A Hybrid Technique to Detect the Edges of Medical Images by Separating Color Channels

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Abstract. The importance of the medical images lies in diagnosing the disease and its degree and giving the appropriate treatment. The aim of present study is to detect the edges of colored medical images by separating their color channels into three channels, determining the edges of each channel by a Canny operator for each color channel and merging the resulting edges to get the best edge. The quality of each edge has been calculated by using statistical measurements and then compared the results of the proposed model to study the effect of the proposed model. Results gave high accuracy by enhancement in the medical image edge which is useful in image optimization for different applications.

Keywords: medical image, splitting color channels, find the edges, canny operator, Image Quality Metrics.

Introduction

A digital image I [m, n] described in 2D discrete space is derived from an analog image I(x, y) in a 2D continuous space through a sampling process that is frequently referred to as digitization [1]. A color digital image is typically represented by a triplet of values, one for each of the color channels, as in the frequently used RGB color scheme. The letters R, G, B stand for red, green, and blue. The individual color values are almost universally 8-bit values, resulting in a total of 3 bytes (or 24-bits) per pixel. This yields a three-fold increase in the storage requirements for color versus monochrome images [2] . Edge detection is a process that detects the presence and location of edges constituted by sharp changes in colour intensity (or brightness) of an image [3]. Medical image segmentation is an accurate detection method for boundaries within a 2D or 3D image. This technology is important in identifying and displaying vital information in images, the most important of which are medical images. Increasing the contrast of the image presents a major challenge in the segmentation of medical images [4-5]. There are several attempts to use the technique of detecting the boundaries of images, as in [6] which studied edges in blurry images by making use of contrast in intensity. A method was developed by [7] which using of digital processors, while in [8] there is another one to implement hybrid thresholding and produce improved images. Another hybrid method for improving accuracy during segmentation has been introduced by [9].

This algorithm effectively uses the information provided by the X-ray image to obtain a merged edge generated from the edges of the three color channels, which increases the efficiency of edge detection using MATLAB. To evaluate the effectiveness of the algorithm by measuring image quality, using metrics to determine the efficiency of image edge merging is Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Structural Content (SC), Normalized Absolute Error (NAE), Normalized Cross – Correlation (NK) and entropy factor (entropy). At the end the results will be presented and discussed.

Background

Medical Images

Medical images are a specific type of images, and these images are used to diagnose diseases and determine the type of treatment for patients.
X-ray radiographs are used to create an image that is copied onto a thin plate called a radiograph. Parts of the body appear light or dark due to uneven tissue scattering of X-rays. Calcium in the bones is very capable of X-rays, which makes the

bones appear white on the X-ray. Black Color. [10] [11].

Canny Edge Detector

This influencer is one of the effective algorithms for edge detection because it depends on three criteria in estimating the efficiency of estimating the efficiency of the algorithm. The second adopted by the algorithm is the accuracy in defining the edge, which means achieving the least distance between the location of the selected edge and its real location in the image.

As for the third criterion, the algorithm made one response to one edge, as this criterion is complementary to the first and second criteria, because edge repetition means adding false edges (shadow edges) and thus difficulty in determining the exact location of the edge. [12]

To define these criteria, the following tasks are defined:

1-to calculate the value of fx and fy

$$f_x = \frac{\partial}{\partial x}(f * g) = f * \frac{\partial}{\partial x} g = f * g_x \dots\dots\dots\dots(1)$$

$$f_y = \frac{\partial}{\partial y}(f * g) = f * \frac{\partial}{\partial y} g = f * g_y \dots\dots\dots(2)$$

Derivative of $g_x(x,y)$ dependent on :x

$$g_x(x,y) = \frac{-x}{\sigma^2} g(x,y)$$

Derivative of $g_y(x,y)$ dependent on :y

$$g_y(x,y) = \frac{-y}{\sigma^2} g(x,y) \dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

2-Regression calculation:

$$Edge\ Magnitude = \sqrt{p_1^2 + p_2^2} \dots\dots\dots\dots\dots\dots(4)$$

The Proposed Work

The basic steps of the proposed system in this study can be clarified as follows:

Step 1. Take RGB color medical image and read the file image.

Step 2. Separating the color bands to red ,blue and green.

