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Creative Technology for Human Life

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Improved Edge Detection Based on Adaptive Gaussian Smoothing in X-Ray Image

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Abstract—*Currently technological developments are needed in all aspects of human life. It also covers the provision of data or information because it is related to someone's life. Data or information that provided in image formats is developed in health field of a human's life because it contains a lot of information about patient health that can't be described by text or audio format. Currently due to the human body is susceptible to radiation rays then as long as the patient is detected by x-ray it will be subjected to a process of radiation exposure so that the x-ray image results in a decrease (degradation) of quality. There are several operations used in image processing to solve that problem. One of them is an edge detection. Due to the current edge detection is still considered not perfect because there is still Gaussian noise. So in this paper proposed method to improve image quality from quantum noise disorder by improving the method of Sobel, so can help the medical world in detecting a disease.*

Keywords—radiation exposure, Sobel method, quality degradation, edge detection, Gaussian noise.

I. INTRODUCTION

Currently technological developments are needed in all aspects of human life. It also covers the provision of data or information because it is related to someone's life.[1] Data or information can provide in various formats such as image, text, audio, and video format. Data or information that provided in image formats is developed in health field of a human's life because it contains a lot of information about patient health that can't be described by text or audio format. [2]

For example, a technology that developed in the health field is an x-ray. The description of an x-ray is the information about patient's health. The most common issue in x-ray image detection is removing soft-tissue area or bones-tissue. The soft-tissue or bones-tissue has a negative impact to the quality of x-ray image detection.[1] Currently, the human body is susceptible to radiation rays then as long as the patient is detected by x-ray it will be subjected to a process of radiation exposure so that the x-ray image results in a decrease (degradation) of quality. The degradation of image results that caused by digital data storage also called a noise.[1]

Noise can be caused by optical instrument problem in image receiver, such as photo lens which is full of dust or unsuitable image process, such as Gaussian, Salt and Pepper, and Speckle Noise. There are several operations used in image processing to solve that problem. One of them is an edge detection.[3] Due to the current edge detection is still considered not perfect because there is still Gaussian noise, so we proposed a new method of edge detection which improve image quality from quantum noise disorder by improving the method of Sobel with Gaussian Smoothing, so the improved algorithm can help the medical world in detecting a disease. The purpose of Gaussian smoothing is to manipulating image parameters. Because of that manipulated parameters the quality of x-ray images improved.

This proposed method discuss about image segmentation especially in background removal. Main goal of this paper is to eliminating the unnecessary areas of x-ray images which aren't the main region.

II. RELATED RESEARCH

Li Hua[4] proposed an improve method of Sobel algorithm based on eight directions to improve the accuracy of Sobel operator. The eight direction used to implement an edge detection on multiple directions. The result of this experiment is a new method that reduce the lost information of an image which is the image in a smooth and continuous direction. This new method show us a better accuracy for a complex images that have a texture. The function of this method is to make sure the pixel width is closer to a single pixel width.

Lin Li[5] proposed an optimization of Sobel algorithm. Sobel operator is the most trustworthy method because it gives an efficient output to the result of the image. This method use to extract the object of the image. However, Sobel operator is a very complex process and the implementation process of this algorithm is very difficult, so it optimized Sobel operator using MBD optimization workflow.

MBD workflow can automatically generate HDL code to validate FPGA design process of image processing. MDB workflow can accelerating the design process of image processing system, so it's development time can be reduced. Because it optimized a particular solution to compare a different solutions in order to obtain the best tradeoff between cost and performance.

Shi Tian[6] proposed a parallel computer system, to detecting surface defects of cameras by adding six different directions (45°, 135°, 180°, 225°, 270° and 315°), to ensure the grayscale output in the allowable error. It allows an accurate and efficient positioning to reduce noises, so it's extracted more efficient features and the parameters characteristic. With neural network training it defects classification and obtain precision with 106 iterative steps and time of 3 s less than the Sobel algorithm.

