Stroke Identification System on the Mobile Based CT Scan Image

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Abstract— **A stroke occurs if the flow of oxygen-rich blood to a portion of the brain is blocked. Without oxygen, brain cells start to die after a few minutes. Sudden bleeding in the brain also can cause a stroke if it damages brain cells. Stroke is a harmful disease in which most of the cases of this disease bring an effect of the physical defect on patients. One of the methods of examining this disease is by means of head CT scan. However, there is a weakness of head CT scan for consisting of some unclear or invisible parts. Hence, it needs a technique for improving the image quality to again emerge the invisible parts. Adaptive histogram equalization (AHE) is a technique that can cope with the weakness of HE by enhancing the contrast in local area. The contrast enhancement, however, can be excessive sometimes. Using the contrast limited adaptive histogram equalization (CLAHE), the excessive contrast enhancement in AHE can be coped with by giving the limit value on histogram. In this research, a stroke identification system has been built comprising image enhancement with CLAHE, feature extraction statistically with the mean value, deviation standard, skewness, kurtosis, and segmentation using the statistical region merging method. The result then showed that the method of image processing significantly conducted was able to be used as a tool to identify the stroke disease in order to distinguish the type of CT scan to the normal or sick state.**

Keywords— ***Head CT scan photo, contrast limited adaptive histogram equalization, statistical feature extraction, statistical region merging***

I. Introduction

Computed Tomography (CT) is an imaging technique where digital geometry processing can be used to generate a 3D-image of brain’s tissue and structures obtained from a large series of 2D X-ray images. CT scans furnish the detailed images of an object such as dimensions, shape, internal defects and density for diagnostic and research purposes.

Image processing techniques can assist to differentiate the abnormal tissue growth (tumours) in question from other tissues, providing more detailed information on head injuries, stroke, brain disease and internal structures than do regular CT scans. By using suitable programs into the first stage we performed multiple processing on a typical tomographic image of a normal brain and abnormal brain.

The scanned image such as CT scan is an analogue gray level image that experiences the degradation of quality due to the external factors (noise) and the medical equipment used. Hence, a process of image enhancement using the techniques of gray level image processing is deemed essential. This is aimed to produce a better image compared to the initial image. The next step needed is the processing of gray level image is the image analysis purposely to identify and display the parameters associated with the features in the representation of the object in image in which the image later on will be used as the image interpretation.

In medical field, the medical image commonly has a histogram that tends to be around the dark value in the gray level. Thus, it can be assumed that the use of digital image processing is not optimal yet though the use of this utility can assist the radiologists in determining a diagnosis of an abnormality due to the tissue damage. Detecting the impaired brain using the CT-scan image is an attempt to introduce the computerized method of detecting the impaired brain that is newer compared to the visual method to date [4].

From a number of researches the writer has found so far, the researches concerning with the segmentation of medical image particularly head CT scan to detect any impairment of brain tissue are found scarce. Hence, it can be assumed that the topic proposed is something that will be developing.

From a number of references, research conducted by Paniran was on the optimal filter on digital binary image affixed by noise, mathematical morphology for binary image, morphological operator for the image and compressed video, segmentation of ultrasound image using morphological operator, analysis on the property of median filter,

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morphological derivative for image processing, decomposition of gray level element structure and the introduction of medical image patterns with artificial neural tissue using the Adaptive Resonant Theory (ART) method. The next research was conducted by Paniran on the Medical Image Enhancement Using Morphological Filter [5][6].

Further research was conducted by Yulianto indicating that the image enhancement to make the CT scan image of the brain clearer can be conducting using histogram equalization, contrast stretching, histogram classify, ROI (Region Of Interest) and the edge detection using the operation of image morphology that included the combination of dilation and erosion. This research would be more emphasized on the use of accurate segmenting method for the head image CT Scan and the analysis on the correlation on the detection of impaired brain tissue to the stroke person[7][12].

The aim of this research is to make software to assist in the identification of the type of mobile based head CT scan by extracting a number of features embedded in the image by means of a statistical analysis on mean value, deviation standard, kurtosis, and the skewness from the image head CT scan.

II. THEORY

Digital image processing is aimed to improve the quality of image to be easily interpreted by human and computer. In image processing, the process from the initial image to be the image with a better quality is conducted. The enhancement of image contrast is an example of the operation of image processing [13].

