Graphic User Interface for Extreme Level Eliminating Adaptive Histogram Equalization

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***Abstract*—In this paper, a Graphical User Interface (GUI) for Extreme Level Eliminating Adaptive Histogram Equalization (ELEAHE) is developed in this paper. This new developed GUI is used to visualize and emphasize the hypo-dense area in Computed Tomography (CT) brain images by applying ELEAHE. In the GUI, the original image and the processed image are displayed side by side when the CT images of brain are loaded. Window center and window width setting is set to default values and both of them are adjustable. Besides that, expert diagnoses on the locations of brain lesions are also provided and marked for each brain images for reference purpose. This developed GUI shows great potential to improve the manual examination and analysis of CT brain images by connecting the user with image processing algorithm. The developed application is suggested as a practical education application for medical students and fresh medical doctors in brain lesions analysis using CT images.**

***Index Terms*—ELEAHE, local HE, medical image processing**

I. Introduction

For the examining brain area and the detection of brain abnormalities, Computed Tomography (CT) are generally used in medical field due to low cost, high practicability, and high availability [1], [2]. The Digital Imaging and Communications in Medicine (DICOM) is standardized format of medical imaging which generate by CT [3]. A raw DICOM image is a 16-bit greyscale image. From the 16-bit DICOM, 12-bit is used for image visualization and the left 4-bit is function to store the related medical information [4]. As a 12-bit image, the large dynamic range of a DICOM image can be from 2^0 up to 2^{12} grey levels. Thus, window setting, a linear intensity stretching technique was introduced by Romans to apply on the CT images for display the region of interest in brain area. [5].

However, this window setting does not sufficiently highlight the hypo-dense area due to low contrast. Hence, an image processing techniques (Histogram Equalization HE) have been introduced to enhance the contrast of the medical images [6]. HE increases the global contrast by mapping a function generated from the global histogram. This allows the images of lower contrast to gain a higher contrast. Generally, HE methods present nowadays can be categorized into two categories. First, the global methods that applies HE in the entire image. Second, the adaptive or local HE methods apply in small local regions in the image. Nevertheless, when the global HE is applied on the CT brain images, it would bring the undesired enhancement. Thus, adaptive HE methods have to apply in order to boot the contrast of CT brain images.

On the other hand, applying HE without a visualization of the images HE is meaningless. Therefore, a GUI is necessary to design in order to visualize the effect of the HE. Besides, a proper designed GUI would speed up the job for computation process. In this article, a GUI with local HE method, known as ELEAHE is designed and developed to emphasize the hypo-dense area in CT brain images for visualization.

II. Global HE

There are plenty of enhanced global HE methods. This section discussed some common HE technique for the contrast enhancement of medical images.

For standard HE, the average grey level of the output image is always in the middle grey level of the entire grey-scale range of input image. It maps the input image so that the output image has a uniform density [7].

The global HE methods are straight forward and fast computation, but they cannot alter to local brightness intensity of the image. This is because they are using only the global histogram over the whole image. In addition, some global HE methods cause significant undesired enhancement defects like noise amplification and over-enhancement, especially when there is no limit on the contrast enhancement. As the result, the local HE methods are introduced to overcome the global HE problem in more effective and powerful way [8].

III. Local/Adaptive HE

The adaptive histogram equalization is also referred as local HE or sub-block HE. The local HE uses the local histograms of small regions in an image to determine the transfer function. It is complex and time-consuming when compare to global HE because of huge computational task of generating the mapping function pixel by pixel. However, local HE can effectively improve the local contrast of CT brain images compare to global method.

Pfizer *et al.* presented an improvement scheme Contrast-Limited Adaptive Histogram Equalization (CLAHE) to overcome the problems of the non-

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overlapped sub-blocks local HE [9]. This technique aims reduce the over-enhancement and noise amplification effect for the original images. The CLAHE is widely employed in medical image processing due to its effectiveness in local contrast enhancement [6]. In CLAHE, the blocking effect is eliminated by bilinear interpolation method. Besides, the CLAHE also includes the contrast limitation to allow minimize undesired noise amplification and over-enhancement. The contrast limitation limits the density and redistributes the clipped pixels.

In this article, the HE method used, namely ELEAHE which is a local HE approach. According to T. L. Tan 2012, ELEAHE apply the for contrast enhancement inside the brain area is successfully improved the visualization of the subtle hypo-dense area while the background brightness is maintain at the original level [10]. This method evolved from the global HE method, namely ELEHE [10]. The ELEHE consist of two variations; these variations are basically established from the conventional global HE and acts as a benchmark for the ELEAHE.

