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MEDICAL IMAGE ENHANCEMENT BY HYBRID METHOD IN THE SPATIAL DOMAIN

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ABSTRACT

In this paper a new model with a hybrid method to improve the brightness and contrast of medical images is developed from the NA equation and the Newton-Raphson method, as well as configured candidates (3 × 3) of solving equations by Newton-Raphson technique and by using the candidates to enhance equality and contrast for the same medical images. Stats of image quality have been extracted and compared it with the statistics of original image quality that have been processed by the average candidate. The results of PSNR, MSE, and RMSE showed the efficiency of the novel NA equation to enhance brightness and contrast of medical images, the statistical results showed the efficiency of the novel equations NR1 and NR2 to enhance the brightness and contrast of images of computed tomography scanning (CT), venography and interventional radiology (Angiography and interventional) and fluoroscopy imaging compared with the statistical results to improve Brightness and contrast of the same images with the average filter.

Keywords— image processing, improved contrast and lighting medical images

1. INTRODUCTION

During recent years the using of digital images has increased in due to the accessibility of technology and equipment that made the procedure of dealing with images conceivable. Conventional cameras implement a physical foundation that controls the user's quantity of lighting incoming the lens by controlling its amount and the path of the light, whereas the digital camera involves only a simple information of the user, the principle of its work depends on adapting light into electric charges, and adapting the image into a sequence of binary numbers (0 and 1) to characterize the pixels that form the image. [1]

The wonderful expansion in computer technology, and the excessive development in the field of digital image recording, helped the appearance of devices that permit images to be obtained without chemical dealing. Some of the rewards providing by digital imaging, such as: the constancy of image quality (irrespective of the length of the storage period), the number of copies, and the ability of computer processing, have provoked the attention of many medical workers, and involved them to the field of digital imaging [2].

Computer-Aided Simple Triage (CAST) are computer-aided methods or systems that support physicians in original clarification, categorizing of medical images, and simple computer-aided triage is a subclass of Computer-Aided Detection Diagnosis (CAD). Computer aided simple triage software systems achieve completely programmed initial triage (classification) of analytic medical imaging educations. "Simple Computer Aided Triage" has been equipped mostly for cases significant in analytic imaging, in which the fast analysis of critical and life-threatening cases is essential. Unlike traditional computer-assisted analysis, which is chiefly used to distinguish spites, simple computer-assisted screening deals with severe states, when an instant analysis is critical in dealing with the state. Whereas, the main goal of conventional computer-assisted diagnostics is to improve the analytic precision of the user [3].

With the fast expansion in the medical field, what is known as (electronic doctor) has become a truth that can be reliable to a high degree and an significant feature in detection numerous diseases and diagnosis them primary, which helps in early recapture or even evading many of these diseases, especially cancerous diseases.

The role of these systems is rising with the excessive developments in medical imaging techniques using the computer, which produce huge amounts of data that need to be understood, and data can be extracted from them to rapidly and efficiently identify diseases.

2- THE THEORETICAL ASPECT

2-1 BASIC CONCEPT OF DIGITAL IMAGE

a person perceives the scenes or images around him by the arbitration of the eye, as the image receives the form of a cluster of light intensity dispersed in a precise order and that these images are named optical images, which characterize its information in the form of analogy electrical signals, and when dealing with it with a computer, it must be changed into a digital form. form or distinct form before any computer processing is achieved on it, and this is achieved by the process of digitalization and in equally the proceedings of space and amplitude, and the digitalization of the space is called sampling and digitizing the amplitude by quantization. in colour images, the quantization process is done by selecting a group of colours that denote the colour sequence of the image [5]. the separation procedure means excruciating the image into small elements, each element named pixels, and then counting the values of these elements by taking the ratio of intensity for each element and representing it with a quantified precise amount within the period [7.6]. the resultant image of the separation process is called the digital image. it is a two-dimensional matrix organized in the form of columns and rows, and each element of this matrix is called in pixels

since the intensity analysis specifies the minimum obvious change in the grey level, the number of levels is usually an integer l represented by the following: [6]:

$$L = 2^n \qquad \text{………… (1)}$$

Where n is an integer that represents the number of binary orders to represent the grey level, the greatest common number to characterize the level of intensity is 8 bit, meaning that L = 28 = 256 and there are some applications that use n = 12bit or n = 16bit that individual the image data will be controlled. [8] [7]

2-2 Typeset of The Digital Image

1. **Image Binary**

Where it is represented by only two numbers, namely (0) and (1), the value of zero represents black and the value of one represents white and on this foundation, this type of image refers to 1bit / pixel, meaning taking only one binary number for each image element [4]. The binary image can be produced from grayscale images by execution the preparation technique using a quantified threshold where the quantity of the threshold depends on the illumination of the image [9].

2. **Image Gray Level**

This image contains intensity information only and does not contain colour information. Each point of the image signifies 8 bits for each pixel element, which denotes 256 grey levels, and their values are definite in the range (0 - 255). Examples of this type are regular photos, either in the case of astronomical images, this type of image representation offers with a more precise brightness of the necessities of the human graphic system [5].

