Analysis of Sigmoid Function Method And Histogram Equalization for Enhancement Contrast Image

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Abstract. Image Is one file that is able to provide information graphically to humans. However, not all images have a brightness level that suits the user, thus reducing the information obtained. To overcome this, it is necessary to increase contrast. The results of the tests show that the Histogram Equalization algorithm has an execution time of 83,109 ms, when compared to the time of the ACEBSF method which is 121.315ms. Whereas for the SSE value that is owned by the ACEBSF method is 14.619.460.211 greater than the SSE Histogram Equalization, which is 12.526.602.683. However, both methods have disadvantages if the K1 and K2 values are too small, the image quality improvement will fail.

1. Introduction

Contrast enhancement technique (contrast enhancement technique) is often used in various applications where image quality is an important thing. Contrast enhancement is a process that allows image characteristics to be displayed properly, so that the image displayed will have good quality. The contrast enhancement of the image refers to the amount of difference in color that exists between the various characteristics of the digital image. This is related to the range of brightness contained in the image. Images that have contrast levels display colors with a greater degree of change compared to lower contrast levels.[1].

In a previous study with the title A New Approach for Contrast Enhancement Using Sigmoid Function that uses modifications of the Sigmoid function and also the Histogram Equalization algorithm.[3].

Adaptive Contrast Enhancement Based Algorithm on modified Sigmoid This function has two process stages, where in the first stage poor quality images will be processed using a modified sigmoid function and in the second stage, the output from the first stage will be further processed using the Histogram Equalization algorithm. to increase the contrast of the image. The results obtained are the ACEBSF algorithm used has better results when combined with the Histogram Equalization algorithm.[11].

In the study entitled Analisis Citra Digital CT Scan Dengan Metode Ekualisasi Histogram Dan Statistik Orde Pertama, using the Histogram Equalization algorithm to improve image quality. The results obtained are an increase in image quality using the application software histogram equalization method can significantly clarify the digital image of CT Scan with statistical analysis that includes the mean, standard deviation, variance extracted from the characteristics of objects in the image can indicate a healthy brain condition and higher usually sick by comparing each statistic of a healthy image and the image detected by abnormalities.[7].

In another study with the title Implementasi Metode Median Filter Dan Histogram Equalization Untuk Perbaikan Citra Digital, using the Histogram Equalization algorithm to improve image quality.
The results obtained are the Histogram Equalization algorithm capable of improving image quality, so that the information in the image is more clearly visible. [8]. Therefore, the authors are interested in raising this problem by comparing two image improvement algorithms namely the Sigmoid Function (ACEBSF) algorithm and the Histogram Equalization algorithm.

2. Image

An image is defined as a two-dimensional function, \( f(x, y) \), where \( x \) and \( y \) are spatial coordinates, and the swing width of the function \( f \) in the coordinate pair \( (x, y) \) is called the intensity or gray level of the image at that point. Data recording systems will provide output images that can be optical in the form of photographs, are analogous in the form of video signals, or are digital that can be stored directly on a storage medium. The image contains a number of basic elements that are manipulated in image processing. The important basic elements include:[2].

- Brightness
- Contrast
- Contour
- Color
- Shape
- Texture

To save photos and images, a free screen image format (in the form of a box) consists of small image points called pixels. Pixels are also called dot. Square pixels with a relatively small size. The number of pixels per unit area depends on the resolution used. The diversity of pixel colors depends on the bit depth used. The more number of pixels per unit area, the better the quality of the resulting image and of course the larger the file size.[4].

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2.1. Image Processing

Digital image processing is a discipline that studies matters relating to image quality improvement (contrast enhancement, color transformation, image restoration), image transformation (rotation, translation, scale, geometric transformation), feature image selection optimal for the purpose of analysis, the process of drawing information or object descriptions or object recognition contained in the image, compressing or reducing data for the purpose of data storage, data transmission, and data processing time. Input from image processing is image, while output is processing image. Image processing basically includes the following three steps:[6].

- Import images through an image acquisition tool.
- Analyze and manipulate images.
- Output whose results can be changed by an image or report based on image analysis.

2.2. Image Quality Improvement

Generally, operations in image processing are applied to the image if:[9].

- Improvement or modification of the image needs to be done to improve the quality of the appearance or to highlight some aspects of the information contained in the image.
Elements in the image need to be grouped, matched, or measured. Some images need to be combined with other parts of the image.