A. Extreme Levels Eliminating Histogram Equalization (ELEHE)

ELEHE, a global HE method is presented by Tan *et al.* to improve the contras brightness of CT brain images [10]. In CT brain images, the maximum grey level is mostly corresponding to the background, while minimum grey levels are mostly corresponded skull. Both of them occupy more than 50% of the image pixels. From this consideration, it is able to stretch the other grey levels as much as possible while maintain the extreme grey levels at the same stage [10]. The flow of algorithm of ELEHE is show below:

- Initially, the histogram of the image is plotted. Then the pixel count is accumulated for all grey levels. The density of maximum and minimum grey levels are eliminated by clipping to 0, where the other grey levels are remains the as original.
- The total excessive pixel (total clipped pixels) are equally reallocate to all the grey levels except the maximum and minimum grey levels. The pixels are reallocate in the condition of the other grey levels' new pixel count does not surplus the threshold level which define early [10]. The pixel reallocation is obtained from average number of redistributed pixel.
- The new Probability Density Function (PDF) is then defined when pixel reallocation is completed. Next, the new PDF is used to compute the new Cumulative Distribution Function (CDF). As the result, it produce optimal enhancement on the region of low density levels without amplification of noise in output image by stretched the grey levels.

B. Extreme Level Eliminating Adaptive Histogram Equalization (ELEAHE)

The ELEHE is a global HE method, has a drawback of over-enhancement of output image. The enhancement version of ELEHE, ELEAHE is established based on ELEHE to overcome the limitation of ELEHE. In ELEAHE, ELEHE is implemented locally into each part of input image. Then, the final output image is altered to the local brightness intensity change in the original image [10]. The flow of algorithm of ELEHE is show below:

- A W×H image is segmented into X×Y equal-size, square non-overlap sub-blocks with N number of sub-block. A zero array Z, with the size of X×Y, is initialized.
- The histogram of the first sub-blocks is plotted. For the first sub-block, the ELEHE is applied as show above section to determine its CDF. Then the array Z which initialize in first step is then used to store the CDF obtain. This process is repeated until the array Z is stored with the CDF of all the sub-blocks which divided from original image.
- As the discuss in CLAHE above, the bilinear interpolation uses the CDF as the transfer function of the nearest sub-blocks to estimate the best value of the pixels located on a sub-blocks boundary and the sub-block tiles that form this boundary [10]. Hence, the blocking effect eliminated in the output image. At the same time, the output image is formed with optimal enhancement without amplification of noise.

C. Graphical User Interface (GUI)

By having the algorithm of ELEAHE, it is functionless without having a proper interface. The Graphical User Interface (GUI) is designed with the algorithm of ELEAHE to perform image processing. The designing of the GUI is based on the following aspect:

- Ability to display the original image, and output image.
- Ability to store the image list in the GUI from input folder.
- Adjustable window width and window center setting.
- Ability to show the expert diagnoses on hypo dense area of brain CT image.
- Auto and manual mode for image processing (ELEAHE).

The GUI provides a connection between user and the algorithm to perform image processing. User may use the interface to load the DICOM images into the environment for image processing.

Refer to Fig. 1(a), original image, output image, and expert diagnosis are displayed in the white box as shown in Fig. 1(b), and Fig. 1(c) respectively. For the bottom part, the user control panel consists of 3 sub-panels: list panel, parameters panel, and process panel, as shown in Fig. 1(d) and Fig. 1(e) respectively. The parameter panel contains the window setting (window width and window center) and rescale slope and rescale intercept of the DICOM images. As default, the window setting is obtain through the computation to obtain optimal setting, however this setting is adjustable for user to achieve desire display for the brain hypo dense area. In List panel, the loaded images name will be display here and it allow user to select the image to be process. In process panel, Load button is used to load the DICOM images folder to the interface and contain of the folder will display in list panel. The ELEAHE button functions to give instruction to the interface to implement ELEAHE to the input image and display the result in Fig. 1(b), while expert diagnosis of selected input image will be displayed in Fig. 1(c) when expert button in Fig. 1(d) is pressed. These steps can be skip by checked the Auto Boolean, as the Boolean is checked the original image box, output image box and expert diagnosis image box will display original image, output image, and expert diagnosis image respectively when the desire image is selected. The instruction to operate the GUI has shown below:

- Initially, click the Load button to select folder, which contains the DICOM images folder. After loaded, the name of the DICOM images in the file will be appeared in the List panel.
- For manual mode, select the interest image to be process by clicking the name in the List panel. The original image will display in top left hand side box, to apply image processing (ELEAHE) click the ELEAHE button. The output image will display in top middle box, and expert diagnosis image will be displayed in top right box.
- For auto mode, checked the Auto Boolean to activate. Select the interest image to be processing by clicking the name in the List panel. The original image, output image and expert diagnosis image after apply ELEAHE will be display in respective box.
- For the case of display output image without emphasize the hypo dense area of the brain due to window setting, the window width and window center both can be adjusted by inert the correct value in the Parameter panel.

