

Human visualization system based intensive contrast improvement of the collected COVID-19 images

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ABSTRACT

Enhancement and color correction of images play an important role and can be considered as one of the fundamental and basic operations in image analysis for the purpose of speeding up the diagnosis of the medical images. Improving the quality and contrast of the medical image is the basic requirement for clinicians for obtaining an accurate and accurate medical diagnosis. Thus, getting a clear X-ray image reduces the effort and time-wasting. In this study a new idea will be applied for improving image contrast of the collected COVID-19 X-ray images, this idea is based on using Wiener filter, multilevel of histogram equalization (HE) technique with OpenCV library and then using contrast limited adaptive histogram equalization (CLAHE) techniques with OpenCV library. The proposed methodology programmed in MATLAB software and then implemented using Rasperry Pi 3 model B. The size and resolution of images are different as inputted images and this difference succeeded in proving the strength of the proposed idea. The collected X-ray images have undergone experiential evaluations which clearly showed the effective performance of the proposed methodology.

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1. INTRODUCTION

Nowadays with the rapid developments of medicals images it has become very popular to obtain the definitive diagnosis of different medical cases. The contrast of the computed image must be enhanced by a set of techniques applied to improve image quality. Human eyes can't detect the diagnosis of some medical image easily. Some images are not always functional without required contrast enhancement. Medical image enhancement now playing an important rule not only in the detection of diseases but also required in the urgent surgical cases, pregnancy, tracking serious, and early diagnosis. [1]. There are also some systems that use low-cost Raspberry Pi microcontrollers to control a system, detect, tracking, objects in image [2], [3] or even in medical field for diagnosis of infections like COVID-19 computerized tomography (CT) scans and chest X-ray images [4]. X-ray images that have been advanced in medical research are the main types of medical image. X-ray beam pass more quickly in skin than in bone this led to create a lighter area around the photographic plan's bon like structure. X-ray picture is essential in many of applications in medicine. The most familiar use of X-rays is checking for fractures (broken bone), some tumors (breast cancer), and chest X-ray to diagnose infection (COVID-19) [5]. Contrast enhancement technique makes the image features stand out more clearly. Morphological operators have been used beside contrast enhancement technique to make important bone segments and soft tissues appear more clearly [1], [6]–[9]. Top-hat and bottom-hat

transform are important in enhancement the image used for enhancing the image by calculating the gradient magnitude value and then select the structuring element size automatically and provided very accepted results. researchers [10], [11] presented enhancement of contrast of the images type mammographic [10] utilizing retinex with contrast limited adaptive histogram equalization (CLAHE) technique, while [11] utilizing indirect contrast enhancement techniques. An efficient system has been suggested in [12] based on multilevel of histogram techniques histogram equalization (HE) and CLAHE techniques and new architecture of convolutional neural network (CNN) in order to intensive enhancement and recognition of chest X-ray images with COVID-19, for matching the fingerprint of authentication system in [13]. Novel UNet model has been suggested based on one of the image enhancement techniques that is gamma correction to detect the COVID-19 in the chest X-ray images. This work has been compared with the UNet network for lung segmentation and proved to be reliable, fast, comparable, and of satisfactory accuracy when applied to X-ray images for the detection of COVID-19 [14]. A DeepCOVIDExplainer model is designed to automatically detect coronavirus from chest X-ray images. Evaluation results of this work showed confidently and efficiently with values of positive predictive [15]. COVID-XNet system is proposed based on Deep learning techinusing using one of methods of the enhance images to diagnosis and identity the COVID-19 X-ray images, which helps the radiologist make the correct diagnosis easily [16]. Oleiwi *et al.* [17] has presented comperasion study for matching the fingerprint of authentication system. The proposed models have proven the effective performance. All previous studies that were mentioned above either using complicated techniques or handled with fixed size and type of image, nevertheless the suggested methodology used Wiener filter, multi levels of HE and CLAHE techniques with OpenCV library to enhance the contrast of collected COVID-19 X-ray images. As a result of the difference between the resolution and format of the images the robustness of the proposed idea has been proved. The following sections are arranged in this paper: Section 2 describes the suggested methodology that used multi levels of HE and CLAHE techniques with OpenCV library. Section 3 includes the results of HE and CLAHE techniques, and Section 4 provides the conclusion and discussion of the work.