III. PROPOSED WORK

Image processing can be described as a processing of a signal that have an image input. The input image of this process produce a characteristic or parameter that represent the image or may be present a new image. This new image related to digital form that has been converted with image enhancement process, such as restoration, compression, etc.[3]

Image enhancement can be described as an accentuation of some image features. These features include boundaries, contrast, gray level & contrast manipulation, noise reduction, edge detection, sharpening, filtering, etc. That process doesn't increase content of this data just make this image more useful. [7]

Image restoration can be described as an image filtering to defects the effects of degradations. This process depends on the filter design of degradation process to adjust the effectiveness of this process. Image restoration and image enhancement has a different in extraction and accentuation for some image features. Image restoration has more concerned of image extraction than image enhancement. [7]

Image compression can be described as a minimizing bit process of the represented image.

On this paper we proposed a new model of edge detection which is a fundamental subject in image processing. It also included in machine vision and computer vision subject. [7]

Edge detection can be used to extract a features in some area. This algorithm (Canny, Sobel, Robert) can be used to extract some features of an image to detect some of different types of sharp changing points. In image processing the changes brightness abruptly can be defined as edges points. [7]

Edges points can be created by shadows, textures, geometry, etc. It also defined as a discontinuities of image intensity in an image structure. Edge detection can be described into four steps, such as:[7]

1. Image Smoothing process: a suppress process of a noise without defect the true images.
2. Image Enhancement: A process that applying a filter into an images to enhance the quality of image edge.
3. Image Detection: A process to determine the pixel of an edge, which is should be discarded as a noise or retained as an image. This process also include the thresholding process.
4. Image Localization: A process that determine the exact location of an edge

Due to the current edge detection is still considered not perfect because there is still Gaussian noise, so we proposed a new method of edge detection which improve image quality from quantum noise disorder by improving the method of Sobel with Gaussian Smoothing, so the improved algorithm can help the medical world in detecting a disease. The purpose of Gaussian smoothing is to manipulating image parameters. Because of that manipulated parameters the quality of x-ray images improved. [3]

This proposed method discuss about image segmentation especially in background removal. Main goal of this paper is to eliminating the unnecessary areas of x-ray images which aren't the main region.

In this research we need a research flow that will be used illustrated by the following diagram :

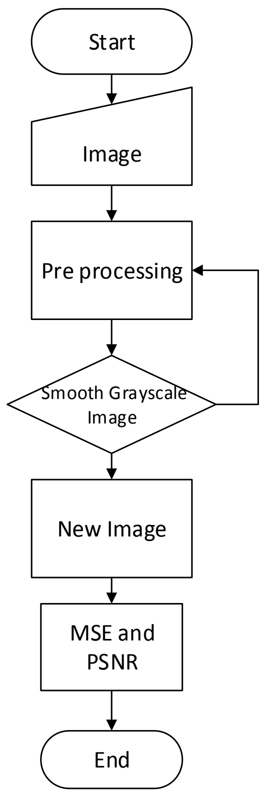

Fig. 1 Methodology Research

First process is the preprocessing that change RGB image to Grayscale which will be followed by smoothing method using Gaussian method. After that edge detection will be done by using Sobel method to produce a new image whose quality can be measured by MSE and PSNR.

A. GRAYSCALE

The image that we use for research is a grayscale image. The definition of grayscale is an image that has only one channel value, which is marked by the similarity of Red and Blue pixel values. In the initial process there should be a definition of objects and variables that will be used to accommodate the value of RGB images used. Then do the calculations horizontally and vertically each pixel and then save the value. Calculate the pixel value with the formula: 0.299 * Red, 0.587 * Green, and 0.114 * Blue. Show Grayscale results into the variables we have created at the beginning. [8]

This process can be described by this pseudocode:

```
Input : pixel value x in frame X = 0,..,Last Frame
Output : Image with Binary mask Value
    1. Initialize model C for pixel P0 and store
       it in Array
    2. For X = 0, Y = 0 , Last Frame
    3. Get pixel RGB
    4. Grayscale = (R+G+B)/3
    5. Set pixel grayscale
```

