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X-RAY IMAGE ENHANCEMENT USING RETINEX ALGORITHM BASED ON COLOR RESTORATION

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Abstract

In this research, clarity of medical x-ray images has been increased, which is difficult because of the limited range of intensity. The proposed algorithm based on the technique of improving contrast using Retinex Algorithm based Color Restoration (RACR). The RACR method of enhancement compared with several ways as Multi-Scale Retinex Improvement for Nighttime Image Enhancement (MRINE), contrast enhancement approach for dark images with non-uniform illumination (CEDNI), Multi-Scale Retinex Algorithm with Color Restoration (MSRCR) and Histogram Equalization (HE). The comparison based on Entropy and histogram analysis. The results showed the proposed method succeeded in increasing the contrast of x-ray images compared to other methods.

Keywords: Histogram equalization, Image enhancement, Intensity enhancement, Retinex, X-ray images.

1. Introduction

X-ray was found out by Conrad Roentgen Wilhelm and through his operations, he was inadequate to describe the glow of barium salts which is attributed to an unexplained factor and when answering equations, this factor was placed in the letter x, which is identified as x-ray [1]. It is considered one of the ancient images films that are firstly employed in the treatment and medical diagnosis such as the analyse and determine the bone fracture which is a beloved shape for the physicians and doctors [2, 3]. The area of medical analysis, whose implementation is much broader than the discovery of cancer, one of the fields where they are utilized widely Orthopaedics and Traumatology, nowadays the use of x-rays in medical fields is not only common but also used in science and engineering [1].

The quality of X-rays is not consistent with the images taken by a regular camera considering sunshine as a light origin. Therefore, the researchers suggested that its strength take up to 10000 hours for intended use to improve the expertise wanted to read X-rays images [4]. Despite this fact, we do not have a good vision of x-ray images in real life, and this a problem arises often due to the bad goodness of X-rays images, particularly the bad difference in the attractive fields. Consequently, the algorithm of image processing can improve the quality of x-ray images which are of high privilege in the study of optical quality improvement [1, 4].

Image processing is, therefore, image, the primary objective of improving the image in order to the decision is more relevant than the fundamental image for specific applications, and from image improvement applications in the area of engineering and science, such as meteorological science, underwater environment, biomedicine, astronomy, computer vision, etc. [5, 6].

Many methods include enhancement in the general image [7-11], several methods have been planned to enhancement the quality x-ray images the degraded captured in different situations, like Retinex-based approaches [12]. The theory supposes that colour thoughts have a significant relation to reflection and that the quantity of apparent light that reaches superintendent relies on the output of representation and information [13].

Most Retinex-based methods will reflect reflection as an enhanced result by eliminating the light, so they can clearly enhance items, On the other hand, it is difficult to effectively eliminate the lighting for the soft deepness viewer. Some surround centre methods get the local twisting of light instead of light without looking at a reflection. In fact, reflection must be inside (0-1), that means the surface cannot be reflected lighter than it receives.

Furthermore, it is simply unreasonable to eliminate the knowledge that is necessary to describe the atmosphere [14], the disadvantages of this algorithm are the influence of the aura [15]. Histogram equalization (HE) is utilized generally in image improvement; since conventional his methods may result in over improvement, several methods with limitations, were proposed such as contrast limitation [13] and light conservation [16], brightness conservation is helpful in applications that require to maintain density. Nonetheless, for non-uniform lighting images, maintaining light will enhancement detail in areas dark fields.

Limited-contrast methods prevent over-recovery by redistributing the histogram so that its height does not exceed the clip limit. However, it is not easy to define the limits of culture for highly non-uniform illumination images where the histograms of various fields are very different. Ili et al. [17] introduced three methods that were proposed to improve bone X-ray images by using (HE), Gamma Correction (GC), and contrast limited adaptive histogram equalizer (CLAHE), by analysing their results, it was found that the method CLAHE better than other methods.

Xiao et al. [18] introduced the scheme of the optimization method in [18] for the X-ray image, which consists of a noise removal method and a homogeneous filtration method, and the fuzzy noise removal method consists of detecting fuzzy noise and filtering. Area detection and pitch detection are offered to detect hazy noise, and a modified average weight filter is suggested to filter the noise.