Step 3. Applied Canny operator of each band and save three color spaces.

Step 4. collection the edges of the red channel with the edges of the blue channel with the edges of the green channel.

Step 5. Calculate the PSNR, MSE, SSIM, Entropy, SC, NAE and NK in order to check for the image quality of the edge based segmented image .

Thes steps shown above are described in figure 1 as follows:

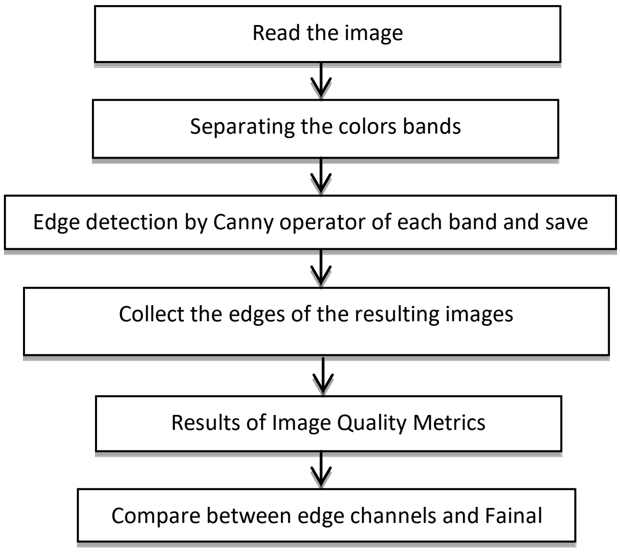

Figure 1: scheme of proposed procedure.

As exposed in Figure 1, the insert image separated into three colour bands R,G, and B. after that each componenet is treated by applying canny operator to detect edges. the Hybrid Method in this work represents the combination of modified clusterd images after segmentation. The final image showed edges with high visibility as compared with the origin image. The above-mentioned steps are illustrated in figure 2. The implementations of this proposed method are done by MATLAB program.

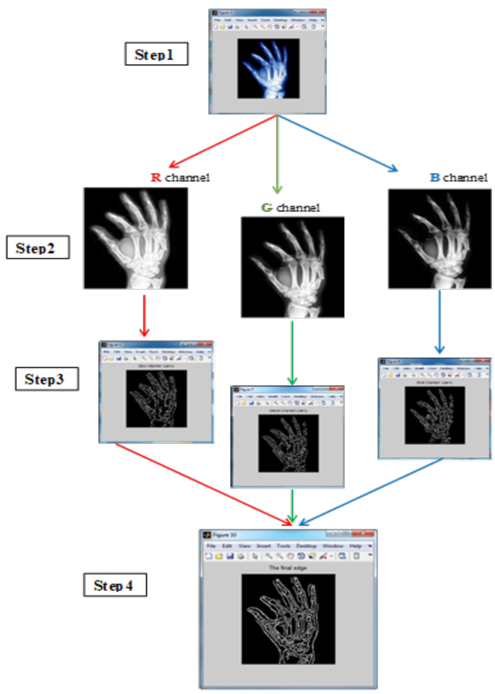

Figure 2: the implementation of the steps of the proposed algorithm.

Statistical measurements

Mean Square Error (MSE): A measure used to simplify the quality of an image. Where when the value of MSE is large for MSE, it indicates a lower quality of this image and vice versa. and it defined by: [13]

$$\mathrm{MSE} = \frac{1}{MN}\sum_{i=1}^{N}\sum_{j=1}^{M}\left[x(i,j) - y(i,j)\right]^2 \ldots\ldots\ldots\ldots\ldots(5)$$

Where x(i, j) and y(i, j) are original and enhancement imge elements in position (i, j). M, N are matrix dimensions of contribution images.

The MSE represents the cumulative squared error between the compressed and the original image. The lower the value of MSE, the lower the error.

Peak Signal To Noise Ratio (PSNR): The quality of the images can be measured by knowing the magnitude of the signal's greatest power relative to the power of the corrupted noise, which affects the accuracy of the signal's representation. If the value of PSNR is large, it indicates that the image quality is poor and vice versa, It can be calculated through the following relation [14]:

$$\mathrm{PSNR} = 10 * log_{10}\left(\frac{255^2}{MSE}\right) \ldots\ldots\ldots\ldots\ldots (6)$$

Entropy (E): It is a statistical measure that expresses the irregularity in the components of the image. It is used as a standard of quality and can be calculated by: [15]

$$\mathrm{E} = -\sum\left(f(I,j)\log_2 f(i,j)\right) \ldots\ldots\ldots\ldots (7)$$

where f(i, j) is the coordinate of the image.