Image enhancement is one of the initial processes in image pre-processing. Through this process, the image quality is improved thus the image can be used for further application. There are many factors of why an image has the poor quality. One of them is the poor quality that is too dark or bright. One of the techniques most frequently used in image enhancement is the increase of contract enhancement. Contrast shows the distribution of lightness and darkness in an image [9].

Histogram illustrates the number of pixels distributed on head CT Scan image (y-axis) for each level (gray value) from darkest (0) to brightest (256). The total pixel count was also calculated and displayed, as well as the mean, modal, minimum and maximum gray value. Count indicates the total number of pixels corresponding to the intensity level. Mean shows the average intensity value. It is the sum of the gray values of all the pixels in our selection divided by the number of pixels. With RGB (24-bit) head CT Scan images, the mean was calculated by converting each pixel to gray scale by using the formula: gray = 0.299 red + 0.587 green + 0.114 blue. Std Dev (Standard Deviation) indicates how widely intensity values vary. Min (0) and Max (255) represents the minimum and maximum gray values within head CT Scan image [13].

Histogram equalization (HE) refers to a process of histogram equalization with the distribution of value of gray level in an image made even. To do this, it requires a function of cumulative calculation from histogram. The function of cumulative distribution function (CDF) can defined in the equation (1).

$$f(k) = \frac{(N-1)}{M} . \sum_{k=0}^{n} h(k); \qquad (1)$$

with n = 1,2,3,…,N-1, M denotes pixels, N denotes the grayscale, and h(k) refers to histogram in a gray value k [3].

Adaptive Histogram Equalization (AHE) is a technique of image contract improvement by improving the contrast of image local obtained by forming a number of symmetric grids on image called region size. The problem in the excessive increase of contrast in AHE can be coped with using Contrast Limited Adaptive Histogram Equalization (CLAHE) that is by giving the limit value in histogram. This limit value is called clip limit stating the maximum height of a histogram [7][1]. The way to calculate the clip limit of a histogram can be defined with the following equation (2).

$$\beta = \frac{M}{N}\left(1 + \frac{\alpha}{100}(s_{\max} - 1)\right) \qquad (2)$$

M variable refers to the area of *region size*, *N* refers to the value of *grayscale* (256), and α is a *clip factor* stating the addition of a limit of a histogram with the value in the range of 0 to 100.

Segmentation is a first step commonly used prior to conduct the analysis process towards an image. The algorithm of segmentation for the picture of monochrome in general is based upon one of two picture features those are discontinuity and similarity embedding the value of gray level. [8]. Not only did this research use the CLAHE method but also the SRM (statistical region merging) method with Q = 10. Statistical Region Merging (SRM) is a recent colour image segmentation technique based upon region growing and merging. [10]. The method models segmentation as an inference problem in which the image is treated as an observed instance of an unknown theoretical image, whose statistical (true) regions are to be reconstructed. The advantages of this method include its simplicity, computational efficiency, and excellent performance without the use of quantization or colour space transformations. Statistical Region Merging is a fast and robust algorithm to segment an image into regions of similar intensity or colour [11][14].

The idea is to start with one region per pixel and then applying a statistical test on neighbouring regions (in ascending order of intensity differences) whether the mean intensities are sufficiently similar to be merged. The aim of the segmentation is to divide the digital image into region. The determination of region limit is based on the discontinued intensity. Once the process of segmentation is complete, the next process is to analyse the object to observe the object [13].

Feature extraction is a process of taking the features of an object in the image to learn about the object. It is an initial step in performing classification and interpretation of an image. This process is related to the quantization of characteristics of image into a group of appropriate feature values. A number of general features used to learn one or some objects in an image include size, position or location, and orientation or the skewness angle of the object towards the reference line used. One of the methods used in the feature extraction is the statistical feature extraction of the first order and the feature extraction of the second order. [2][3].

The feature extraction of the first order is a method of taking the feature based upon the characteristics of image histogram. The histogram shows the probability of the emergence of the value of gray scale in an image. From the obtained values of histogram, a number of parameters of the statistical feature of the first order can be calculated such as means, skewness, variants, and kurtosis [2].