Koonsanit et al. [19] proposed a method for improving the X-ray images by relying on the logarithmic transformation and then using a method CLAHE. The optimization algorithm combines adaptive high pass for a region, temporary artifacts, and noise reduction For The fluoroscopy x-ray images, they got a good improvement to the X-ray images in the edge region [20].

Mark et al. [21] suggested a method for improving contrast in x-ray images based on combining multiple exposures into a composite that uses only the pixels of those exposures that have not been overexposed or overexposed. The composite image is created similarly to high dynamic. Morphological contrast enhancement to enhancement x-ray for bone images [22], this method depending on gradient value is calculated to automatically determine the size of the structuring element.

Rafid et al. [23] introduced a way to improve medical images, including X-ray images depending on the Fuzzy Logic by Stretch Membership Function. They rely on the entropy scale to measure the quality of improvement, where they obtained high values in improving various medical images Falsification of colours is the defect of this algorithm and (CEDNI) contrast enhancement approach for dark images with non-uniform illumination [24]. It was introduced to solve a difficulty in the parallel step for high-Intensity or low (LIPC) images and low contrast (HIPC). The CEDNI scheme includes three steps: First, an RGB colour image is regenerated to an emphasis image, then an adaptive intensity arrangement with local contrast improvement is achieved parallelism, by a using a bilateral Gaussian filter with transformation and Taylor's second-order expansion approximation technology. Finally, colours are restored, have a significant improvement, but a defect in time it has a long time run [24]. In this paper is an analysis and comparison of the results of x-ray images enhancement in several methods.

2. RACR algorithm

The proposed algorithm RACR enhanced X-ray images based on colour restoration. As X-Ray images suffer from almost a few colours and tend to Gray, colour recovery adds colour information, even if little in turn, improve the contrast in those images. As well as to increase the improvement was used MSR algorithm to play an essential role in increasing the quality of lighting and contrast in those images as follows:

2.1. Contrast enhancement based on colour restoration

We proposed input colour image h as three channels and done image colour mapping by using histogram stretch depending on mean and standard deviation. The average value and regular deviation in green, red and blue elements are determined then, the minimum and maximum of each component in the x-ray image are computed by [8].

$$c_{max,i} = c_{av,i} + \propto c_{std,i} \quad (1)$$

$$c_{min,i} = c_{av,i} - \propto c_{std,i} \quad (2)$$

where $i \epsilon [\mathrm{r,g,b}]$; $c_{av,i}$ and $c_{std,i}$ are the average value and conventional deviation in the *c* component; is a parameter to measure the image effective; and are the minimum and maximum of the *i* component, sequentially. The colour-restored image is given by:

$$c_{r,i} = \frac{c_i - c_{min,i}}{c_{max,i} - c_{min,i}} \times 255. \quad (3)$$

2.2. MSR algorithm

The retinex technique is a non-linear spectral/spatial Conversion that makes an excellent improvement in the colour constancy and local contrast. This algorithm performs well in promoting the contrasting imagery standard of low-visibility conditions by using [25]:

$$Rt_i(x,y,c) = log[\,I_i(x,y)] - log[\,G(x,y,c) \otimes I_i(x,y)] \quad (4)$$

where $Rt_i(x,y,c)$ the output of part *i* are the R, G and B channels at point *x*, *y*, the Gaussian kernel *k* is finding by [25]:

$$G(x,y,c)\, dxdy = 1 \quad (5)$$

The MSR is a Gaussian weighted collection of the outputs of various SSR where [18]:

$$R_{MSR}(x,y,w,c) = \sum_{n=1}^{N} W_n Rt_i(x,y,c_n) \quad (6)$$

where *N* is the number of scales, $Rt_i(x,y,c_n)$ the *i*'th components of the *n*'th scale, $R_{MSR}(x,y,W,c)$ the *i*'th spectral components of the MSR output and W_n the weight associated with the *n*'th range.

Details of the proposed method are shown in Fig. 1. It represents X-ray image with a colour restoration mechanism, and improved contrast with histogram representation for each stage After enhancement, the width of the histogram for (R, G, B) components are increased due to the contrast enhancement.