Structural Content (SC) : The greatest rate of the content of compositional (SC) between the two images indicate that the picture quality has a weak (Poor Quality) [16].

$$\mathrm{SC} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)-y(i,j)]^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)]^2} \ldots\ldots\ldots\ldots (8)$$

Normalized Absolute Error (NAE): The largest absolute error standardisation (NAE) value between the two images indicates that the image has poor quality. This scale is defined according to the following equation: [17].

$$\mathrm{NAE} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)-y(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)|} \ldots\ldots\ldots\ldots (9)$$

Normalized Cross – Correlation (NK): This scale is definite according to the following equation: [18].

$$\mathrm{NK} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)-y(i,j)]}{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)-y(i,j)]^2} \ldots\ldots\ldots\ldots (10)$$

Results and Discussion

Figure 3 presents the results obtained due to the application of the proposed model. In this figure, the studied images were divided into splitting channels color , then a canny operator was applied to all channels color to find edge, then add the red channel edge with the blue channel edge with the green channel edge. In the end edges final image, which appears to be clearer.

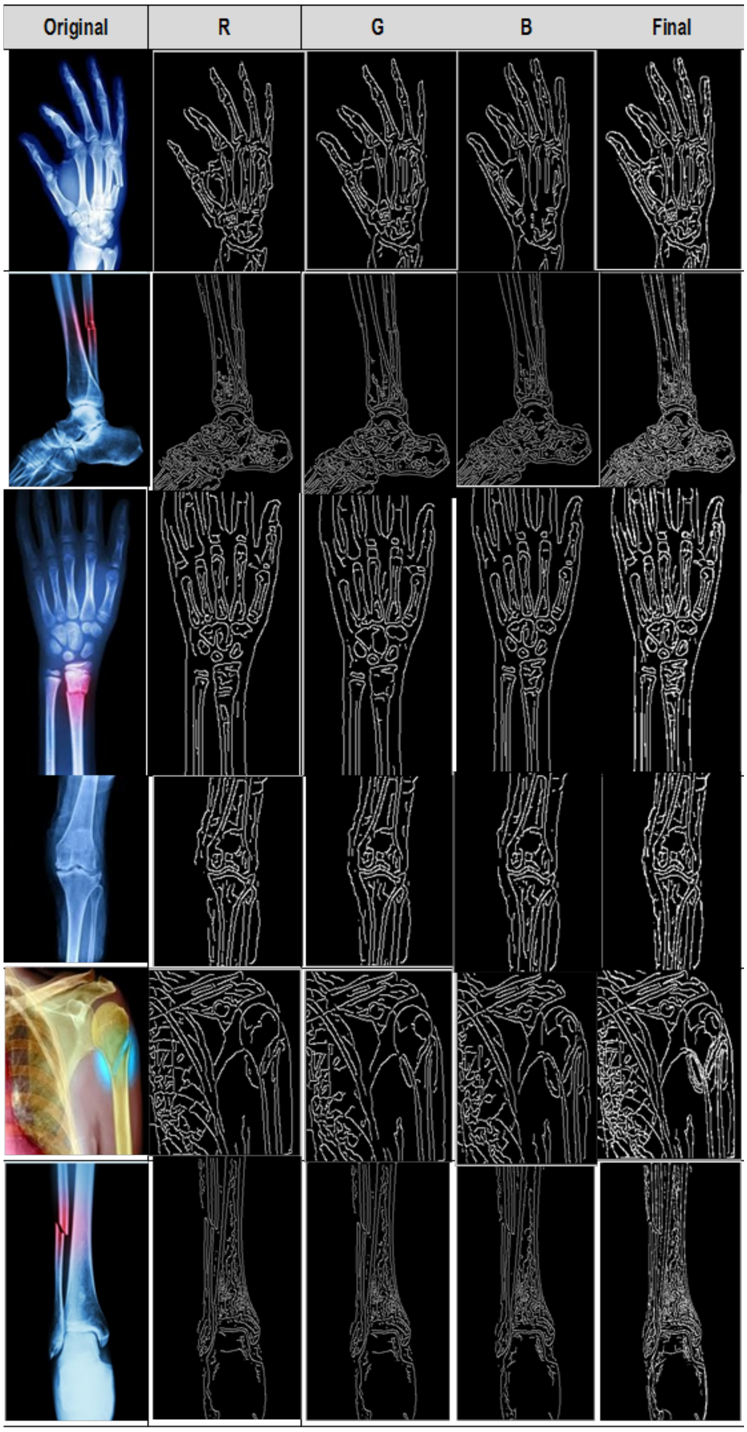

Figure 3. the obtained results of the hybrid method. R,G,B: are the channels splitting, while Final is the final

image resulting from merging the edges after processing it by adding canny operator .

The result is assessed on numerous measurments such as mean, standard aberration, Entropy, RMS, correlation, variance, smoothness, kurtosis, and skewness in order to examine many features of this projected system as shown in Tables 1 -6 which describe show the statistical results for all steps of implementing the hybrid model to examine the result of this model on the final images.