Fig. 2 Pseudocode Process

Here is a Grayscale process diagram:

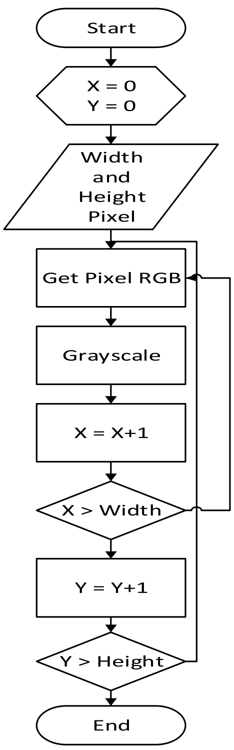

Fig. 3 Grayscale Method

B. Gaussian Smothing

Gaussian smoothing is a method that uses gaussian function and serves to smooth the noise on the image. Another mask that is often used for image refinement is the gaussian smoothing mask. The weights on the gaussian refining mask follow the normal distribution as \ which is expressed in the equation below:[9]

$$f_0(x,y) = \frac{f^r(x,y) + f^g(x,y) + f^b(x,y)}{3} \dots\dots (1)$$

In the Gaussian Smoothing Process the original image will be filtered using a mask with the formula:[9]

$$\frac{1}{2\pi\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}} \dots\dots (2)$$

Where :

π= radius (3,14)

σ= the length of matrix

(x, y)= X and Y point pixel

e= Natural logarithm (2,7182)

After that proceed with the creation of objects and definitions of variables which will then be initialized with an array of lists that will be done scanning process horizontal and vertical scan the results will be stored in the variables that we define at the beginning of the process.[9]

Here is a Gaussian Smoothing process diagram:

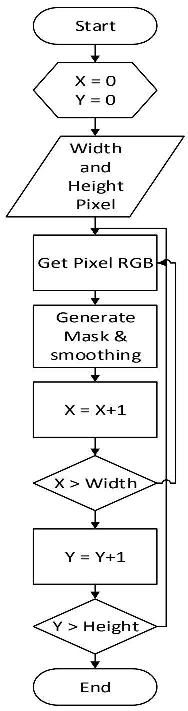

Fig. 4 Gaussian Smoothing Process

Here is a Gaussian Smoothing process pseudocode :

```
Input : pixel value x in frame X = 0,..,Last Frame
Output : Image with Binary mask Value
   1. Initialize model C for pixel P0 and store it in Array
   2. For X = 0, Y = 0 , Last Frame
   3. Get pixel RGB
   4. Generate Mask
   5. Gaussian Smoothing
   6. Set pixel Gaussian Smoothing
```

Fig. 5 Pseudocode Gaussian Smoothing Process

C. Edge Detection

Edge is a sudden change in the intensity of a sudden large degree of gray within a short distance. So the definition of edge detection is the detection of the value of the intensity change in an image. There are three kinds of edges in the digital image, namely: Steep Edge, Landed Edge and also the Edge with Noise.[10]

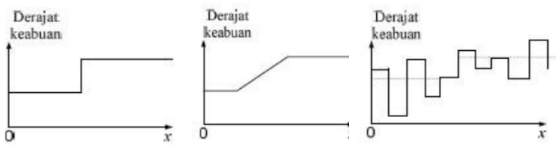

Fig. 6. Various edges a. Steep Edges b. Landed Edge c. Edges with noise

Inside this edge detection there are many different methods used in detecting the edges of this image. One of the best methods is Sobel. In edge detection, generally the image edges are considered discontinuous whose derivative values are taken at their maximum values to determine edges. Sobel edge detection is used to calculate the intensity gradient of the image and to find the possible direction of improvement from the phase of light to the dark phase and the rate of change of direction. The results show sudden or subtle changes in point intensity.[5]

In the Sobel edge detection process the first thing to do is create the object and define the variables, then initialize the Array list and also do the scanline horizontally and vertically which will then be filtered, after which the result will be displayed.[7]