The steps of the RACR algorithm given by:

1. In put x-ray image *c*(*x*, *y*, *i*), *x*, *y* being the position and *i*=1,2,3 (red ,green and blue).
2. Applied contrast enhancement for each channel (*i*) red, green and blue by using $c_{max,i} = c_{av,i} + \propto c_{std,i}$, ∝ = [2-3] , we used 2.6.
   $c_{av,i} = mean(c(x,y,i))$ and $c_{std,i} = std(c(x,y,i))$.
3. Calculated The colour-restored image is given by:

$$c_{r,i} = \frac{c_i - c_{min,i}}{c_{max,i} - c_{min,i}} \times 255$$

where $c_{min,i}$ is the minimum value for each r, g, and b channel. $c_{max,i}$ is the maximum value for each r, g, and b channel.

4. Applied MSR to get final enhanced images by using:

$$R_{MSR}(x, y, w, c) = \sum_{n=1}^{N} W_n Rt_i(x, y, c_n)$$

where, $w_1 = w_2 = w_3 = 1/3$, $c_1 = 18, c_2 = 80$ and $c_3 = 250$.

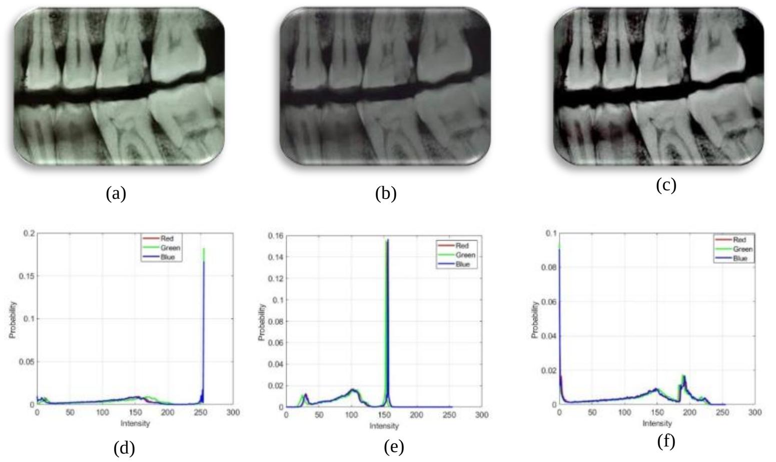


Fig. 1. Original image in (a), in (b) colour restoration, the final contrast enhancement in (c), and its histogram in (d), (e) and (f) respectively.

3. Quality Assessment

In the present study, Entropy was utilized in the assessment of the quality of the image by determining quality in chromatic compounds like hue and saturation [9]. Images which have the highest Entropy have the more excellent quality of the picture. We utilize the visual (*V*), which is subsists of HSV Colour Model.

$$Ent\ (V) = -\sum_{v=0}^{255} p(v) \log p(v) \tag{14}$$

where *p*(*v*) is probability density function at intensity level *v*, (*Ent*) illustrates an entropy of the image and (*v*) the total number of grey levels.

4. Result and Discussions

X-ray images have been enhanced based on the method RACR To determine the quality of enhancement, the proposed method was compared with several other ways as HE, MRINE, RACR and MSR by using the entropy measured and the histogram calculation of the RGB compounds and subjective observation. Eight images of type JPG with size: a-image (300×168), b-image (580×890), c-image (248×203), d-image (466×298), e-image (240×210), f-image (204×247), f-image (240×210), g-image (272×186) and h-image (259×194), were used.

The MATLAB R2018a software was used to process these images. These images are shown in Fig. 2, and Fig 3 represents the histogram distribution of the two original images prior to enhancement. Note that the distribution is limited to certain values and tends to grey. Figures 3 and 4 represent images that have been enhanced using different algorithms. By analysing the distributions, we notice that the histogram distribution of the improved images is broader than the other methods followed by CEDNI and RACR, and in MRINE the method did not change the distribution due to lack of improvement. This behaviour was reflected in the histogram distribution on the macroscopic observation of the enhanced images, as shown in Fig. 4. The quality of the improvement was confirmed according to Table 1, which represents the entropy values for eight images that enhanced where the greatest average value of the proposed method RACR is (7.3992) was followed MRINE has average entropy (6.9705). Followed by CEDNI, MSRCR and HE (Which have average entropy 6.6003, 6.5146 and 5.7796 respectively), this indicates the lack of improvement in these algorithms.

