Image Enhancement Using the Image Sharpening, Contrast Enhancement, and Standard Median Filter: Noise Removal with Pixel-Based and Human Visual System-Based Measurements

Adam Nevriyanto, Universitas Sriwijaya
Department of Computer Engineering
Palembang, Indonesia

Diah Purnamasari, Universitas Sriwijaya
Department of Computer Engineering
Palembang, Indonesia

Erwin, Universitas Sriwijaya
Department of Computer Engineering
Palembang, Indonesia
E-mail: erwin@unsri.ac.id (Correspondent Author)

Abstract— **In this paper, we explained the three methods of image enhancement: Image Sharpening by sharpening the edges, Contrast Enhancement using Standard Histogram Equalization and Standard Median Filtering where noise is filtered using these methods first and finally noise is eliminated. Then we put on the measurement parameters using a calculation based on the image quality of the pixel MSE and PSNR and calculations based on human vision system (HVS) that SSIM. The dataset we use is BSDS300 Berkeley and the environment is Matlab 2016a. We can state that the image quality measurement is good where the results are accurate so that we can determine the best methods too. We got SSIM value is close to 1 and the value obtained MSE and PSNR is minimum in Image Sharpening which is mean Image Sharpening is best of basic methods in Image Enhancement.**

Keywords— ***contrast enhancement; image sharpening; noise removal; MSE; PSNR; SSIM***

I. INTRODUCTION

Image Enhancement proposed or declared by problems often experienced by an image of the noise at the time of transmission or blurry, too dark, too bright when getting image(s) through the medium of the camera for example. Image enhancement should involve the manipulation of gray level and the brightness level of the image, noise reduction, sharpening, filtering, interpolation, pseudo-color, magnification, and so on. Image enhancement is useful in image analysis, visual information display and extraction[1], Image segmentation with image enhancement can be used for further applications, for example for application object recognition in the image.

To make the image brighter or darker to do with changes in the brightness of the image. Brightness can be improved by adding (or subtracting) a constant to (or out of) each pixel in the image. Because of this operation, the image histogram was shifted. Low-contrast image can be improved with a contrast stretching operation. Through this operation, the values of the pixel gray ranging from 0 to 255 (in the 8-bit image), instead of all the values of gray pixels used evenly. Image enhancement operation aims to clarify the edges on objects in the image and that's why this operation is also often called as an edge sharpening. Noise removal operation in the spatial domain aims to eliminate noise by means of noise filtering using a median filter.

By using the three methods of image quality measurement that proposed in this study so that it will get more comprehensive results so as we can know which method is better based on the results of their respective calculations.

From the previous research by [2],[3] and [4] says that the good image quality measurement must be accurate and consistent in predicting the quality. Most of them are related to the difference between two images (the original and the distorted image). SSIM is more accurate than MSE and PSNR despite it has cost more and difficult algorithms.

II. METHODS

A. Histogram Equalization

Intensity value adjustment process can be done automatically by using the histogram equalization. Histogram equalization involves changing the intensity values so that the histogram of the output image approximately matches the histogram specified.

The technique is often used for processing the histogram is the histogram equalization (HE) which to produce a histogram uniform or evenly so it is often also called flattening histogram[5], This technique can be done once for the entire image areas (global histogram equalization) or with several times repeated for each image blocks (sub-image). Equation 1 is used to perform a histogram equalization process.

$$H(b_k) = \sum_{i}^{k} \frac{n_i}{n} = \sum_{i}^{k} p_r(b_k), \quad 0 \le b_k \le 1, \quad k = 0, 1, \ldots, L-1$$

$$b_k = \frac{k}{L-1}, 0 \le k \le L-1 \qquad (1)$$

Steps in using the histogram equalization:

a. The value of the gray level image and a constituent.
b. Calculate the maximum value of the gray level image results. Histogram will determining the histogram equalization.
c. From the original image histogram, Save frequency degrees of gray in the array (vector). Set array (vector) whose size depends on the maximum degree value. Then, degrees of gray in the position vector compute frequency.
d. Create the histogram equalization. Histogram equalization was obtained by calculating the degree of gray emergence presentation that is multiplied by the maximum gray level of the original image.
e. Find the value of gray level of the new image results by using histogram equalization.
f. To map the image histogram equalization becomes a new one, empty matrix is equal to the size of the original image. The value of a matrix based on the image.