Here is a pseudocode example of the Sobel edge detection process:

```
Input : pixel value x in frame X = 0,..,Last Frame
Output : Image with Binary mask Value
   1. Initialize model C for pixel P0 and store it in Array
   2. For X = 0, Y = 0 , Last Frame
   3. Clear List
   4. Get Neighbors List
   5. Get Sobel Value
   6. Threshold
   7. Set pixel Sobel
   8. End for
```

Fig. 7. Various edges a. Steep Edges b. Landed Edge c. Edges with noise

After scanning the data horizontally and vertically in the detection of the edge of a Sobel, the need for a process of combining existing data on horizontal and vertical arrays, the process is better known as Gradient Magnitude.

Here is the pseudocode of the process:

```
Input : pixel value x in frame X = 0,..,Last Frame
Output : Image with Binary mask Value
   1. Initialize model C for pixel P0 and store it in Array
   2. For X = 0, Y = 0 , Last Frame
   3. Clear List
   4. Get Sobel Value
   5. Gradient Magnitude
   6. Threshold
   7. Set pixel Magnitude
   8. End for
```

Fig. 8. Gradient Magnitude Pseudocode

IV Evaluation

A. Data Set

In this paper we used an X-ray image from public chest radiograph database of Radiological Technology (JSRT) [11].This database included 247 x-ray image that devided into two cluster. The first cluster contain 154 images and the second one contains 93 images. That images have standard size 2048 x 2048 pixel. In JSRT, images that have been taken in raw format, so if we want to open in our desired format, we must have an additional image file viewer.

Fig. 9. Original Images

B. Parameter

In image processing, quality is highly influential in the interpretation of images. In image quality processing is measured by Peak Signal to Noise Ratio (PSNR). The definition of PSNR is the ratio between the maximum value of the pixel as measured by the amount of noise that affects the pixel. PSNR is measured in decibels. PSNR can also be used to find out the quality comparison of cover image before and after the message inserted. To determine PSNR, MSE should first be determined (Mean Square Error). MSE is the mean square error value between the cover image and image, can be mathematically formulated as follows:[12]

$$MSE = \frac{1}{MN} \sum_{y=1}^{M} \sum_{x=1}^{N} [I(x,y) - I'(x,y)]^2$$

Where :
MSE = Mean Square Error
M = Length Matrix
N = Width Matrix
I(x, y) = Pixel I

Having obtained the value of MSE then the value of PSNR can be calculated from the square of the maximum value divided by MSE. Mathematically, the PSNR values are described as follows:

$$PSNR = 10. log\left(\frac{MAXi^2}{MSE}\right)$$

Where:
MSE = MSE value
MAXi = the maximum value of the image pixels that are

The lower the value of MSE, the better, and the greater the value of PSNR the better the image quality.

Here is the pseudocode of the process:

```
Input : pixel value x in frame X = 0,..,Last Frame
Output : Image with Binary mask Value
    1. Initialize model C for pixel P0 and store it in Array
    2. For X = 0, Y = 0 , Last Frame
    3. Get Pixel Before and After
    4. Get Sobel Value
    5. Get MSE
    6. Get RMSE
    7. Get PSNR
```

Fig. 9. MSE and PSNR Pseudocode

C. Evaluation test

1. Fidelity test

Fidelity test is a test performed to determine the ability of edge detection in the parent image, which is done by looking at the difference between the initial image of the parent and the image of the parent that has done edge detection.

