Contrast and Brightness Enhancement for DICOM Images and Lesions Auto Detection

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***Abstract*—Brain lesions can cause severe dysfunction of the human body, and mind. It may result in fatality if it is not detected early. This paper focuses on the detection of lesions through image processing. Three different approaches are proposed to detect ischemic infarct. The detection of hemorrhagic infarct is done automatically with windowing DICOM images by setting optimal window width and window centre and then the lesion area is found by using human observation, database matching and saturation level detection method. This paper is mainly about way of aiding human to analyses lesion in CT Scan by finding the best windows setting and filter out the unnecessary information in DICOM images. The filtered images are applied with contrast enhancement to make observation and confirmation process easier and more accurate. The possible lesion areas are plotted with mark by human. After that the result is double confirmed with auto detection by computer.**

***Index Terms*—DICOM, histogram equalization, HE, sub-block, contrast, brightness, image processing, lesion**

I. Introduction

With the advanced of technology, even the most vulnerable part of human body can be scanned and analyzed. CT scan and MRI are the two common methods for medical scanning [1]. They use different approach to monitor internal structures of human body that are not visible to plain eye [2]. One of the widest uses of CT scan and MRI is to detect brain lesion [3]. Brain lesion is the abnormal area of brain due to injury. Brain lesion is proven to be fatal if correct treatments are not given [1]. Medical images are saved in a standard format named Digital Imaging and Communications in Medicine (DICOM). DICOM is a standard developed by National Electrical Manufacturers Association (NEMA) and American College of Radiology (ACR) on 1993 [1]. It is 16 bits file format that contain medical image scan and scan information.

Due to the nature of DICOM image format, extra image processing is needed to extract the information needed [4]. Windows setting and contrast and brightness enhancement is needed to aid medical official when identifying lesion [5]. Due to medical image scanning usually comes in large volume, inspecting all slices is a tedious job, and with so many scans to look at, the chances of error naturally increase. Some lesions, particularly early infarcts, are known to be subtle in their appearances in brain scan images, and the less experienced medical practitioners may miss out such subtle signs.

X-ray beams used in CT scan are directed to patient transversely. During examination, patient remains static while the X-ray tube rotates around the patient. The emergent beam which is registered by radiation detectors will be attenuated by the patient’s body. This caused the resulting beam is different for each part of organs or structures. Finally, its intensity is transformed into the attenuation coefficients through computer. These coefficients, or better known as Hounsfield Unit (HU) will then being mapped into the anatomical section [5]. HU typically ranges from -1000 to 1000, where -1000 is representing air, 1000 is representing bones, and water is used as reference with value 0.

II. Methodology

Window width and window centre are critical parameters to show the useful information of DICOM image. To adjust the window centre setting with additional window width setting for an image, the rescale intercept and slope are applied to transform the pixel values of the image into values that are meaningful to the application [6]. Applying the rescale slope/intercept to pixel value converts the original values into optical density or other known measurement units (e.g. Hounsfield) [7]. When the transformation is not linear, a lookup table is applied. After the modality transform has been applied (rescales slope/intercept or LUT), then the window width/centre specifies which pixels should be visible: all the pixels outside the values specified by the window are displayed as black or white. For instance, if the window centre is 120 and the window width is 40 then all the pixels with a value smaller than 80 HU (Hounsfield Unit) are displayed as black and all the pixels with a value bigger than 160 HU are displayed as white. This allows to display only portions of the images (for instance just the bones or just the tissues). The formulas of the transfer function are shown in (1) to (3).

$$Min\_value = window_{centre} - \frac{window_{width}}{2} \quad (1)$$

$$Max\_value = window_{centre} + \frac{window_{width}}{2} \quad (2)$$

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$$K = \left(\frac{HU - \left(window_{centre} - \frac{window_{width}}{2} \right)}{r} * Kmax \right) \quad (3)$$

where *Min_value* represents the minimum value of the window; *Max_value* represents the maximum value of the window; and *Kmax* = maximum range (255 for greyscale format). Fig. 1 shows the different window width setting. When window width is increased, more information is shown as largest range is displayed. Fig. 2 shows the effect when different window centres are used.

Setting the correct window width and window centre setting is crucial for lesion detection. There is no absolute value of window width and window centre. The reference value for certain part of body is decided by experience and not necessary suit particular scan. Window centre and width are adjusted one by one and observed by human eye for the best value for a set of scan [8].

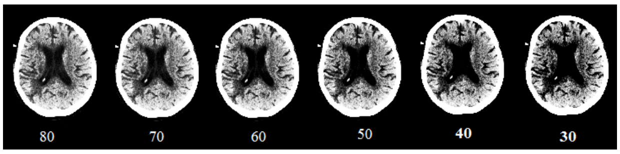

Figure 1. Comparison of window width setting from 30-80.