3. **Image Colour**

Coloured images contain illumination information as well as colour information. Each point of the image is denoted by a number of 24 bits per 24 bit/pixel image element. Any colour point in the image is a mixture of the three main colours RGB, where 8bit/pixel is allocated to each of the primary colours. Examples of this type are the usually used colour images [1].

4. **Image Multi Spectral**

The multi-spectrum images contain information outside the boundaries of visual perception, where the information of this type of images (with a number of spectral beams) is collected by a distinct sensor in which the sensitivity function when taking pictures is distributed over the number of spectral beams implemented by the sensor. An example of this type is the images captured by the satellites. Satellite image information is composed in a number of beams ranging from (2-7) a spectral beam, one to three of these beams fall within the ranges of the visible spectrum and one or more of the other beams and fall in the ranges of the invisible spectrum [2]

2-3 Lightness

Lighting is a very important factor of colour reproduction. The light entering the eye is a result of the intensity of illumination and the reflection coefficient of the scene for any wavelength [3]. The colour sensation in the eye is affected if there are changes in the colour of the scene as a result of a change in the intensity of the lighting. When moving from a room lit by artificial light to sunlight, the human optic nervous system automatically compensates for the change in the intensity of lighting, unlike the camera that does not perform such compensation and has the changes occurring The intensity of the luminance has a strong influence on the chromaticity values of the image element for RGB beams [4] Illumination refers to high lightness or darkness in the whole picture, black has a low intensity, the correct term is called luminance, and white has a high intensity or high luminance. Figure (1) shows the method of schematically representing the edge. Increases to be bright from the right side

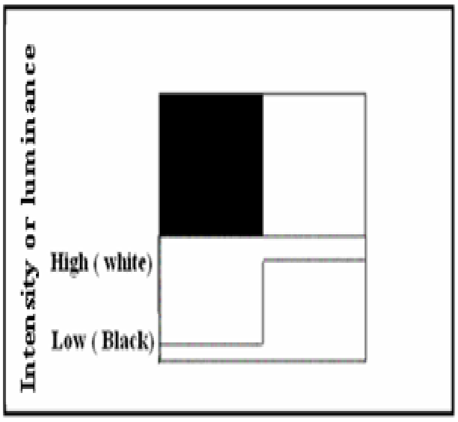


Figure 1: the Lighting method of schematically representing the edge. Increases to be bright from the right side

2-4 The Newton-Raphson Method

It is an actual mathematical method to find the roots of a real function. Therefore, it is an example of algorithms for conclusion roots that can be used to find the higher and lower limits of such functions, by finding the roots of the first derivative of the function. In this method it is assumed that the problem to be solved is in the form [6].

f(x) = 0, Since x is the variable that satisfies the equation f(x) provided that the function is related at least at this root

Therefore, one can examination for a root close to x, say x_n, and substitute it in Newton's method shown in equation (2) to find a more accurate value, let it be x_{n+1}:

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$f(x_n)$ Represent the function, $f'(x_n)$ The derivative of the function.

2-5 Image Quality Statistics

The following numerical standards were applied to measure the value of the image to which the present study filters are applied, namely:

a- Mean Squared Error (MSE)

It is defined as the cumulative square error between the resulting image and the original image, and is calculated from the following relationship:

$$MSE = \frac{1}{MN}\sum_{y=1}^{N}\sum_{x=1}^{M}[I_1(x,y) - I_2(x,y)]^2 \quad \ldots (3)$$

$I_1(x,y)$ The original image item on the site

$I_2(x,y)$ Image element required to be calculated

M, N are the number of items for which to calculate the square error of error may signify the size of the whole image or the size of part of the image.

b- Peak Signal to Noise Ratio (PSNR)

Peak signal-to-noise ratio, meaning the ratio of the highest value and lowest signal-to-noise value [6]:

$$PSNR = 10\log\left(\frac{(L-1)^2}{MSE}\right) \quad \ldots\ldots\ldots (4)$$

L: is the number of grey levels.

c-Root Mean Square Error (RMSE)

It is defined as the square root of the MSE square error rate, so the lower its value, i.e., the lesser error, the closer to the original [7].

$$RMSE = \sqrt{\frac{1}{MN}\sum_{y=1}^{N}\sum_{x=1}^{M}[I_1(x,y) - I_2(x,y)]^2}$$

3 – Proposed Method

The method which proposed in this work illustrated in figures 2,3 bellow:

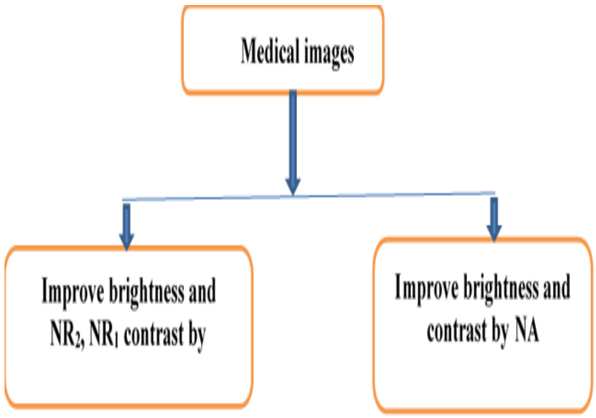


Figure 2: algorithm of the proposed method

Table 1: the information of proposed method

Mathematical relationship	Coding	method	
$s = c/2[\log(1+r) + (r)^g]$	NA	Improve brightness -1 and contrast	A
$1 - f(X) = X - \cos(X)$ $2 - f(X) = X\,exp(X) - 1$	NR1 NR2	Improving brightness -2 and contrast using the Newton-Raphson method	B