Table1. Comparative Results of MSE Values

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	42.42	41.86	41.49	38.33
2	41.86	42.62	42.57	37.98
3	45.98	46.37	46.60	42.71
4	27.72	27.79	27.92	26.14
5	73.97	74.51	74.19	68.46
6	42.58	42.93	42.91	39.44

Table 2. Comparative Results of PSNR Vaules

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	31.8887	31.9473	31.9857	34.0928
2	31.9465	31.8689	31.8738	32.3697
3	31.5391	31.5026	31.4806	31.8590
4	33.7365	33.7258	33.7058	33.9925
5	29.4741	29.4429	29.4613	29.8104
6	31.8724	31.8368	31.8397	32.2051
	142	777	065	945

Table3. Comparative Results of Entropy Values

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	1.7588	1.80571	1.8416	1.8726
2	1.9601	1.9422	1.9481	1.9989
3	1.9205	1.8999	1.9095	1.9436
4	1.6208	1.6225	1.6092	1.6407
5	2.0926	2.0674	2.0742	2.1384
6	1.8025	1.7781	1.7596	1.8380

Table4. Comparative Results of Structural Content (SC) Values

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	0.7959	0.8342	0.8515	0.8377
2	0.7982	0.8366	0.8539	0.8400
3	0.8005	0.8389	0.8562	0.8424
4	0.8029	0.8413	0.8586	0.8448
5	0.8053	0.8438	0.8611	0.8472
6	0.8077	0.8462	0.8636	0.8497

Table 5. Comparative Results of Normalized Cross – Correlation (NK) Values

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	1.0771	1.0641	1.0581	1.0629
2	1.0771	1.0638	1.0578	1.0626
3	1.770	1.0636	1.0575	1.0624
4	1.0769	1.0633	1.0571	1.0620
5	1.0768	1.0629	1.0566	1.0617
6	1.0765	1.0625	1.0561	1.0612

Table 6. Comparative Results of Normalized Absolute Error (NAE) Values

No. Image	The red channel edge	The green channel edge	The blue channel edge	Final
1	0.1398	0.1161	0.1054	0.1140
2	0.1370	0.1135	0.1028	0.1113
3	0.1343	0.1109	0.1002	0.1087
4	0.1316	0.1083	0.0977	0.1062
5	0.1290	0.1057	0.0951	0.1036