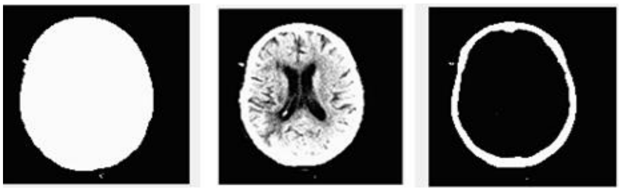

Figure 2. Comparison of window centre setting. From left to right 800, 1065, 1100HU.

A. *Contrast Enhancement*

The intensity of an image is often referred as luminance, which is referring to how much the average white level for the overall of an image. For greyscale images, the intensity is the grey level which refers to value between black and white. Contrast is the difference that differentiates between objects and the background in an image. Therefore, for grey-scale images, contrast is the grey level difference that discriminates the main objects with background. The contrast is basically defined as the ratio of the maximum intensity to the minimum intensity over an image.

Histogram Equalization (HE) is the most common contrast enhancement technique used for contrast enhancement in medical images. HE method increases the pixel value of a whole picture in uniform therefore increases the brightness of an image. Due to the nature characteristic of lesion having close value in Hounsfield scale with brain tissue, it is hard to identify the lesion easily even after doing window width and centre setting. Some medical images might also appear to be too dark for medical official to analyse clearly. This situation will greatly slow down the process of treatment as brain lesion caused from accident or disease might be fatal to patient life. The purpose of having HE is its ability to further improve the images that have been processed with window width and window centre setting. The image is processed once more to enhance the brightness and contrast. With the increase of dynamic range of the background and the brain, the lesion will appear more clearly and easier to identify. A basic HE does not suit medical image processing due to the background is greatly different from the brain and skull. HE is a method in image processing of contrast adjustment using the image's histogram. Basically HE computes the PDF and also CDF of all grey levels in an image to define the transfer function of an image. After that, the greyscale level is remapped to new grey level based on the respective CDF. The intensity of the white of an image is better distributed therefore allows areas of lower local contrast to gain a higher contrast [9].

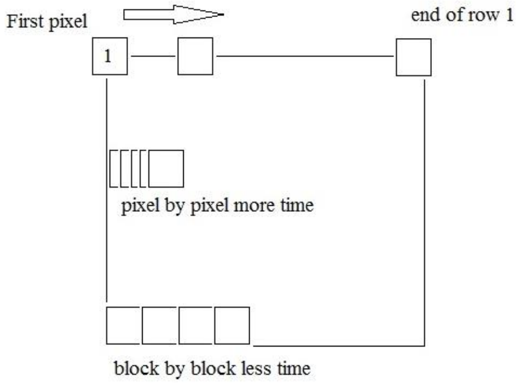

Figure 3. Two types of AHE. Pixel by pixel and block by block.

Adaptive Histogram Equalization (AHE) implements block-overlapped sub-blocks equalization. A rectangle sub-block is first set and is centred at first pixel of an image. The, HE is performed for the sub-block and the respective transfer function is obtained. After that, the same histogram equalization is performed across the image by moving the rectangle from left to the right of the image until the end of the image. The size of block remains constant as predefined. Because of the process repeats for every pixel across the image, it takes longer time and more complex. The method is stronger as it takes nearby pixel of the image and eliminates some of the problem of basic HE method. There is also AHE method that shifts by rectangle which not overlaps with each other. The method gives lower computation time but creates blocking effect. It is because each block is doing own HE and those sub blocks are combined together again at the end of the process. Blocking effect happened because of the different brightness at the nearby pixel of the sub block. Extra process must be performed to eliminate the blocking effect later. Although AHE eliminates some problems of basic HE method, it still suffers from some contrast over enhances. Therefore another improved AHE method is purposed. Fig. 3 is the illustration of both AHE methods. It is clear that pixel by pixel method will take longer time because there are more pixels in 1 row. Fig. 3 shows how overlapping and non-overlapping sub block HE work. The process starts from left to right and then jump to next row.

B. Auto Detection

The purpose of having computer auto detection is to filter the long list of files and choose the potential scans that lesion exists. CT scans usually come with hundreds of images set and filtering will be able to reduce burden of medical officers by decrease the images need to examine by them and in directly increase the efficiency in examination process. Furthermore, auto detection can double confirm the result from human eye observation and reduce the chance of overlook of potential illness in brain. There are 2 proposed methods in this project. The first one is database data matching and the second one is by cropping saturation region.

C. Database Matching

This method detects lesion by doing cross relation between the input image with predefine database. The database consists of small images which are extracted from different set of images during expert examination. These small images consists of the parts that had been confirmed as lesion. A new set of CT scan images will be compared with these small images. If there is any matching, that particular part will be plotted with circle. This circle indicates potential illness exists and further examination must be done. This method requires a huge database for accuracy. Fig. 4 shows the results of a few samples of DICOM images plot with database matching method.