B. *IMAGE SHARPENING*

Image sharpening techniques are designed to enhance the high-frequency aspects of the image. High-frequency aspects, such as edges around major features of the image, are particularly desirable to sharpen to improve the visual appearance of the image. In principle, image sharpening consists of adding to the original image a signal that is proportional to a high-pass filtered version of the original image. Value high-pass filtered and added to the original image data, which results in improved edge and noise amplification[6]. Image sharpening refers to any enhancement technique that highlights edges and fine details in an image. Image sharpening is widely used in printing and photographic industries for increasing the local contrast and sharpening the images.

C. *NOISE REMOVAL*

Noise Removal is techniques used to eliminate distractions that exist in an image. In this experiment, the noise is removed in the form of Salt and Pepper (the type of noise that contains bright spots and dark in an image). One of the methods used in the noise removal process, Standard Median Filter (SMF). SMF is a method of filter is used to suppress impulse noise by blurring the fine line detail and then overwrite it with the median pixel next to it[7], [8].

III. EXPERIMENTS AND RESULTS

For the three of image enhancement methods, they were performed in experiments using Berkeley BSDS300 dataset and Matlab 2016a. The following test results:

A. *Using the Image Sharpening*

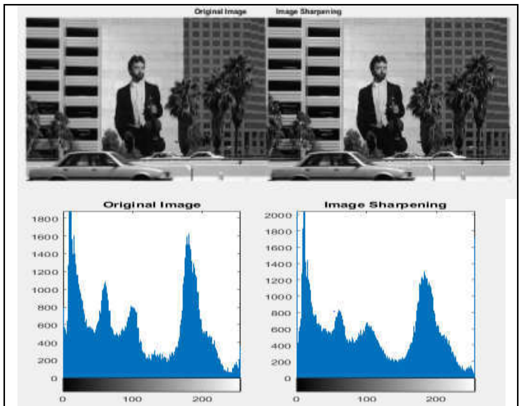

Figure (1.1): The Results of Image Sharpening image1

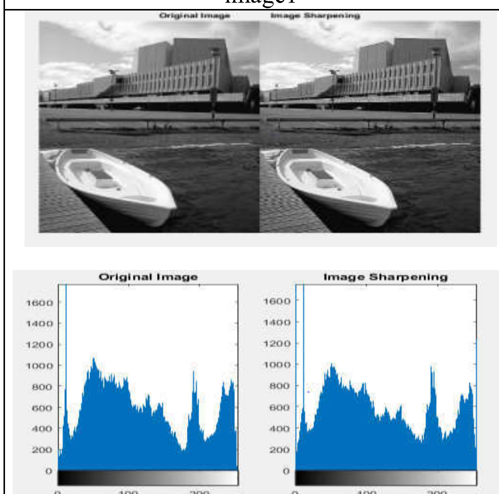

Figure (1.2): The Results of Image Sharpening image2

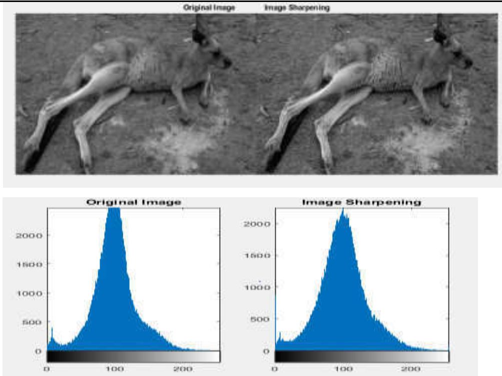

Figure (1.3): The Results of Image Sharpening image3

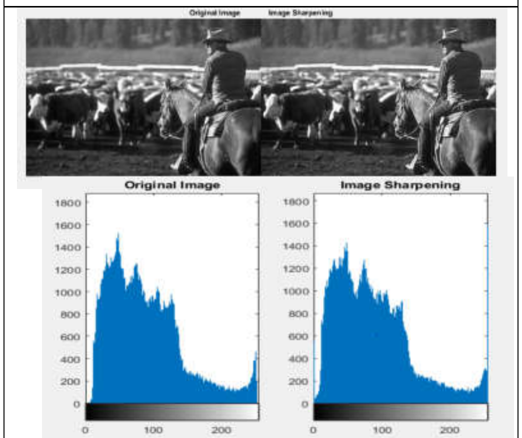

Figure (1.4): The Results of Image Sharpening image4

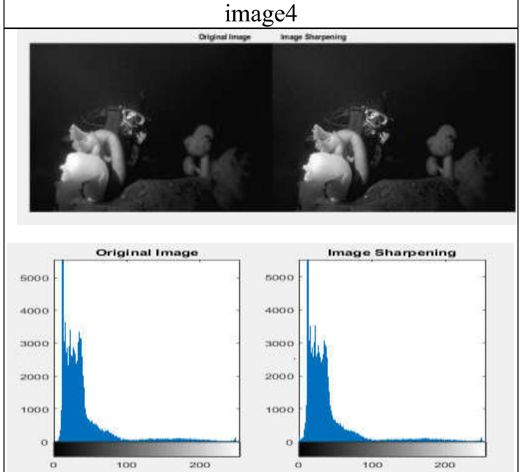

Figure (1.5): The Results of Image Sharpening image5

B. Using Contrast Enhancement with Histeq

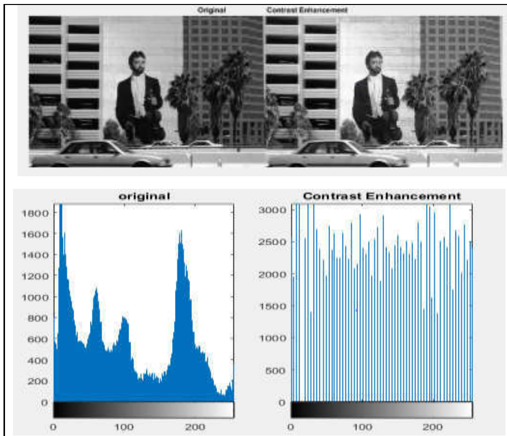

Figure (2.1): The results of contrast enhancement image1

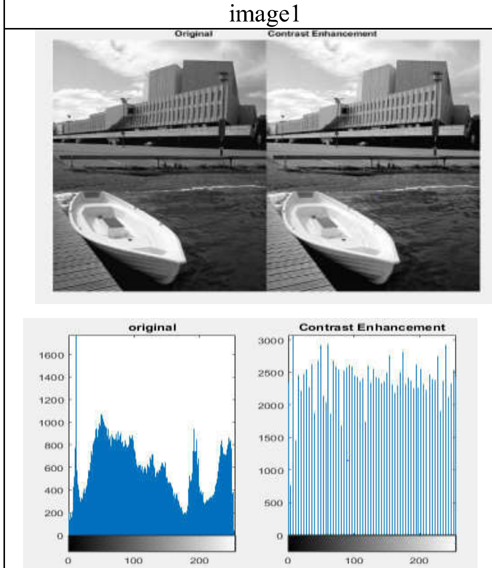

Figure (2.2): The results of contrast enhancement image2

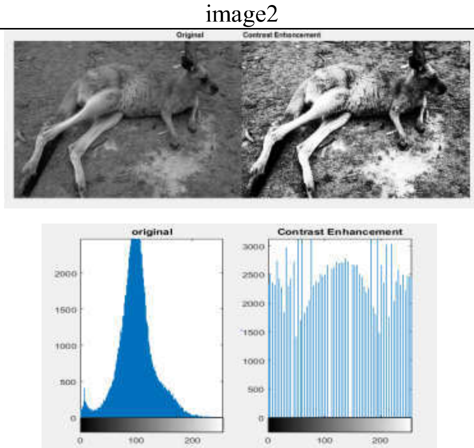

Figure (2.3): The results of contrast enhancement image3

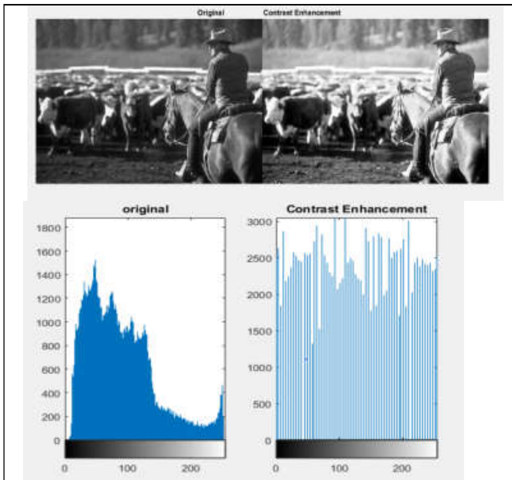

Figure (2.4): The results of contrast enhancement image4

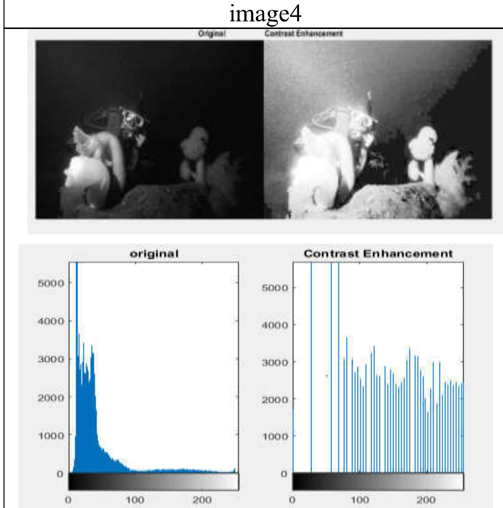

Figure (2.5): The results of contrast enhancement image5

C. Using Standard Median Filtering for Noise Filtering

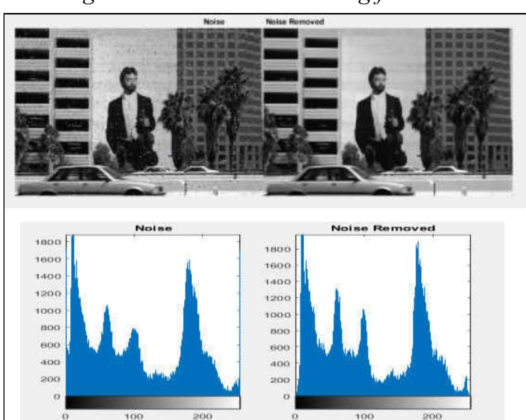

Figure (3.1): The Results of Noise Filtering image1

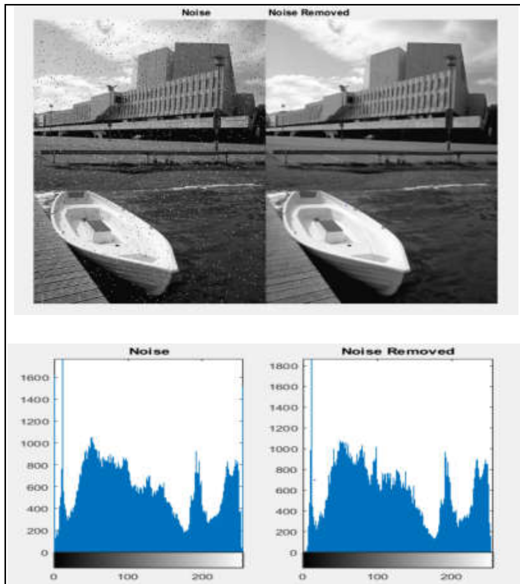