6	0.1263	0.1032	0.0926	0.1011

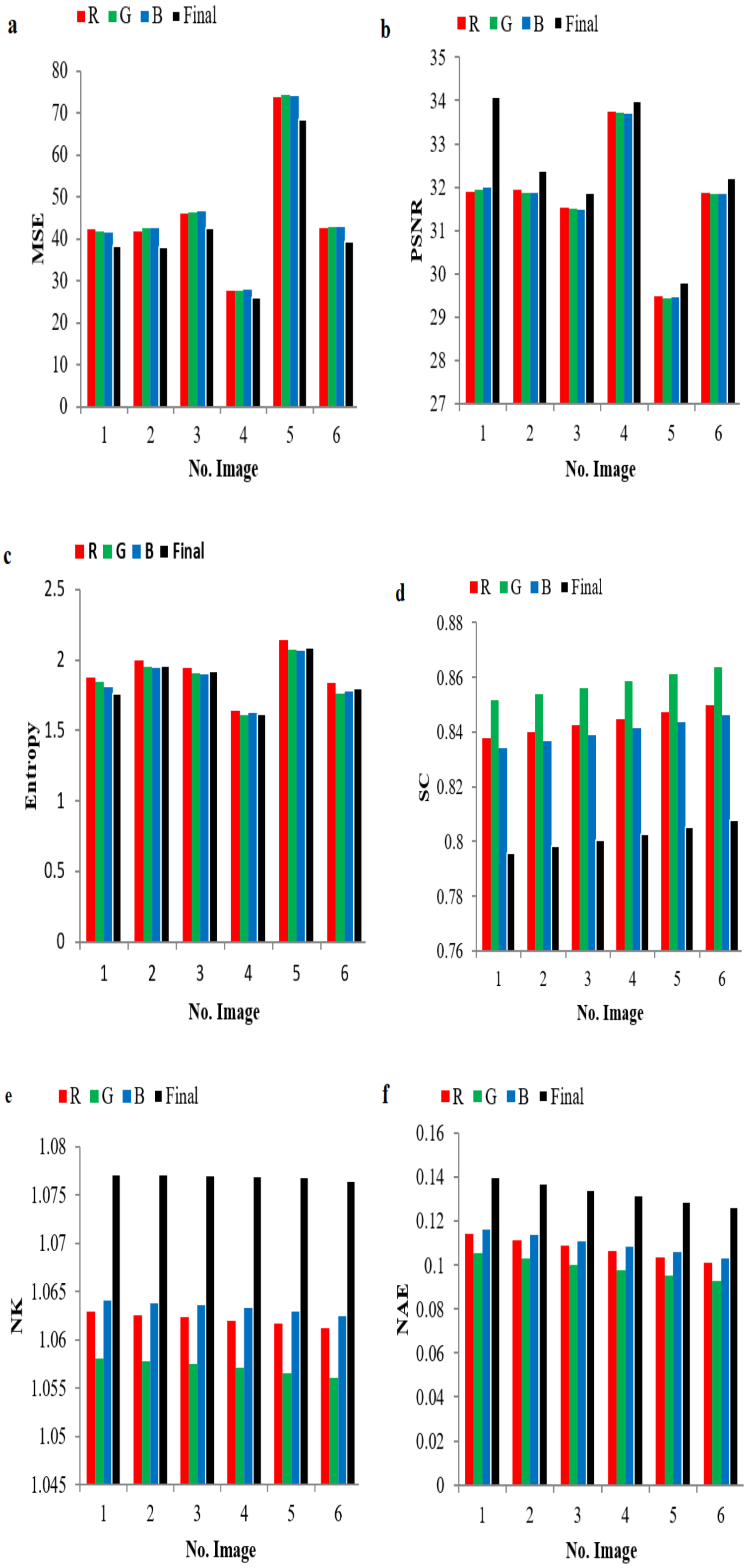

Figure 4 . The statistical results of the above tables.

The effect of the proposed model is clear by comparing the edges of the color channels with the final image resulting from merging the edges of the color channels.

In Figure 4, a graphical representation is used for medical image quality analysis of division techniques based on the use of a Canny operator for each color channel and for the final image resulting from merging the edges of the three channels. If we see the entropy graph presentation that the Canny based division gives the entropy value of the image the final edge is better than the edges of the other output color channels, and also, we see the PSNR graph, the SSIM that shows the Canny-based division of the image the final edge is better than the edges of the production color channel other

Conclusions

In this work, an effective hybrid model is developed to detect and determine the edges of colored medical images by using Canny operator and merging the resulting edges to get the best edge. The results showed a better visual evaluation of the final resulting edge image than the color channel edge images. The final digital image quality statistical results produce the highest PSNR, SSIM of the three channel images as well as the entropy and no other in terms of image quality. This model showes a good results in image processing. A proposed future work is by adding Sobel operator which may increase the capability of our hybrid frameworks.

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