The mean value of a distribution of intensity value of gray image shows the dispersion size of an image that can be found using the following quotation (3).[13].

$$mean\mu) = \sum_n f_n p(f_n) \quad (3)$$

where f_n refers to a value of gray intensity, and $p(f_n)$ shows its histogram value (probability of the emergence of intensity in the image).

The variants of a value distribution of gray image intensity showed a variety of elements in histogram from an image that can be found in the equation (4) below:

$$\sigma^2 = \sum_n (f_n - \mu)^2 p(f_n) \quad (4)$$

Skewness (α_3) shows the level of relative skewness of histogram curve from an image found in the following equation (5).

$$\alpha_3 = \frac{1}{\sigma^3} \sum_n (f_n - \mu)^3 p(f_n) \quad (5)$$

If f_n is a value of gray intensity, then $p(f_n)$ shows its histogram value (the probability of the emergence of intensity in image). Kurtosis (α_4) shows the level of relative kurtosis of histogram curve from an image that can be found in the following equation (6).

$$\alpha_4 = \frac{1}{\sigma^4} \sum_n (f_n - \mu)^4 p(f_n) - 3 \quad (6)$$

III. RESEARCH METHODOLOGY

The tools prepared in this research included software Windows 8.1, ADT bundle android (eclipse + ADT plugin + android sdk), program OpenCV 3.0.0-beta for Eclipse IDE, Jdk 8u31-windows-x32. Meanwhile, the hardware required included Scanner CanoScan Lide 25-type, the hardware of desktop computer of Asus Intel Core i7-4500 U, 4-GB Memory, emulator Smartphone Samsung Galaxy S2 and Nexus 7, HP Samsung galaxy S2 used to capture the image.

There were 28 analogue image data taken from the combination of patients with stroke and normal patients divided into three types of data including head CT Scan for normal, infarct, and bleeding stroke.

The phases applied in the image processing included changing the gray image and the enhancement of local image contrast by means of CLAHE method. The next step was the segmentation using the statistical region merging method and statistical feature extraction including: the mean value, deviation standard of each image including the mean value, deviation standard, skewness and kurtosis. Overall, the research steps are shown in Figure 3.1.

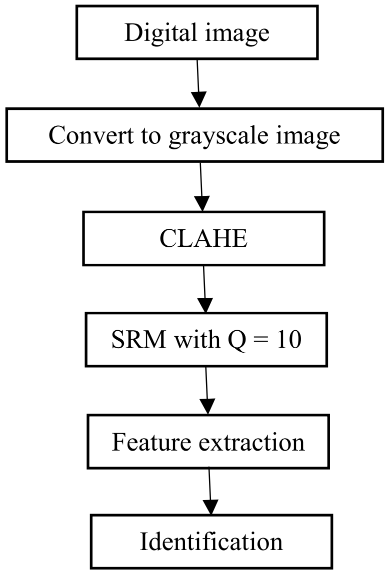
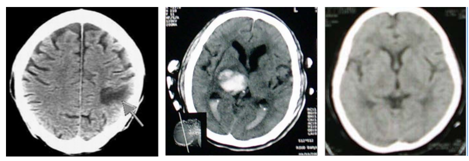


Figure 3.1 Research Steps

IV. RESULTS AND DISCUSSION

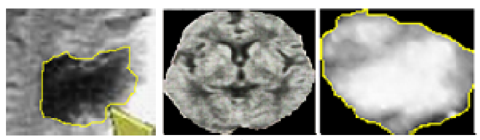
The *head CT Scan* of original image is shown in Figure 4.1 (a), (b), and (c).



(a) (b) (c)

Figure 4.1 Digital Image CT scan with (a) stroke infarct; (b) bleeding; (c) normal

The process of cropping object followed by the processing of contrast enhancement by means of contrast limited adaptive histogram equalization (CLAHE) method is shown in Figure 4.2 (a), (b), and (c) below.



(a) (b) (c)

Figure 4.2 Image CT Scan of the CLAHE result (a) infarct; (b) bleeding; (c) normal

The results of the SRM segmentation with Q = 10 for those three types of image CT scan are shown in Figure 4.3 (a),(b), and (c) as follows.

Figure 4.3 Results of SRM segmentation; (a) infarct, (b) bleeding, (c) normal

The results of the statistical measurement of the mean value, deviation standard, skewness, and kurtosis of three types of CT scan are shown in Table 4.1 below.