Observations are done visually and quantitatively. As a visual benchmark in this study is the image of the parent does not experience significant changes when viewed using the human eye by naked eye. This study aims to find out the implementation of edge detection on true color image with operator method of Sobel. By allowing the current edge detection can find the image and its classification in the future. The steps per step are as follows:

1. The selected image will be inserted into the program
2. After the image is inserted then the image is changed into grayscale

Fig. 10 Grayscale Image

3. After the image changed into grayscale form we perfomed edge detection to the image

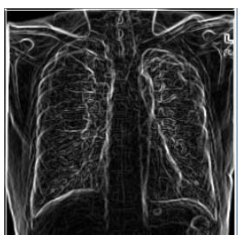

Fig. 12 Edge detection Process

4. After the image changed into edge detection form we perform Gaussian smoothing to the image

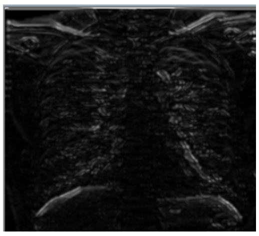

Fig. 13 Gaussian Smoothing Process

5. MSE and PSNR

In this paper the quality of produced image will be tested for durability by robustness testing as measured by various image manipulations. In this study, tests were performed with the addition of brightness and contrast.

The addition of brightness and contrast in the image, used several samples with different levels of brightness (5-20). After the added level of brightness then the image in the count MSE and PSNR it.

Table 1 MSE and PSNR for Edge detection and Edge detection with Gaussian Smoothing

Smoothing	Edge Detection	Improvement
MSE	0,431	0,1979
PSNR	119,252	127,0227

Table 2 MSE and PSNR for Edge detection with several samples of brightness

	Edge Detection		Improvement	
Nilai Contrast	MSE	PSNR	MSE	PSNR
Contrast +5	0,431	127,680	0,431	127,680
Contrast +10	0,431	127,680	0,431	127,680
Contrast +15	0,431	127,680	0,431	127,680
Contrast +20	0,431	127,680	0,431	127,680

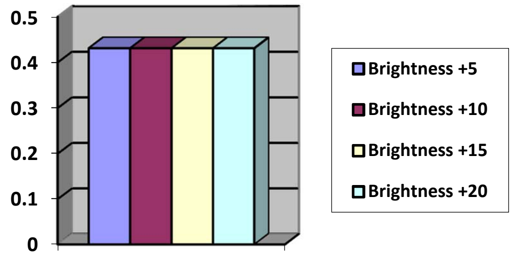

Fig. 14 MSE in different Brightness before Smoothing Process

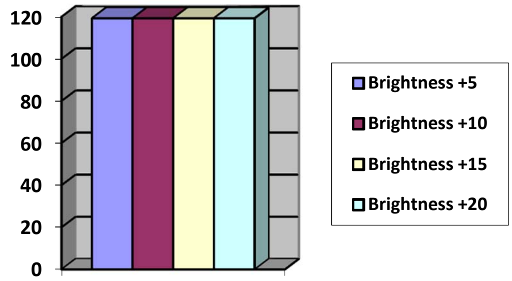

Fig. 15 PSNR in different Brightness before Smothing Process

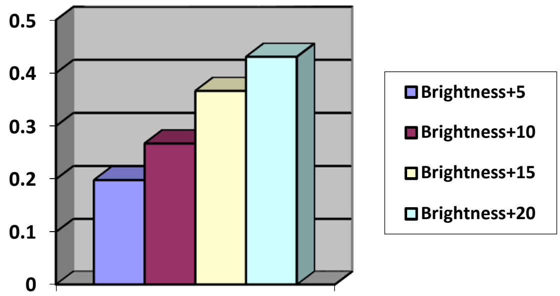

Fig. 16 MSE in different Brightness with Smothing Process

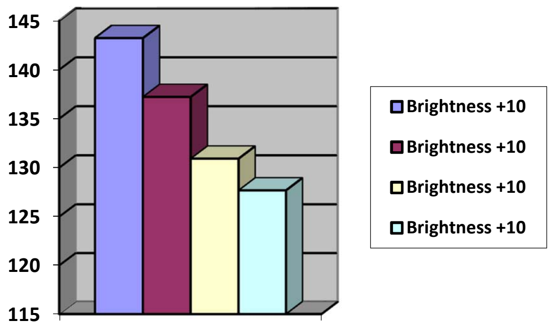

Fig. 17 PSNR in different Brightness with Smothing Process

Table 3 MSE and PSNR for Edge detection with several samples of contrast

	Edge Detection		Improvement	
Nilai Contrast	MSE	PSNR	MSE	PSNR
Contrast +5	0,431	127,680	0,1980	143,220
Contrast +10	0,431	127,680	0,2672	137,218
Contrast +15	0,431	127,680	0,3662	130,917
Contrast +20	0,431	127,680	0,4305	127,680