Improving image quality (image enhancement) is one of the initial processes in image processing (image preprocessing). Quality improvement is needed because often the image used as the object of discussion has poor quality, for example the image experiences noise during transmission through the transmission line, the image is too bright / dark, the image is less sharp, blurred, and so on. It is through this initial processing operation that the image quality is improved so that the image can be used for further applications, for example the application of recognition of objects in the image.

2.2.1. Histogram Equalization

Image histogram is a graph that describes the distribution of pixel intensity values from an image or certain parts in the image. Image histogram is a graph that can be used to determine the gray level distribution of an image. The histogram is calculated by the following formula:

\[ h_i = \frac{n_i}{n} \]

where:

- \( h_i \) = probability of grey
- \( n_i/n \) = the number of pixels representing grey values / total pixels in the image
- \( i = 0 \ldots L - 1 \)
- \( L \) = Interval of color maximum

In case an increase is needed, the most important feature of this image is that it is dark and has a low dynamic range.

\[ K_0 = \text{round} \left( \frac{c_i - (2^k - 1)}{w \cdot h} \right) \]

where:

- \( C_i \) = cumulative distribution of the grayish-scale value of the \( o_i \) from the original image
- \( \text{round} \) = rounding function to the nearest number
- \( K_0 \) = grey values resulting from histogram equalization
- \( w \) = image width
- \( h \) = image height

2.2.2. Adaptive Contrast Enhancement Based on modified Sigmoid Function (ACEBSF)

Adaptive Contrast Enhancement Based Algorithm on modified Sigmoid This function is able to produce images with better quality compared to other image contrast enhancement methods, such as the Histogram Equalization (HE) method. The sigmoid modification function can be defined as shown in the following equation:[5].

\[ o(i, j) = f(i, j) + K_i \cdot \frac{f(i, j)}{1 - e^{\left( -K_1 \cdot (K_2 + f(i, j)) \right)}} \]
2.2.3. Sum Squared Error (SSE)

Traditionally, image quality has been evaluated by humans by subjective methods. A number of observers were selected by testing visual abilities they were then shown a series of image tests on the screen and asked to assess the quality of the image. This subjective evaluation is reliable but is usually very troublesome, takes a long time and is expensive, so there is a computational model that can automatically predict image quality. SSE (Sum Square Error) is one of the statistical methods used to measure the total difference from the actual value of the value achieved. The term SSE is also called Summed Square of Residuals.[4].

\[
SSE = \sum_{i=1}^{n} (X_i - Y_i)^2
\]

where:
- \(X_i\) = actual or actual value
- \(Y_i\) = the value achieved

3. Enhancement Experiment and Analysis of Image Processing

3.1. Enhancement Experiment

The experiment research in image enhancement on one image by using two methods is conducted in this paper. In order to prove the superiority of the method proposed in this paper, the enhancement results of the sigmoid function method are compared with histogram equalization method.

3.2. Analysis of The Enhancement Results

Image quality mainly includes color histogram of the image. The resulting image of the ACEBSF method has a histogram with a more evenly distributed color compared to the histogram of the Histogram Equalization image. On the Histogram Equalization there is still a buildup of color at the beginning of the histogram, whereas in ACEBSF, the color buildup is done at the beginning of the histogram. Similarly, the SSE value using the ACEBSF method is greater compared to the Histogram Equalization.

![Figure 1. ACEBSF Method](image-url)
Figure 2. Histogram Equalization Method

Figure 3. ACEBSF vs Histogram Equalization Method

Table 1. Testing of ACEBSF and Histogram Equalization Method

| Nama Gambar         | Waktu Algoritma | Waktu Algoritma | SSE ACEBSF | SSE HE  |
|---------------------|-----------------|-----------------|------------|--------|
|                     | ACEBSF(ms)      | HE(ms)          |            |        |
| D:\GAMBAR\UJI\1.bmp| 3078            | 1984            | 326358559  | 315583958 |
| D:\GAMBAR\UJI\2.bmp| 5672            | 3250            | 808457488  | 887034572 |
| D:\GAMBAR\UJI\3.bmp| 5610            | 3375            | 421850843  | 706652236 |
| D:\GAMBAR\UJI\4.bmp| 25657           | 17672           | 3267551104 | 3262737981 |
| D:\GAMBAR\UJI\5.jpg| 9266            | 7250            | 1060557260 | 718350477 |
| D:\GAMBAR\UJI\6.jpg| 14782           | 10281           | 2776238767 | 828584137 |
| D:\GAMBAR\UJI\7.jpg| 12110           | 8484            | 1056538216 | 1049985131 |
| D:\GAMBAR\UJI\8.jpg| 35110           | 23516           | 4343294298 | 4313611375 |
| D:\GAMBAR\UJI\9.jpg| 6640            | 4937            | 295825906  | 186811074 |
| D:\GAMBAR\UJI\10.bmp| 3390            | 2360            | 262787870  | 257251742 |
| **TOTAL**           | **121315**      | **83109**       | **14619460211** | **12526602683** |
Table 2. Testing of ACEBSF and Histogram Equalization Method
(one image of different format)