2. METHOD

Improving the visualization of X-ray images of COVID-19 is the major goal of this study. Image denoising is achieved by using Wiener filter first. HE and CLAHE techniques with OpenCV library is then presented to automatically enhance the contrast of collected dataset as COVID-19 X-ray images as shown in Figure 1. Thus, Figure 1 represents general idea of the proposed human visualization system. Figure 1(a) illustrates the flowchart of proposed system while Figure 1(b) demonstrates the haradware design of the proposed system.

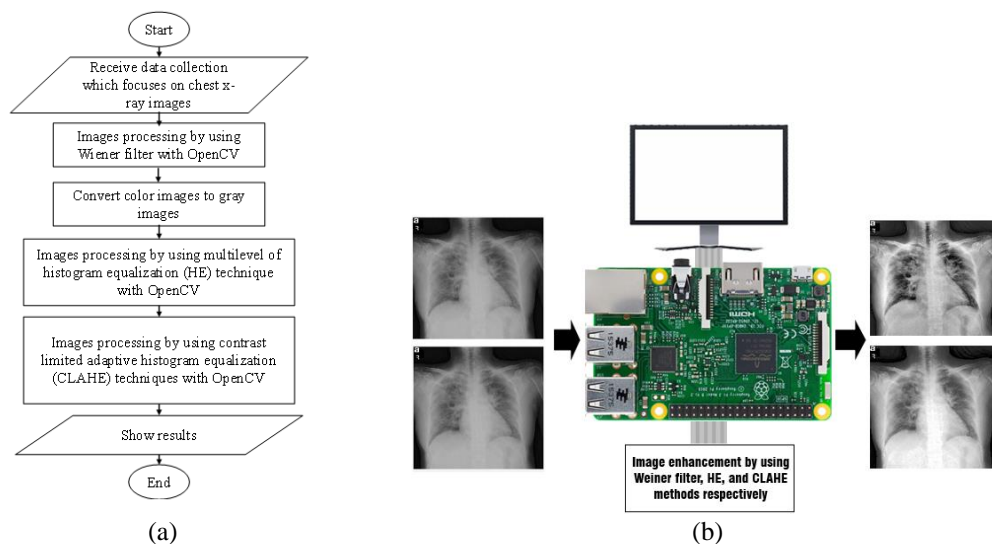


Figure 1. Overall design of the proposed human visualization system (a) the flowchart of proposed system and (b) haradware design of the proposed system

Figure 1 represents the proposed human visualization methodology is based on image processing that modifies an image's global contrast by updating the pixel intensity distribution of the image histogram. In order to convert the low contrast areas into higher contrast in the image of the output. The essential steps of proposed methodology as follows:

- i) Collecting the dataset
- ii) Applying Wiener filter, multi-level of HE and CLAHE techniques with OpenCV library:
 - Removing the noise from the images by using the wiener filter.
 - Computing a histogram of the intensity of image pixels.
 - Spreading out uniformly and assigning the most frequent pixel values (i.e., the ones with the largest counts in the histogram).
 - Giving a linear behavior of the cumulative distribution function (CDF).
- iii) Implementing using Raspberry Pi 3 model B.

2.1. Data collection

The first step in this study is the datasets of COVID-19 X-ray images will be collected. The dataset of COVID-19 Chest X-rays is collected from the Dr. Zaid AL Jubouri Clinic for digital radiology and Sonar in Baghdad-Iraq. The collected dataset as shown in Figure 2 consists of 762 X-rays images which is divided into normal cases with are 376 and abnormal one with are 386, which will be used in the experimental part for enhancing automatically the contrast of collected dataset as COVID-19 X-ray and for testing the performance of the proposed methodology.