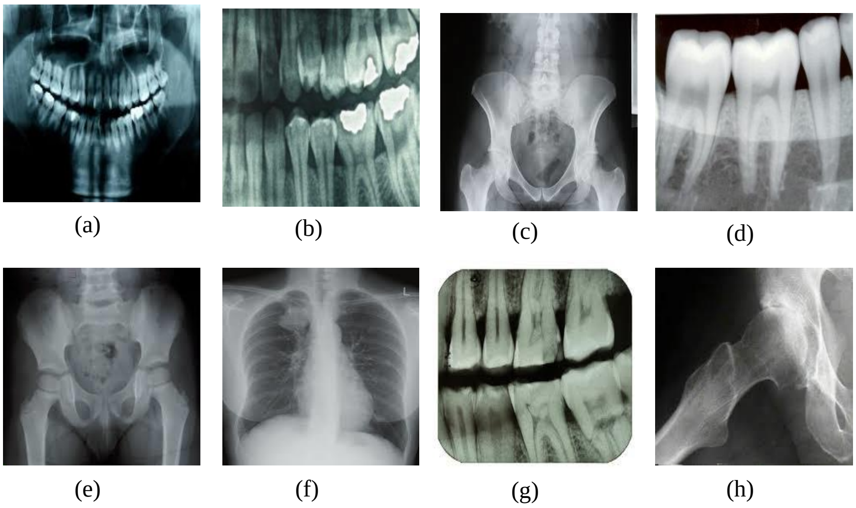


Fig. 2. Original images.

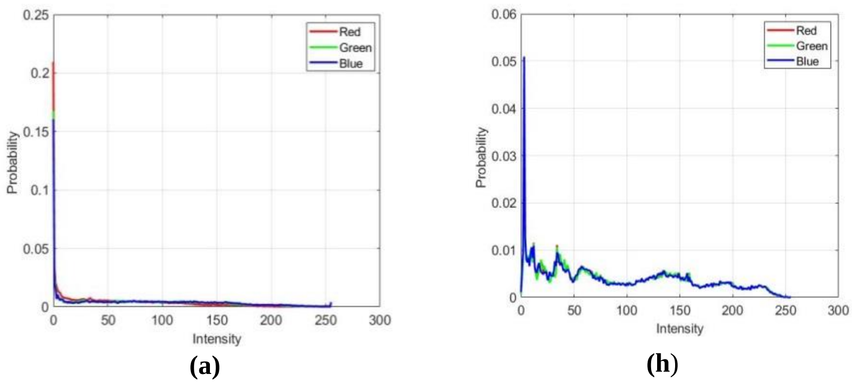


Fig. 3. Histogram of the original images (a and h).