Figure (3.2): The Results of Noise Filtering image2

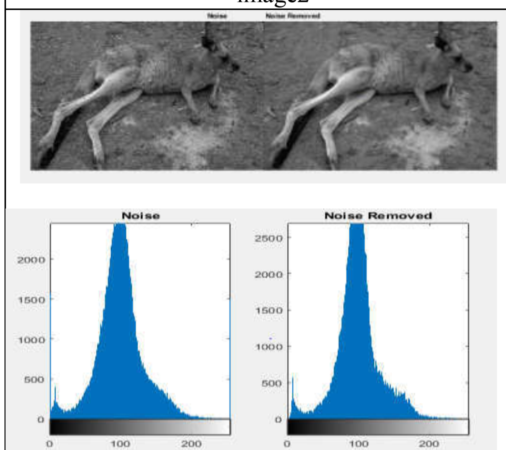

Figure (3.3): The Results of Noise Filtering image3

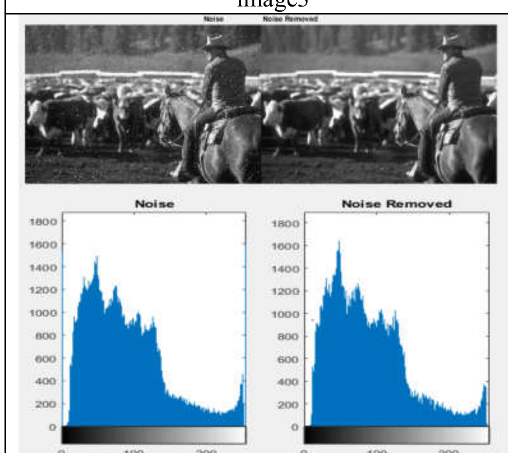

Figure (3.4): The Results of Noise Filtering image4

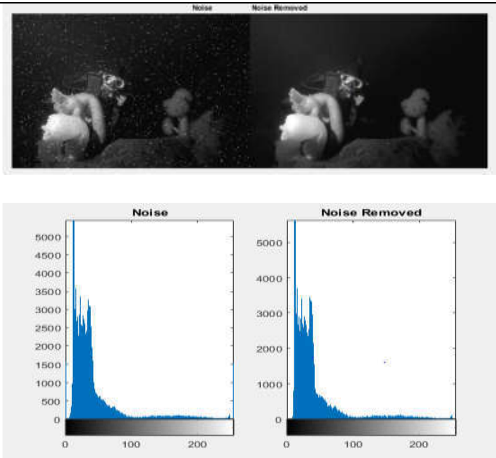

Figure (3.5): The Results of Noise Filtering image5

IV. DISCUSSION

There are many types of image quality measurements that can be implemented to get the quality of an image. Based on full reference, it can be divided into six class [3]:

1. Difference Pixel-Based: MSE, SNR, PSNR, which is quite easy measurements evaluated.
2. Correlation-Based: calculation of the difference between two digital images that will see the correlation of pixels as a measurement parameter.
3. Edge-Based: calculation based on the edge of the original image and the image of the entire image is distorted then consistency is a measurement parameter.
4. Spectral Distance-Based: application of DFT on the original image and a distorted image then the difference magnitude of its Fourier or spectral phase is a measurement parameter.
5. Context-Based: the calculation of the neighboring pixel in the original image and a distorted image compared to its multidimensional context then the probability of a measurement parameter.
6. Human Visual System-Based (HVS): calculations performed by the human eye which typically uses the contrast, color and frequency.