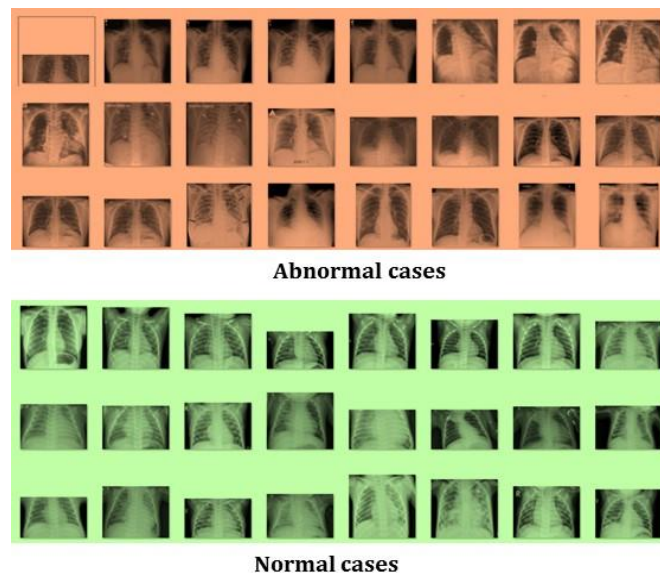


Figure 2. Original COVID-19 X-ray images

2.2. Wiener filter

The Wiener filter is one of the most widely used in image improvement techniques in many applications, including linear prediction, signal recovery, echo cancellation, channel equalization, and identification system. The main goal of this technique is to restore the image and reduce the error value by removing the noise [18]. In this study, the suggested methodology will use Wiener filter, the image denoising will be achieved by using Wiener filter

2.3. Image pre-processing

The images are color with 24-bit depth as 3 dimension or channels and joint photographic experts group (JPEG) format with different size of pixel for each image. In pre-processing stage each image has converted from red, green, and blue (RGB) to Gray, each color can only have values 0 to 255 for 8-bit [19]. In (1) has been used for converting purposes from a color image to grayscale.

$$\text{Gray image} = 0.21R + 0.72G + 0.07B \quad (1)$$

2.4. HE technique

HE plays an important role in image analysis and is one of the essential techniques in the image processing by adjusting the values of the pixel in an image in order to improve the contrast to make those intensities more equal across the board [20], [21]. In general, the histogram of an image is close to a normal distribution, but equalization represents a uniform distribution. This technique marks the brightest pixels as white and the darkest pixels as black and the remaining pixels values will be similarly rescaled. This rescaling is done by a technique include converting the original intensity distribution to computer intensity distribution in order to enhanced contrast [22]. The image processed by HE is normally brighter and has good visual effects by enhancing a low-contrast image [23]. In case the discrete input grayscale Image $X=x(i,j)$, with the discrete levels of L , where the $x(i,j)$ represent the image's intensity levels in the space field (i, j) . Consider histogram of image X is $H(X)$, then $p(X_k)$ can be defined as probability density function as expressed in (2).

$$P(X_k)=n_k/N \quad (2)$$

where, $0 \leq k \leq (L-1)$, where L is the overall grayscale image levels, N is the overall image pixels, n_k is the overall pixel number at the intensity of k . From the $p(X_k)$ can be obtained of the cumulative distribution function $CDF(X_i)$:

$$CDF(X_i)=\sum p(X_i) \quad (3)$$

HE is mapped the input image into the entire dynamic range $[X_0, X_{L-1}]$. It uses the $CDF(X_i)$ in $f(X)$ transform function as (4).

$$f(X)=X_0+(X_{L-1}-X_0)*CDF(X_i) \quad (4)$$

The HE output image, $Y=y(i, j)$ is defined in (5).

$$Y=f(X) \quad (5)$$

That can also be used on a color image by implementing the same process to the RGB color image's Red, Green, and Blue components separately [22].