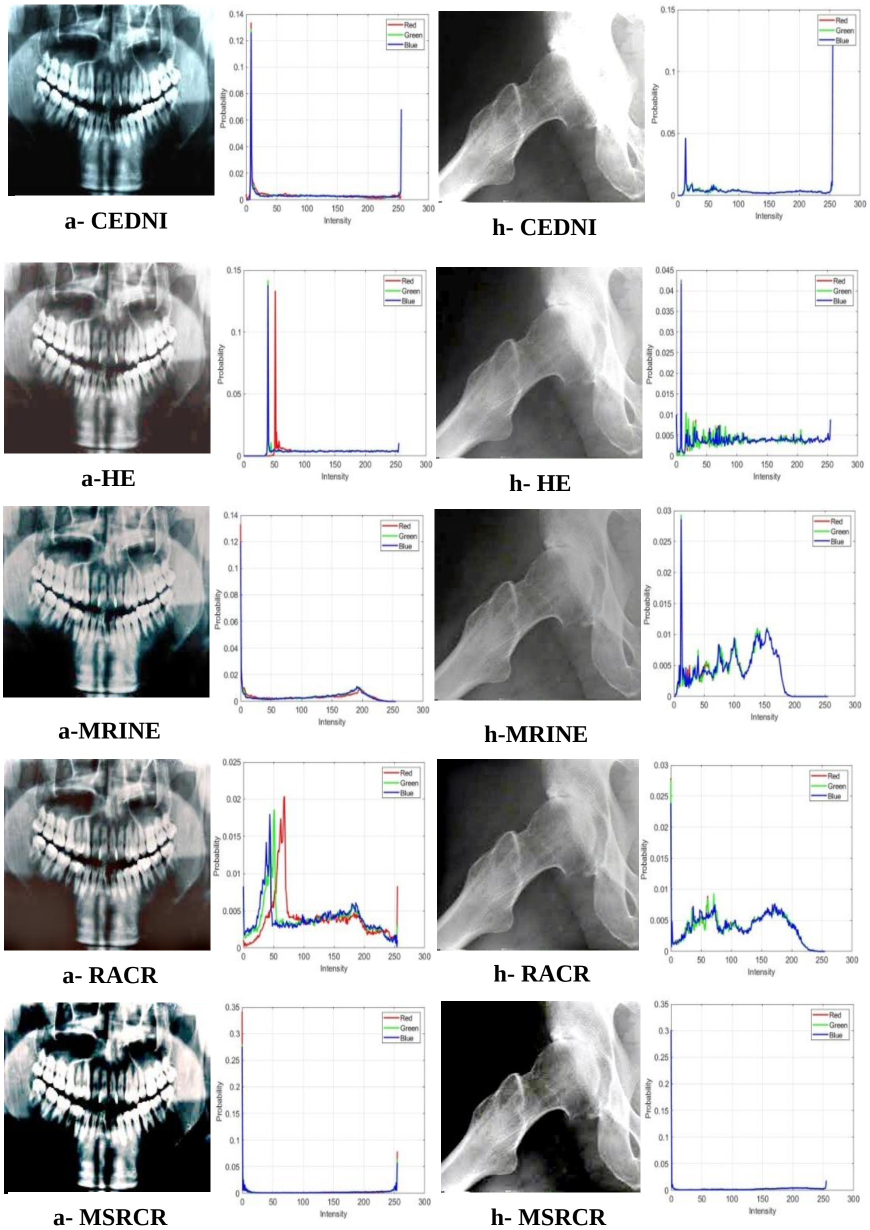
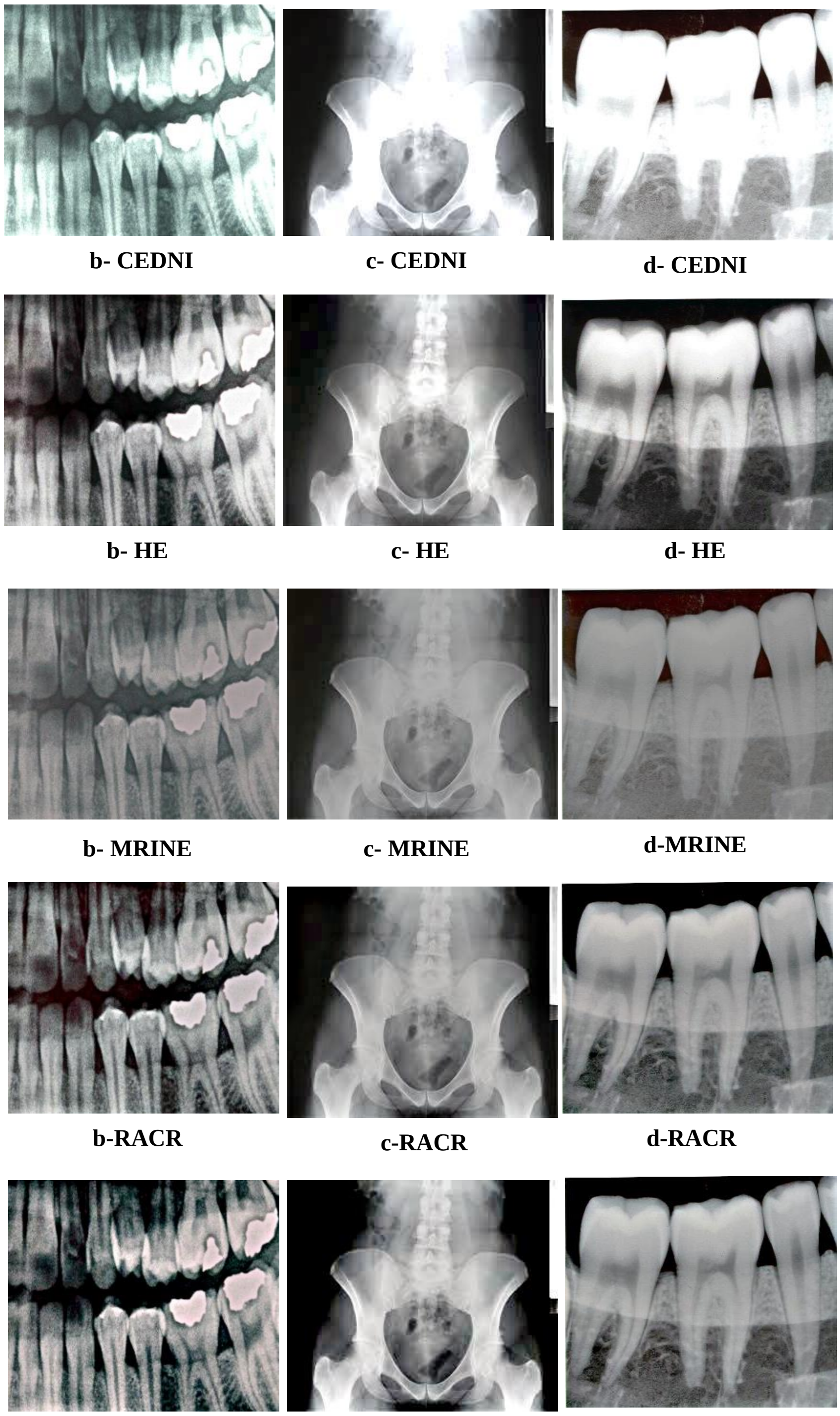


