

Speckle noise is complicated noise which degrades the quality of an image by granulated it. This noise often being seen with images that have high ISO, or in low light places taken from space. Here are the summary for the type of enhancement that had been made.

Table 2: Average MSE and PSNR for all categories of analysis

Image Number	Image Condition	Enhancement Technique	MSE	PSNR
Image 1	Underexposed	Contrast	13298.01	6.94 dB
Image 2	Overexposed	Contrast	7494.26	9.57 dB
Image 3	Normal	Gamma Correction	2215.53	Infinity
Image 4	Blurred	Unsharp Filter	32.54	33.05 dB
Image 5	Salt & Pepper	-	362.68	22.57 dB
Image 5	Salt & Pepper	Median Filter	0.95	48.41 dB
Image 6	Speckle	-	746.61	19.51 dB
Image 6	Speckle	Average Filter	87.88	28.77 dB
Image 6	Speckle	Average Filter (5x)	24.70	34.25 dB

Conclusion

Images are affected with many variables. The enhancement technique can help reduce some of the noise or distortion of an image. The enhancement algorithm can increase the image quality within a short amount of time. With right implementation, the algorithm can produce a robust and efficient output. Therefore, optimizing the image and give faster output in image enhancement techniques. Furthermore, the graphical user interface have been made in user friendly simulation where it can also been use in manual mode.

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