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Enhancement of the Retinal Images and Cropping of its Optical Disks by using C language and OpenCV

Waheed Muhammad Sanya*[1], Mahmoud Alawi[2], Robin West[3]
*[1]Department of Computer Science and IT, The State University of Zanzibar (SUZA), Zanzibar, Tanzania
[2]Karume Institute of Science and Technology (KIST) Zanzibar, Tanzania
[3]Novacom Group Pty Ltd

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ABSTRACT

The Retina images suffer from the low gray level of contrast and less illumination in the region where it is nearby the optic disk with high brightness, while the region where it is far from the optic disk, has a lack of brightness thus can affect the extraction and can increment the computational time. This paper applies the enhancement of extraction and detection of retina images by reviewing the existing mechanisms and then performing experimental comparison of the developed solution through the integration of CLAHE (Contrast Limited Adaptive histogram equalization) and C-language techniques. The use of existing image enhancement mechanisms is with built-in function in Matlab, which is defined as adapthisteq (). The existing mechanism can enhance the contrast of the grayscale image by transforming the values using the Contrast limited adaptive histogram equalization. Based on the review, it was observed that there is still a need for a more timely and effective mechanism for enhancing the image quality in terms of its contrast and illumination. Hence, this study has an implemented image and enhanced mechanism with the use of CLAHE and C-language. In this integration, the c language codes involve the built-in function from the toolbox library of OpenCV (Open-Source Computer vision), like reading the Retina image and other functions. Then, the results produced between the existing mechanism and the new developed mechanism are compared. The difference between Matlab results and CLAHE integrated with C-language in the performed experiment shows the results for the verification of the Experimental is the developed solution with integration of CLAHE and C-language producing more enhanced quality of the image compared to the existing mechanism. Therefore, the study recommends integration of the developed mechanism in the devices used for capturing images such as retina.

Keywords— CLAHE Algorithm, OpenCV, adapthisteq().

I. INTRODUCTION

The eye is one of the most important sensory organs of the whole body which is used to see things found in the world. It has several components that include but are not limited to retina, optical disc, cornea, iris, pupil, lens, macula, optic nerve, choroid and vitreous. Each component of the eye has its functions towards enabling the eye to function accordingly in the whole process of vision. The first step in the process of vision is the conversion of light into signals that can be interpreted by the brain that takes place in the retina. This paper will focus on the retina and optical disc of the eye. The Retina is located at the back of the eye, which is the sensory membrane that lines the inner surface of the back of the eyeball. Whereas the optic disk is the round spot on the retina formed by the passage of the axons of the retinal ganglion cells, which transfer signals from the photoreceptors of the eye to the optic nerve. Optic disc is also found in the back of the inside of the eye where the optic nerve connects to the retina. Overall, the main functions of the retina and optic nerve is to assist each other toward enabling the light to be interpreted well by the brain to complete the vision process in the eye. In addition, the feature of retina differs from one person to another. Furthermore, the pattern of the blood vessels in the retina is unique for every individual, therefore, it is perfect for person authentication in biometrics unless there are some serious changes made in the retina and iris. Hence, emerging technologies such as biometric are using retina features as one of the components for unique identification of a person. Other features that are used by biometric technologies for a person identification include face and fingerprint. Due to these unique features of the retina and optical disc, this paper discusses the implementation of enhancement of extraction and detection of the images of the two features of the eye using C-language and OpenCV so that they effectively assist in the identification devices such as biometric technologies. The following Figure 1 briefly describes the structure of human eye.