Fig. 4. The enhanced images and tis histogram for (a, h)
by using CEDNI, HE, MRINE, RACR and MSRCR algorithms.



b- CEDNI **c- CEDNI** **d- CEDNI**

b- HE **c- HE** **d- HE**

b- MRINE **c- MRINE** **d-MRINE**

b-RACR **c-RACR** **d-RACR**

b-_MSRCR **c- MSRCR** **d-_MSRCR**

Fig. 5. The Enhanced images (b, c and d) by using CEDNI, HE, MRINE, RACR and MSRCR algorithm.

Table 1. The Entropy values for the enhanced images.

Enhancement Method	a	b	c	d
RACR	7.8268	7.6378	7.4761	6.8933
MRINE [23]	7.2405	6.8495	7.1798	6.4597
CEDNI [24]	7.0324	6.9928	6.4211	5.1093
MSRCR [25]	5.0599	7.3981	6.349	6.9363
HE [5]	5.4801	5.9931	5.9881	5.9686
Enhancement Method	**e**	**f**	**g**	**h**
RACR	7.1095	7.3324	7.0907	7.8268
MRINE [23]	7.1591	6.5454	7.0896	7.2405
CEDNI [24]	7.7788	6.4713	5.9641	7.0324
MSRCR [25]	6.9755	7.3365	7.0013	5.0599
HE [5]	5.9515	5.9880	5.3876	5.4801

5. Conclusions

In this research, low-contrast x-images were improved. Enhancement was made using several algorithms including proposed algorithm RACR and other algorithms as (MRINE, CEDNI, MSRCR and HE) used for comparison. By analysing the results based on the analysis of entropy, histogram and subjective observation, we conclude that the proposed method has succeeded in improving the X-ray images much better than the rest, because the proposed method had high entropy values averaged about (7.40). Regarding future studies, the proposed method can be developed by adding my technique as h histogram equalization and adaptive histogram equalization to enhancing X-ray images.

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