D. Result Discussion

Based on Fig. 1(b), left side is original image is the brain medical image without implement any windowing technique and contrast enhancement method. Therefore, it is impossible to find brain lesions through this image. Then, output image is the right side of Fig. 1(b). It is the image implemented with windowing technique and contrast enhancement technique, ELEAHE. In this image, it shows clearer the hypo-dense area, when compare with expert diagnosis image, as shown in Fig. 1(c). This image points out the exact location and sizes of brain lesions with red pointers, after implements windowing technique. The image is used as reference answer for user. These brain lesions are determined by expert medical doctors. Since expert diagnosis image implement only windowing technique, therefore, the hypo-dense area is not clear as output image. In conclusion, ELEAHE method enhances the hypo-dense area to improve the visibility of brain lesions.

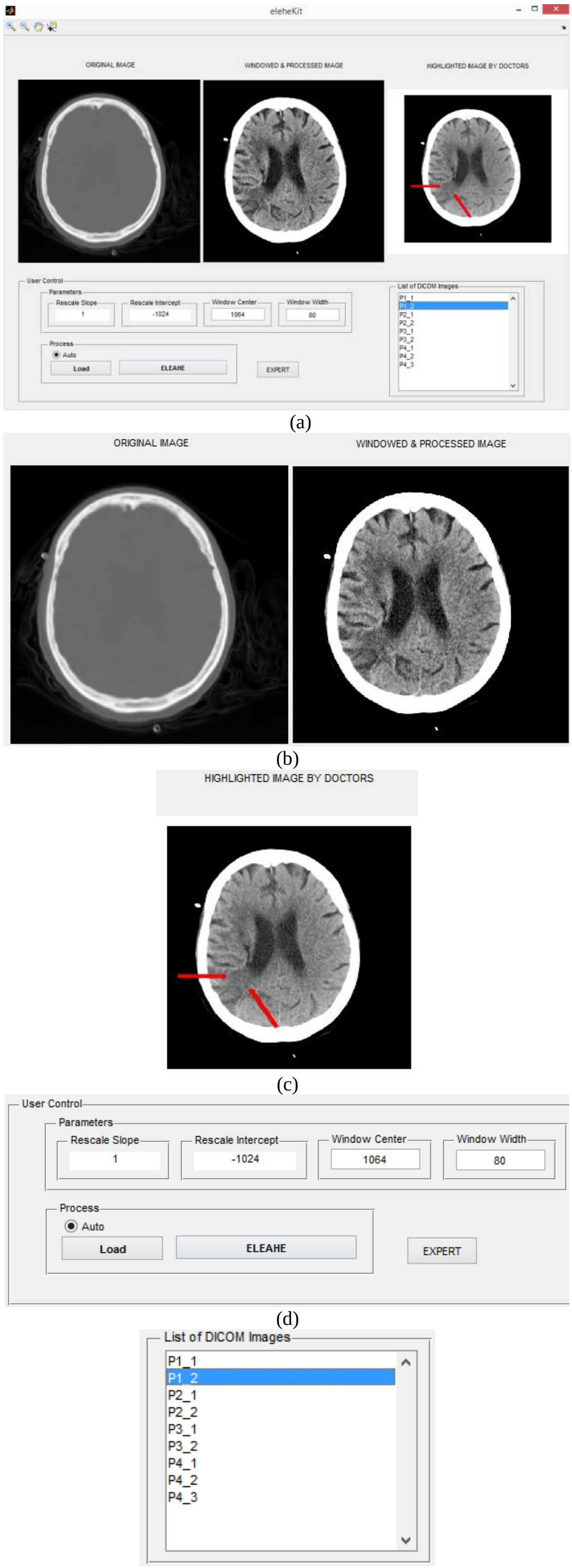

Figure 1. (a) Graphical User Interface (GUI) designed for the application of ELEAHE, (b) original image box, output image, (c) expert diagnosis image, (d) list panel, parameters panel, and (g) process panel.

IV. Conclusion

Histogram Equalization (HE) is one of the image processing methods which used to boot the image brightness. However, it is not suitable to apply for type of image of the minimum and maximum grey levels that occupy more than 50% of the image pixels (like CT brain images). Therefore, a local HE scheme has been presented to perform contrast enhancement with lesser noise amplification and lesser over-enhancement. Moreover, a GUI is design to produce a user friendly system which visualizes the brain images by applying ELEAHE to search for hypo dense area. Expert diagnosis image is provided as verification image.

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