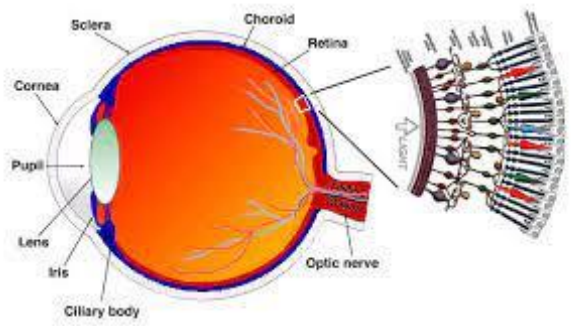

Figure 1: The Structure of Human Eye

II. RELATED WORKS

According to the literature, it has been observed that the lack of effective and accurate capturing of face, fingerprint, retina and optical nerves which are found in the optical disks lead to failure in the unique identification of a person. This challenge may be caused by lack of effective brightness of the retina and optical disks because of human-aging and sickness such as diabetes to mention a few. Due to these challenges, there are a large number of studies and research completed in the development of enhancement algorithms for capturing these unique features. These enhancement algorithm methods can be classified into two major groups namely, data domain and restored model. They consist of a transform-domain algorithm as well as an image-domain algorithm [1]; the transform-domain algorithms crumble an image into several sub-groups to improve the frequency components of the image with accompanying parameters globally or locally [2-3]. These algorithms show favorable results; however, they add computational complexity hence they are not preferred, compared to other enhancement mechanisms such as image-domain contrast.

With ongoing development and research, a number of added efficient methods such as weighted threshold histogram equalization [4], histogram modification framework [5], and adaptive gamma correction with weighting distribution [6] have been recommended based on the HE. Other recommended techniques include a high-performance camera which is a direct way to improve the quality of the image. However, high-performance cameras are costly hence this situation creates some affordability limitation especially in developing regions. In addition, improvement of professional skills is among the mechanisms for the enhancement of capturing of accurate images however they become useless if the image quality has decreased its contrast due to eye diseases. [7, 8]. Moreover, the other technique is the automatic image processing [9, 10–18], which has been comprehensively researched in the past two decades; which includes eye disease detection [11, 12], vessel segmentation [11, 12], vessel tracking [16, 18], etc.; however, they are also effortlessly affected by poor image quality [15].

Furthermore, since the optic disk is the brightest part where the blood vessels and optic nerves appear; this where it does not have the correct shape and its dividing line has many outgoing blood vessels. It is considered the landmark for detecting other features. The optic disk is also used for obtaining some information about some diseases. As we know the pattern of the blood vessels in the optical disk of the retina contains most of the retina information that is used for analysis for further human identification. Hence, the specialty and modularization-based methods are required for the enhancement of retinal images because retinal images have different texture characteristics as well as color. In that case, all the state-of-the-art methods that are highly connected to our proposed solutions are revised [19–22]. The three methods in [19, 21, 22] were developed for the enhancement of low-light outside images that can also be used to improve the quality of retinal images with insufficient illuminance.

Based on the observed challenges in various techniques in image processing, it has been clearly observed that enhancement of the image is a particularly important part, thereby often helping to improve the quality of the image for further identification. In addition, image enhancement reveals the hidden image details and increasing the contrast (brightness) in low contrast areas in the image. Therefore, this study proposes the development of solutions for enhancement of images with grayscale illuminance to contribute to the enhancement of retina image and optical disk detection through the use of integrated CLAHE and C-Language approaches. Lastly, the proposed solution will use less computational time running in the central processing unit (CPU) to extract and detect optical disk center in the process of improving the contrast.

III. METHODOLOGY AND RESULTS

This section presents the deployed methodology for the development of the proposed solution using C language and OpenCV. In this process, the study has deployed a combination of waterfall and agile development methodologies with prototyping for the development of a viable product. The approach has been proven to work successfully by Shimoda and Yaguchi in 2017 who have implemented similar approaches in their study related to “a method that achieves early realization of value and low cost by managing the relation between user stories and common objects in a matrix”. The methodology involved the requirement analysis, system design and development and lastly evaluation. Figure 2 shows the system architecture modeling which shows the interconnection and flow of data in the interfaces of the solution.

A. System Architecture Modeling

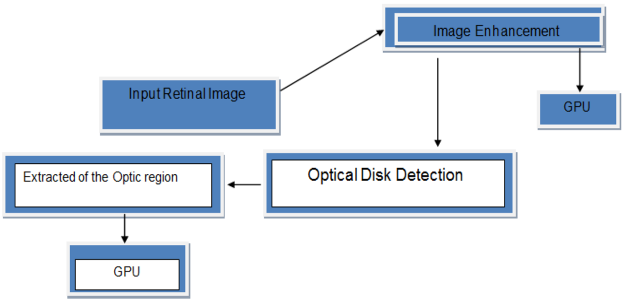

Figure 2: The flowchart steps of the system

B. The Mathematical Modeling of the System

The CLAHE divides the retina image into small tiles (some pixels), while the histogram equalization process is performing in each tile by using the bilinear interpolation so that it can eliminate the boundaries which are artificially induced, thereby restricting the slope of the intensity mapping function by clipping the height of the histogram when the clip level is high and the contrast of the enhancement becomes clear. In addition, CLAHE searches the monotonic gray-level intensity transformation that aggregate the probability or result to match the cumulative output density.