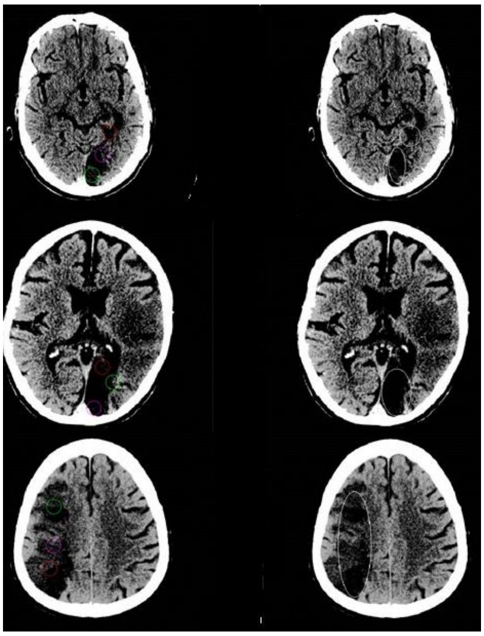

Figure 4. Result of database matching.

D. Saturation Detection

The second method colourizes the input image with certain colour hue. Then, certain level and range of hue are detected in the colour image. The software will crop out the part of saturation with line. This method requires a lot of beforehand experience because there is no standard optimum saturation value. Sometime a lot of times are needed to determine the correct value of saturation before a set of images is sent to process. Colourize method will map different HU range to different colour, and then crop the HU level of brain lesion. Fig. 5 shows the result of lesion that identifies by colour saturation. The area being cropped by green line is the area with possible lesion. Fig. 6 shows the interface of the program and the value of the setting to detect and to crop out the saturation levels of lesions. Fig. 7 shows the review of doctor from a local general hospital, namely Hospital Melaka. The result is compared with auto detection from computer. It is proved that the auto detection methods are reliable.

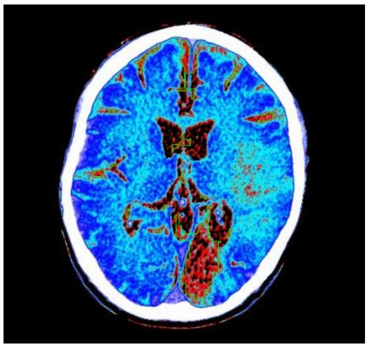

Figure 5. Image sample from Hospital Melaka using colour lesion auto detection method.

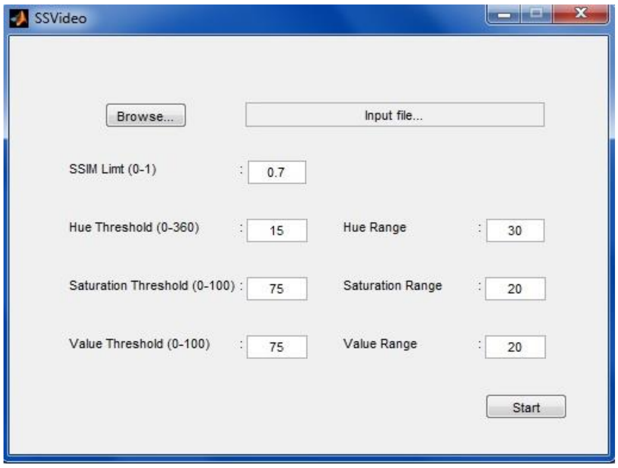

Figure 6. Interface and value of setting for lesion saturation level detection.

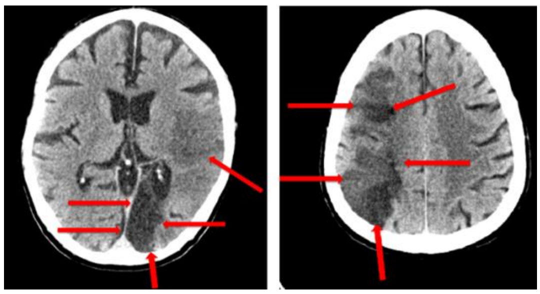

Figure 7. Expert review by doctor from Hospital Melaka.

III. SUMMARY

For summary, DICOM file contains raw 12-bit image file. The image file contains too much information and must be filtered to identify lesion. The process of extracting certain information from the image is called window settings. The process starts with finding optimal window centre by fixing the window width. After the optimal window centre is found, window width is adjusted to the best value. Those values are not absolute and different from set to set of image. After that, the image is applied with various Histogram Equalization methods to observe the lesion area. Lastly, the Histogram Equalization result is compared with computer auto detection to double confirm the result.

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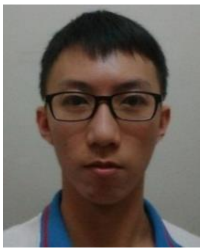

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