2.5. CLAHE technique

Images contrast enhancement obtained with CLAHE and HE are different because HE works on the entire image while CLAHE deals with small regions in the image called tiles. CLAHE works on improving the contrast of each tile, this obtained by making a match between the histogram of the output region with a specific histogram after applying equalization. CLAHE technique avoids any noise in the image by combining the adjacent tiles with the help of by linear interpolation to remove artificially induced boundaries. In homogeneous areas the contrast can be limited by using "adaphisteq" optional parameters [24], [25].

2.6. HE techniques based OpenCV

HE techniques is an image manipulation for adjusting the contrast using an image histogram. The equalization of the histograms in OpenCV is useful for images with both bright and dark with foreground and background images. OpenCV has a function for doing this step which is called `cv2.equalizeHist()`. Its input and output are only grayscale image and the histogram equalized image, respectively. In other words, in order to equalize the histogram of a grayscale image using function called "`cv.equalizeHist()`" based on input as grayscale image, 8 bit single channel and output as histogram equalized image [26].

3. RESULTS AND DISCUSSION

The HE and CLAHE techniques with OpenCV library can be used mainly in medicine to help the medical specialist making the exact and early diagnosis of COVID-19 infected patients. In order to verify the efficiency of the proposed methodology the experimental test is made in MATLAB software using Raspberry Pi model 3. At first, COVID-19 X-ray image datasets have been collected. Followed by using Wiener filter, multi-levels of HE and CLAHE techniques with OpenCV. Figure 3 illustrates the original and enhanced images using HE technique. Figure 3(a) shows the original X-ray image and its output histogram distribution before applying HE technique while Figure 3(b) shows the original X-ray image and its output histogram distribution after applying multi-level of HE technique. As can be seen in Figure 3(b), the uniform histogram

distribution and the contrast improvement of the image. Where, x axis and y axis represent gray level and frequency count, respectively. As can be seen on the left hand side of Figure 3(a) the original image in grayscale status has been showed, while the right hand side of Figure 3(b) the new enhanced image after performing Wiener filter, multi-level of HE technique, the representation of histogram is extended parallel with the intensity and the result of applying histogram equalization is an image with higher global contrast. But the histogram equalization can be further improved by applying CLAHE technique, as shown in Figure 4 presenting higher quality output images. Figure 4. demonstrates the original and enhanced images using CLAHE technique Figure 4(a) original X-ray image and output its output histogram representation before applying CLAHE technique Figure 4(b) original X-ray image and output after applying multi-level CLAHE Technique. Where, x axis and y axis represent gray level and frequency count, respectively. As can be observed on the left-hand side of Figure 4 the original image as grayscale mode has been presented, and after applying multi-level of CLAHE Technique the new improved image has been illustrated on the right-hand side of Figure 3, and as can be noticed in the right side of Figure 4, the representation of histogram is extended along the intensity. As mentioned, Figure 3 and Figure 4 demonstrated the comparison of the output result of HE with CLAHE techniques, hence the sample images are carried out on the collected Chest X-rays. As can be noticed that proposed methodology generated high visual improved system and clear output result will be helped the physicians for identifying the proper disease correctly.