| Nama Gambar | Waktu Algoritma ACEBSF (ms) | Waktu Algoritma HE (ms) | SSE ACEBSF | SSE HE |
|-------------|-----------------------------|--------------------------|------------|--------|
| Fellaini.bmp | 4290                        | 4368                     | 2977016910 | 2979328114 |
| Fellaini.jpg | 4274                        | 4680                     | 2980420676 | 2979109248 |
| Fellaini.png | 5694                        | 6490                     | 2977016910 | 2979328114 |

Of all extensions (jpg, png, and bmp) that are tried on the fellaini image, the conclusions obtained in table 2 above are as follows:

- The largest SSE value for ACEBSF is an image with a .jpg format
- The biggest SSE value of a histogram
- Equalization is an image with the .bmp format.

The fastest execution time is the image with the .jpg format for the ACEBSF algorithm, and the image with.bmp format for the Histogram Equalization algorithm.

4. Conclusion

From the discussion in the previous chapters, finally conclusions from this thesis can be taken, among others.

1. Improving image quality done by changing distribution of gray level values on an image so that it becomes uniform. Histogram Algorithm Equalization and Algorithms ACEBSF is two algorithms which can improve quality image by changing distribution gray level value in an image.

2. Testing of two methods is done by comparing the SSE value and execution time of the two algorithms. From testing what is done, Algorithm Histogram Equalization has the shortest execution time with 83.109 ms compared to ACEBSF time with a value of 121.315 ms. Meanwhile, the SSE value owned by the ACEBSF algorithm with a value of 14,619,460,211 is greater compared to SSE Histogram Equalization 12,526,602,683.

References

[1] Gonzalez Rafael C and Woods Richard E. 2002. *Digital Image Processing*. New Jersey: Prentice Hall.

[2] Gonzalez Rafael C, Woods Richard E and Eddins Steven L. 2009. *Digital Image Processing*. United States : Gatesmark, LLC.

[3] Hassan Nagla, Norio Akamatsu. 2004. *A New Approach for Contrast Enhancement Using Sigmoid Function*. Department of Information and Science and Intelligend System, Tokushima University, Japan.

[4] Jayaraman S, Esakkirajan S and Veerakumar T. 2009. *Digital Image Processing*. New Delhi: Tata McGraw Hill Education Private Limited.

[5] Kapoor Kanika and Shaveta Arora. 2015. *Colour Image Enhancement Based On Histogram Equalization*. Guragon, Haryana: Departmen of ECE, ITM University, India.

[6] Munir Rinaldi. 2004. *Pengolahan Citra Digital dengan Pendekatan Algoritmitk*. Bandung: Informatika.
[7] Murinto, Willy Permana Putra, Sri Handayaningsih. 2008. *Analisis Perbandingan Histogram Equalization dan Model Logarithmic Image Processing (LIP) Untuk Image Enhancement*. Fakultas Teknologi Industri Universitas Ahmad Dahlan Yogyakarta, Yogyakarta.

[8] Ngah Syahrulanuar, dkk. 2016. *Two Steps Implementation Of Sigmoid Function For Artificial Neural Network In Field Programmable Gate Array*. Faculty of Computer Systems and Software Engineering, Universiti Malaysia Pahang, Malaysia.

[9] Pal Ravrinda. 2015. *Histogram Equalization: A Strong Technique for Image Enhancement*. International Journal of Signal Processing. Image Processing and Pattern Recognition. India.

[10] Panicker Manish, C.Babu. 2012. Efficient FPGA Implementation of Sigmoid and Bipolar Sigmoid Activation Functions for Multilayer Perceptrons. Department of Electronics and Communication, Amrita School of Engineering, Bangalore.

[11] Patel Omprakash, Yogendra P.S Maravi, and Sanjeev Sharma. 2013. *A Comparative Study of Histogram Equalization Based Image Enhancement Techniques For Brightness Preservation And Contrast Enhancement*. School of Information Technology, RGPV, Bhopal, Madhya Pradesh, India.

[12] Zhuang Liyun And Guan Yepeng. 2017. *Image Enhancement via Subimage Histogram Equalization Based on Mean and Variance*. Comput Intell Neurosci.