In this experiment, we use the parameter measurement based on pixel based MSE and PSNR and SSIM the Human Visual System.

MSE values is obtained from the average square intensity of the original image f (x, y) and the resultant pixel of the image f '(x, y) can be written in equation 2[2]:

$$\text{MSE} = \frac{1}{MN}\sum_{y=0}^{M-1}\sum_{x=0}^{N-1} e(y,x)^2 \quad (2)$$

Where, e (x, y) ^{2} is the error difference between the original image and a distorted image.

PSNR values is obtained from the pixel difference between the original image and a distorted image which the SNR of all its pixel value is the maximum value of the most appropriate, can be written in equation 3[2]:

$$PSNR = 10\log\frac{s^2}{MSE} \quad (3)$$

Where, s = 255 for 8-bit image

SSIM value obtained by dividing the original image and a distorted image in the 8x8 block size and then converted into a vector. Then the calculation for the average two, two standard derivation, and the covariance can be written in equation 4, 5, and 6[2]:

$$\mu_x = \frac{1}{T}\sum_{i=1}^{T} x_i \,;\, \mu_y = \frac{1}{T}\sum_{i=1}^{T} y_i \quad (4)$$

$$\sigma_x^2 = \frac{1}{T-1}\sum_{i=1}^{T}(x_i-\bar{x})^2 \,;\, \sigma_y^2 = \sum_{i=1}^{T}(y_i-\bar{y})^2\sigma_y^2 \quad (5)$$

$$\sigma_{xy}^2 = \frac{1}{T-1}\sum_{i=1}^{T}(x_i-\bar{x})(y_i-\bar{y}) \quad (6)$$