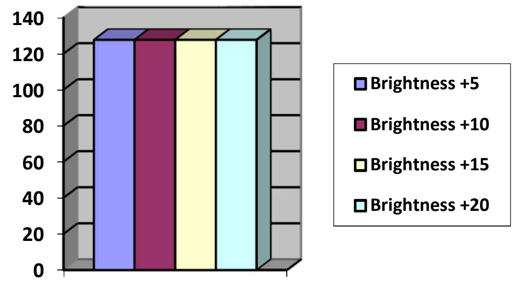

Fig. 18 MSE in different Contrast with and without Smothing Process

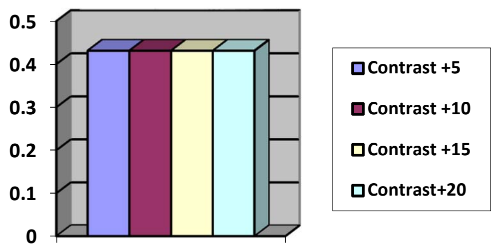

Fig. 19 PSNR in different Contrast with and without Smothing Process.

2. Robustness Test

Robustness test is the best test for edge detection. It used to compared the edge detection method and our proposed method with 20 samples images to determine which method that the best quality of MSE and PSNR. From this table we know that Gaussian Method is better because it's MSE and PSNR better than edge detection method.

From the visual test, the main image and the result image shows that the bigger the PSNR, the more the parent image and the clearer the result image.

From the test of brightness, we can conclude that the higher the brightness MSE is getting bigger and its PSNR is getting smaller

Table 4 MSE and PSNR for Edge detection with several X-ray dataset

	Edge Detection		Improvement	
	MSE	PSNR	MSE	PSNR
Image 1	0,431	119,252	0,431	119,252
Image 2	0,431	119,252	0,1979	127,0227
Image 3	0,431	119,252	0,1979	127,0227
Image 4	0,431	119,252	0,3662	120,8709
Image 5	0,431	119,252	0,431	127,680
Image 6	0,431	119,252	0,431	119,252
Image 7	0,431	119,252	0,431	119,252
Image 8	0,431	119,252	0,431	119,252
Image 9	0,431	119,252	0,431	119,252
Image 10	0	infinity	0	infinity
Image 11	0	infinity	0	infinity
Image 12	0,0049	163,912	0,0049	163,912
Image 13	1,6433	105,858	0,4475	118,866
Image 14	1,2570	108,538	0,8215	112,792
Image 15	0,5543	116,727	0,1633	128,946
Image 16	0,00495	163,912	0,00495	163,912
Image 17	0,14846	129,900	0,04950	140,8857
Image 18	1,25697	108,538	0,44539	118,9134
Image 19	1,25697	108,538	0,79674	113,0975
Image 20	0,55426	116,727	0,16331	128,9465
Average	0,528006	109,7959	0,312255	114,4564

IX. CONCLUSION

In this research, some conclusions are drawn:

a. From the visual test, the main image and the image of the result shows that the larger the MSE the more the parent image and the resulting image becomes less clear (blur).

b. From the visual test, the main image and the result image shows that the bigger the PSNR, the more the parent image and the clearer the result image.

c. From the test of brightness, we can conclude that the higher the brightness MSE is getting bigger and its PSNR is getting smaller

d. From contrast testing, we can conclude that the higher the contrast then the MSE and PSNR not change.

X. ADVICE

The suggestions that the author can provide in this study are as follows:

The uncertain results of MSE and PSNR are due to the multitude of ways MSE and PSNR search

Display results still look rough so there needs to be further filtering

The pixel processing still chooses pixels in sequence so it takes a long time so it needs to be improved in terms of accuracy and efficiency.

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