C. Accelerating Image Enhancement by using GPU

Graphics Processing Unit (GPU) is an electronic hardware unit designed to modify and handle the acceleration and formation of images in the specified frame buffered to display the result, so that the image enhanced can be accelerated. The main usage of the GPU is to give speed in the enhancement process as it has many cores for handling the tasks in parallel. Therefore, the GPU can perform better than CPU since it has several cores to handle parallel tasks at the same time.

D. CLAHE Algorithm

The new preprocessing method is to do the enhancement of the entire retinal images and locate and extract the optical disk for further processing. This method is called the Contrast Limited Adaptive Histogram Equalization (CLAHE). Enhancement techniques improve the total quality of the processed images. CLAHE is one of the enhancement techniques which increase the contrast in low contrast images.

CLAHE operates on the small regions in the image, it is called tiles rather than the entire image, it also enhances the contrast of the image by its intensity of the image to be transformed. Each tile contrast is enhanced so that the histogram of the output region approximately matches the histogram specified by the distribution parameter. Then the closet tiles are combined using the bilinear interpolation to eliminate artificially induced boundaries. The contrast, especially in the homogeneous areas, can be limited to avoid any kind of noise that may happen in the image.

The following is a step-by-step overview of the algorithm of CLAHE for calculating the grid size on the maximum dimension of the image. Note, it is known that the minimum grid size is 32 pixels square.

- First, if the window size is not specified, then we choose the gride size as the default window size.
- Second, identify grid points on the image; starting from the top-left corner. Each grid point is separated by grid size pixels.
- Third, for each grid point, calculate the histogram of the region around it, having an area equal to the window size and centered at the grid point.
- Fourth, if a clipping level is specified, a clip of the histogram is computed above that level and then uses the new histogram to calculate the CDF.
- Fifth, after calculating the mappings for each grid point, repeat steps 6 to 8 for each pixel in the input image.
- Sixth, for each pixel find the four closest neighboring grid points that surround that pixel.
- Seventh, using the intensity value of the pixel as an index, find its mapping at the four grid points based on their CDFs.
- Eighth, interpolate among these values to get the mapping at the current pixel location. Map this

intensity to the range [min: max] and insert it in the output image.

Lastly, use the binary search method to identify the point at which the clipping should be performed. The following is an overview of the clipping algorithm;

- Let the specified clip level be Top and 0 be the Bottom.
- Until the difference between Top and Bottom become exceedingly small, perform the following steps:

1. Calculate the Middle between the Top and Bottom.
2. Find the sum of the excess above the Middle in each bin of the histogram.
3. if excess +Middle is greater than Clip level set Top=middle
4. if excess +Middle is less than Clip level set Bottom=middle.
5. if excess +Middle is equal to Clip then Middle is the value at which clipping needs to be performed. Hence break out of the binary search loop.

Then, clip the histogram at the value of the middle and redistribute the excess into each bin equally. After that apply the CLAHE to the image to display the results. The following is the algorithm steps for CLAHE method;

1. Obtain all the inputs:

- The image
- A number of the regions in a row direction
- A number of the regions in a column direction.
- Numbers of bins that histogram will be used (dynamic range).
- The clip limit for contrasting limiting (from 0 to 1).
- The Range (There is a maximum range of the image and minimum range of the image).

2. Pre-process the inputs: To determine the real clip limit from the value 0 to 1 (normalized) and pad the image that will use before splitting it into regions.
3. Processing of each tile (contextual region) that producing the gray level mappings: Extracting a single image region, and then make a histogram for that region by using the number bins that we specified in our input, clipping the histogram by using the clip limit creating the mapping for the region used.

4. Interpolating the gray level mappings to assemble its final CLAHE image extracting the cluster of the 4 neighboring mapping functions and partly process the image.