Finally, it is calculated based on a comparison of illuminance, contrast and structure on its statistical value that can be written in equation 7:

$$SSIM = \frac{(2\mu_x\mu_y+c_1)(2\sigma_{xy}+c_2)}{(\mu_x^2+\mu_y^2+c_1)(\sigma_x^2+\sigma_y^2+c_2)} \quad (7)$$

Here are the test results of five images of BSDS 300 Berkeley Dataset:

Table 1. Comparison of MSE, PSNR and SSIM on Image Sharpening

Image Sharpening			
Image	MSE	PSNR	SSIM
citra1	97.73	28.23	0.95
citra2	80.04	29.1	0.95
citra3	61.62	30.23	0.92
citra4	51.85	30.98	0.97
citra5	9.01	38.59	0.98

Table 2. Comparison of MSE, PSNR and SSIM on Contrast Enhancement

Contrast Enchancement (Using HISTEQ)			
Image	MSE	PSNR	SSIM
citra1	665.09	19.9	0.88
citra2	253.89	24.08	0.96
citra3	2906.7	13.5	0.56
citra4	2344.25	14.43	0.8
citra5	11203.08	7.64	0.37

Table 3. Comparison of MSE, PSNR and SSIM on Noise Removal Filtering

Noise Removal (Using SMF)			
Image	MSE	PSNR	SSIM
citra1	145.81	26.49	0.86
citra2	136.89	26.77	0.83
citra3	103.39	27.99	0.72
citra4	70.53	29.65	0.94
citra5	10.71	37.83	0.97

V. CONCLUSION

In this paper, image quality improvements have been tested using a contrast enhancement, sharpening and noise reduction of the dataset BSDS300 Berkeley. We can see from the test results in table 1, table 2, and table 3 that the calculation of the average SSIM, its result close to 1 where it has an accurate result than the MSE and PSNR. SSIM have a good calculation compared to the MSE and PSNR but SSIM is not easy to be evaluated as like as the MSE and PSNR. Image Sharpening has good results for this topic because it isn't change information or pixel, it's close to the original image information.

REFERENCES

[1] B. Hartono, "Analisa Teknik Adaptive Histogram Equalization dan Contrast Stretching untuk Perbaikan Kualitas Citra," *J. Teknol. Inf. Din.*, vol. 19, no. 1, pp. 1–10, 2014.

[2] Z. Wang and A. C.Bovix, "A Universal Image Quality Index," *IEE Signal Process. Lett.*, vol. 20, pp. 2–5, 2002.

[3] K. Sayood, "Statistical evaluation of image quality measures," *J. Electron. Imaging*, vol. 11, no. April, pp. 206–223, 2002.

[4] Y. A. Y. Al-najjar and D. C. Soong, "Comparison of Image Quality Assessment :," *Int. J. Sci. Eng. Res.*, vol. 3, no. 8, pp. 1–5, 2012.

[5] R. C. Gonzalez and R. E. Woods, *Digital Image Processing Second Edition*, Second Edi. New Jersey: Prentice-Hall Inc, 2002.

[6] F. Russo, "Piecewise linear model-based image enhancement," *EURASIP J. Appl. Signal Processing*, vol. 2004, no. 12, pp. 1861–1869, 2004.

[7] T. Chao Lin and P. Ta Yu, "Salt-Pepper Impulse Noise Detection and Removal Using Multiple Thresholds for Image Restoration," *J. Inf. Sci. Engineeering*, vol. 198, pp. 189–198, 2006.

[8] Z. M. Ramadan, "Salt-and-Pepper Noise Removal and Detail Preservation Using Convolution Kernels and Pixel Neighborhood," *Am. J. Signal Process.*, vol. 4, no. 1, pp. 16–23, 2014.