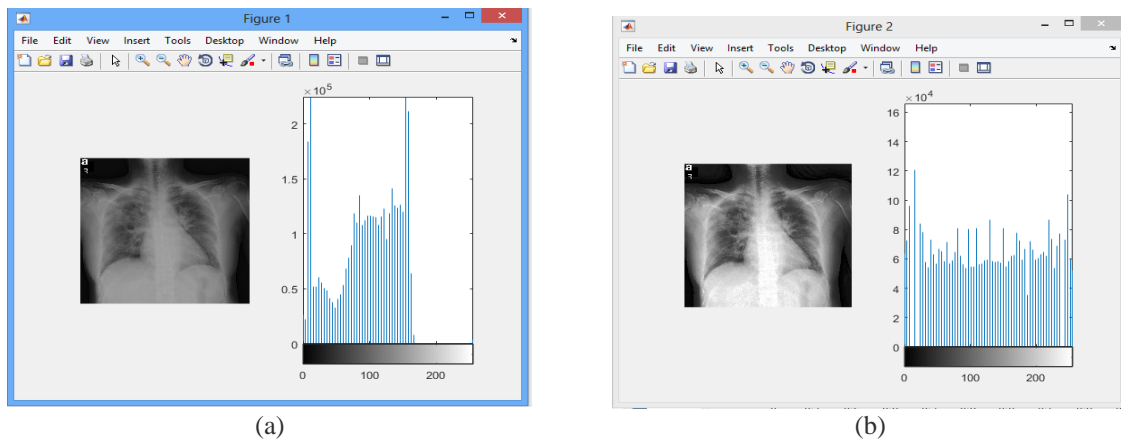


Figure 3. Displays the original and enhanced images using HE technique (a) original X-ray image and its output histogram distribution before applying HE technique and (b) original X-ray image and its output histogram distribution after applying multi-level of HE technique

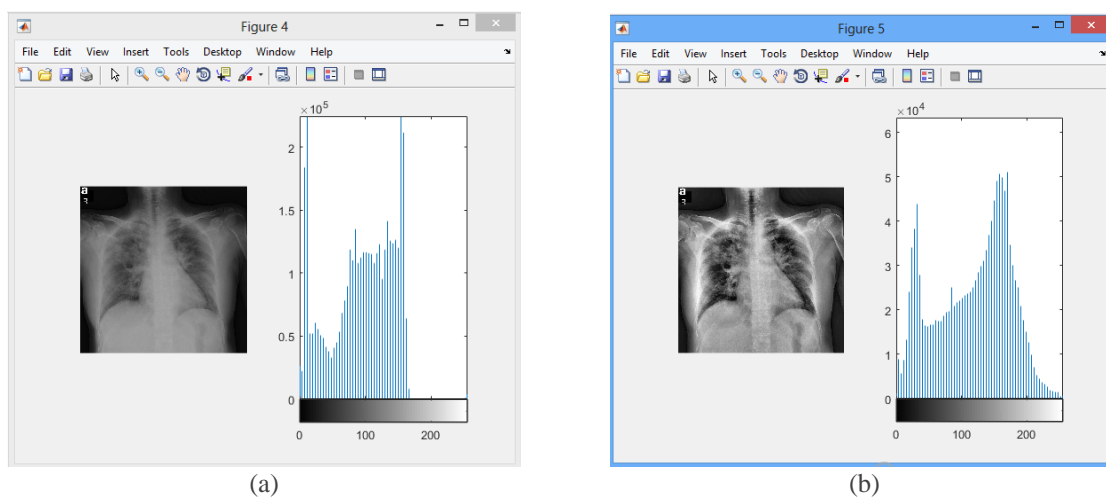


Figure 4. Displays the original and enhanced images using CLAHE technique (a) original X-ray image and its output histogram distribution before applying CLAHE technique and (b) original X-ray image and its output histogram distribution after applying multi-level of CLAHE technique

4. CONCLUSION

The objective of this research is to study the effect of image enhancement on COVID-19 Chest X-rays images. Images improvement can be considered as one of the basic and essential operations in image analysis in image analysis. The main goal of image contrast improvement is to enhance the quality of medical images to become more useful in the disease diagnosis application. In this paper, an image enhancement technique based on Wiener filter, multi-levels of HE and CLAHE techniques with OpenCV library was presented. The proposed methodology programmed in MATLAB software and then carried out using Rasperry Pi 3 model B. The evaluation results have been proved that the quality of the image improvement results is increased. Both techniques gave very satisfied results for improving the gray scale X-ray images. Future work a specific region of interest such as the heart, lung, and clavicle. can be showed with the help of chest X-ray for identifying a specific disease. This study will be provided guidance to other researchers to suggest new advanced improvement techniques. As an extension of this work, it is possible to conduct a comparative study with other methods or another dataset.

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