Overlapping each of the mapping tiles, extract any single pixel, and apply the four mappings to that pixel and do the interpolation between the results to obtain the output pixel; this will be repeated to the entire image. The following in Figure 3 briefly describes the flowchart of the CLAHE method.

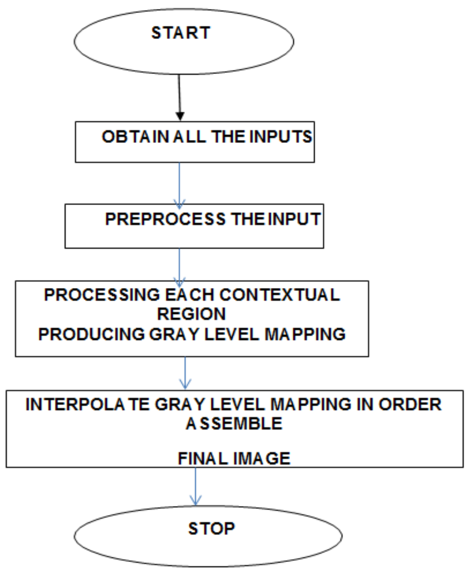

Figure 3: Flowchart of CLAHE [23]

Based on the methodology used in the process, the following are the results of the developed solution and its validation as shown in the comparison of the C-language and Matlab. It can be observed that there is a poor quality of the image when using Matlab compared to the implemented solution (C-language).

Module Test Result in both C and Matlab

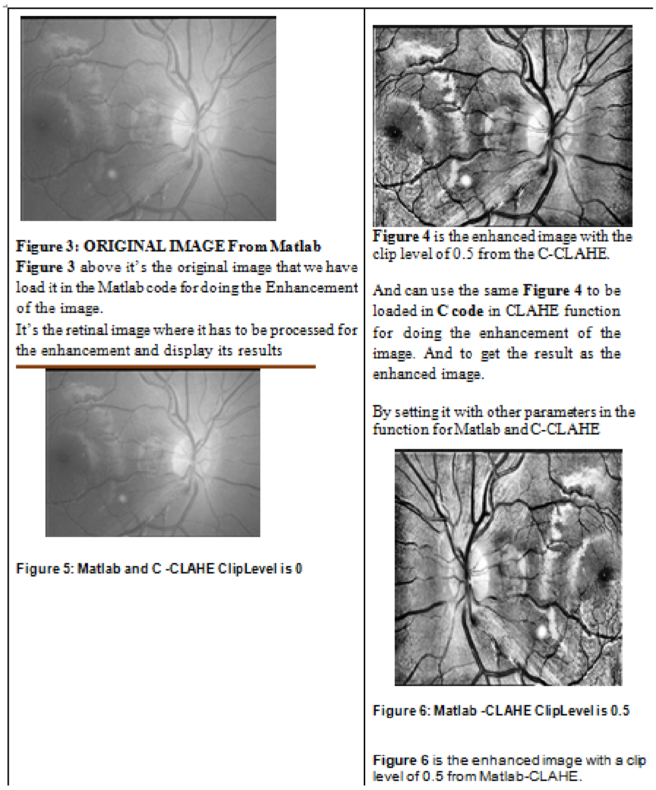

Figure 4: Comparison of image display in Matlab and Chart of CLAHE [23]

E. Verification of the Experimental

The final experimental results allowing comparing with the Matlab results and the c results and get the Black result in the image. The difference between Matlab results and c results is for the verification of the Experimental

The figures below describe the obtained different results:

Figure 7: Diagram A Result of Matlab result – C results

Figure 8: Diagram B Result of Matlab result-C result

Figures 4 and 5: Matlab Results

F. Optical Disk Detection and Extraction

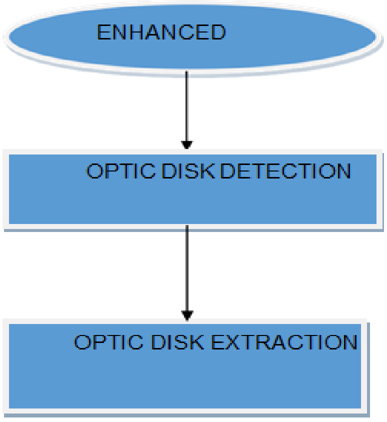

Figure 6: General flow chart for optic disk detection and extraction

The following are algorithm steps that were used in the detection of the optic disk.