Table 4.1 Results of Statistical Measurement

	mean	std	skewness	kurtosis
Normal	123	77	-0.04	-1.16
hemorrhage	195	45	-0.66	-0.31
infarct	120	61	0.05	-1.16

The results of the statistical measurement of CT scan showed that the highest mean value occurred in the CT scan for bleeding. Meanwhile, the highest value of the deviation standard was in CT scan for normal, and the highest value of skewness is in CT scan for infarct. In this case, the kurtosis of CT scans for normal and infract provided an almost equal value. This then shows that visually the CT scan image to the patients with infarct stroke and the CT scan for the normal is difficult to be distinguished. However, using the statistical measurement to distinguish the image CT scan for the patient with normal and the patients with infarct stroke is possible to be observed from the smaller value of skewness.

V. CONCLUSION AND SUGGESTION

From the discussion that has been done, two conclusions can be described as follows:

1. The enhancement of image quality using the application software of CLAHE and SRM method significantly can clarify the digital head CT scan image.
2. The statistical analysis including mean, deviation standard, skewness and kurtosis extracted from the object features on image can show the condition of the healthy and sick brain by comparing each of the statistical value of healthy image and the image detected to have an abnormality. The results of the statistical analysis from the texture feature show that the digital image with the least mean value was found in digital head CT scan image for infarct. Meanwhile, the digital image head CT scan for bleeding had the highest mean value. The highest value of deviation standard was found in CT scan for normal.

SUGGESTION

In the processing of CT scan image, it needs to develop an automatic and real-time segmentation; thus, it can be directly used in the head CT scan image that will be analysed. The number of the data needs to be added and the statistical analysis of the second order needs to be done to improve the accuracy.

VI. REFERENCES

[1] Byong Seok Min, Dong Kyun Lim, Seung Jong Kim and Joo Heung Lee, A Novel Method of Determining Parameters of CLAHE Based on Image Entropy, International Journal of Software Engineering and Its Applications Vol.7, No.5 (2013), pp.113-120

[2] Nurhayati, O.D., 2008, The Application of a Proper Segmentation Method in The Analysis of Head CT Scan Images, master's in electrical engineering, UGM, Yogyakarta

[3] Angenent, S., Eric Pichon, and Allen Tannenbaum, 2000, Mathematical Methods in Medical Image Processing, Bulletin of the American mathematical society.

[4] Bailey, D.G., 2004, An Efficient Euclidean Distance Transform, Institute of Information Sciences and Technology, New Zealand.

[5] Isnanto, R.R, 2002, Bone Damage Identification Using Image Analysis of X-ray photos, Master's electrical engineering, UGM, Yogyakarta.

[6] Leggett, R., 2004, Automatic Segmentation of Medical Images, http://www.google.com/dissertation.pdf.

[7] Loncaric, S., A.P. Dhawanb, D.Cosica, D.Kovacevica, J.Brodericke, Th.Brott, Quantitative intracerebral brain hemorrhage analysis, https://bib.irb.hr/datoteka/49676.mi99ich.pdf

[8] R.Ganesan and S. Radhakrishnan, Segmentation of Computed Tomography Brain Images Using Genetic Algorithm, International Journal of Soft Computing, 2009 | Volume: 4 | Issue: 4 | Page No: 157-161

[9] Munir, R., 2004, Digital Image Processing Approach to Logarithmic, Informatics, Bandung.

[10] Nock, Richard and F. Nielsen, Statistical Region Merging, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 26, no. 11, November 2004

[11] Celebi, M. Emre, Hassan A. Kingravi, Hitoshi Iyatomi, Y. Alp Aslandogan, William V. Stoecker, Randy H. Moss, Joseph M. Malters, James M. Grichnik, Ashfaq A. Marghoob, Harold S. Rabinovitz, Scott W. Menzies, Border detection in dermoscopy images using statistical region merging, Skin Research and Technology 2008; 14: 1–7

[12] Yulianto, P., 2005, Improved Imagery to Clarify Brain CT-Scan photos, Master's electrical engineering, UGM, Yogyakarta.

[13] Gonzalez, R.C., Woods, R.E, 2008, Digital Image Processing New Jersey: Prentice Hall.

[14] http://fiji.sc/Statistical_Region_Merging