1. Get the radius of the circle, which should be divided by modulus and decrement the radius.
2. Load the original image.
3. Convert the image to grey and blur it and use the maxinlocation function.
4. Circle it.

The following are algorithm steps which were used in the extraction of the optic disk that is conducted following the detection process. Its brief description is also shown in Figure 7.

1. Obtain the radius of the circle, which should be divided by modulus and decrement the radius.
2. Load the original image.
3. Convert the image to grey and blur it and use the maxi location function.
4. Circle it.
5. Display the resultant image of the detection.
6. the following will be executed

```
Mat m = Mat::zeos( originalimage.rows, originalimage.cols, CV_8UC1);
  //CV_BGR(b,g,r)
  //the -1 should be filling
  circle( m, (minLocation,maxLocation), radius,Scalar(255,255,255), -1, 9, 0 );
  // if the value of m > 1 and copy the values of the original image to the dst

originalimage.copyTo( destination, m );
```

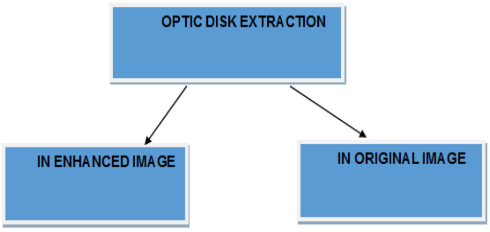

Figure 7:Flow Chart of Extraction

The following are module test results;

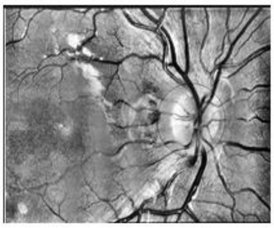

Figure 11: Retinal image enhanced and detect its optic disk

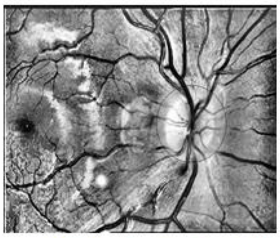

Figure 12: Retinal image enhanced and detect its optic disk

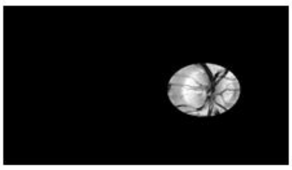

Figure 13: extracting of the optic disk in the enhanced image

The above figure shows the extract of the optic disk in the enhanced image which it's was detecting first and extract.

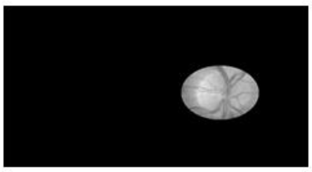

Figure 14: extracting of the optic disk in the original image

The above figure shows the extract of the optic disk in the original image which it's was detecting first and extract.

Figures 8: Model Test Results

IV. CONCLUSION AND FUTURE WORK

Image processing is an especially important part in the field of informatics science and technology in general, where we try to identify humans based on their retina and provides the best accurate authentication. Subsequently, poor quality retinal images not only decrease the accuracy of the diagnosing results but also increases the computation time for recognition of the results. This paper has implemented the enhancement of the retina image and optical disk detection by integrating CLAHE and C-Language approaches as well as extracting the optical disk center after the detection process. In addition, the study confirms through the experimental approach with the comparison of the result displayed with the Matlab results and the C results and obtains the Black result in the image. The difference between Matlab results and C results is for the verification of the experiment; whereby C was the preferred language based on its computation and GPU performance. In addition, C can assist further processing after obtaining the results in the world of biometrics. Hence, the findings of the study conclude that the use of CLAHE and C-language enhances the quality of the image compared to the use of the existing mechanism. Therefore, there is a need to implement the proposed mechanisms in devices.

The study recommends development of C code on all enhancement techniques based on Histogram Equalization and implemented and comparison of their results by paralyzing them in GPU and view their real-time results on each technique. This validation and comparison process will further yield in identifying improved techniques for gray-level images and colored images. In addition, reading the images should be interacted directly with the hardware i.e., cameras that will interact with C code. Lastly, new techniques of equalization must be developed to obtain the best outcomes that can run in less time in GPU to compare to the existing techniques.

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