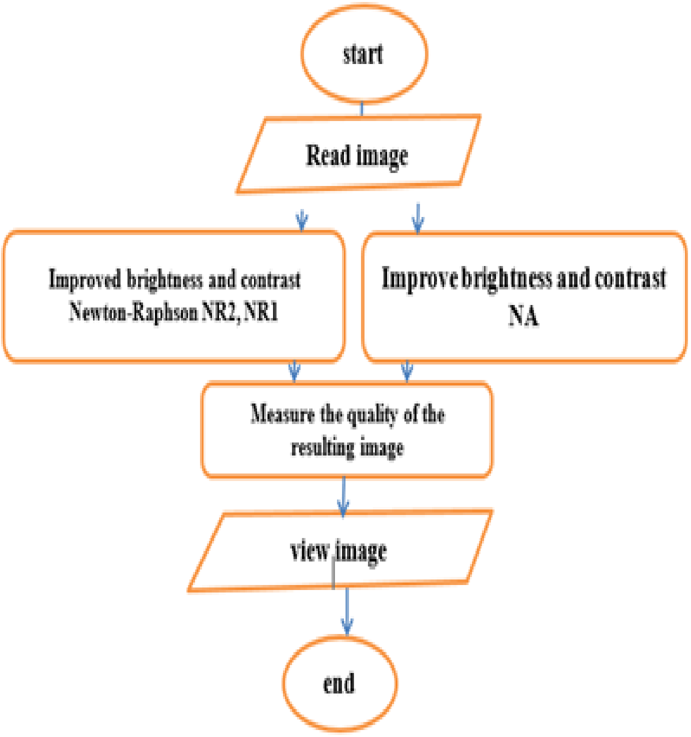


Figure 3: steps of work to investigate enhancement process.

4- RESULTS AND DISCUSSION:

4-1 Results of the first axis: Improving the brightness and contrast of the image by the NA equation:
Substituting the intensity values ((r) of the image, whose value ranges between (0-255), into the equation NA in Table (1), we obtain the value of the output intensity of the enhanced image s for different values of g. Which is equal to (0.04, 0.1, 0.2, 0.4, 0.67, 1, 1.5, 2.5, 5, and 10) with a constant value of (c = 1). Figure (4) represents the relationship between the strength of the input image (r) and the enhanced image intensity (s) which was calculated from the NA equation.

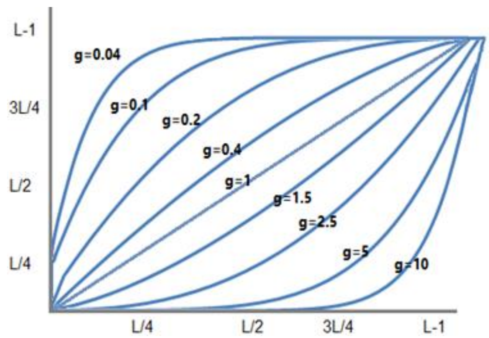
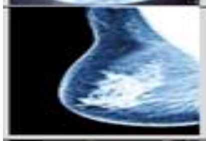
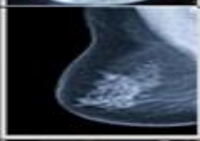


Figure (4) represents the relationship between the strength of the input image (r) and the enhanced image intensity (s) according to the equation NA.

Table (2) represents the pre-treatment and post-processing images with improved brightness and contrast using the NA equation

Table (2) Pictures before processing and after improving their brightness and contrast

Image after processing	Image Beforeprocessing	Imaging techniques	ت
		x-Ray g= 0.2	1
		Magnetic Resonance Imaging MRI g= 0.4	2
		Ultrasound (D) g= 0.2	3
		Mammography g= 0.04	4
		Computed Tomography (CT) Scan g= 0.2	5
		Angiography and Interventional g= 0.4	6
		Fluoroscopy g= 0.04	7

4-2 Results of the second axis: image improvement by the Newton-Raphson method

The Newton-Raphson equation (2) becomes as follows [18]

$C_j = C_i - \frac{f(C_i)}{f'(C_i)}$ …………… (6)

C_i = Central pixel.

C_j =Neighboring pixel of C_i . by solving the following equation and configure the NR1 filter based on the distance between pixels and its neighbours:

$f(C_i)= i\text{-}\cos(i),\ f'(C_i) = 1 + \sin(i)$ … (7)

This distance has been used to optimize the unwanted pixel value to remove noise and enhance image quality. In the same way, we solve the following equation and its derivative in equation (6), and we get the 2NR filter:

$f(C_i)= i\ exp\ (i)\text{-}1,\ \ f'(C_i) = i\ exp(i) + 1$…(8)

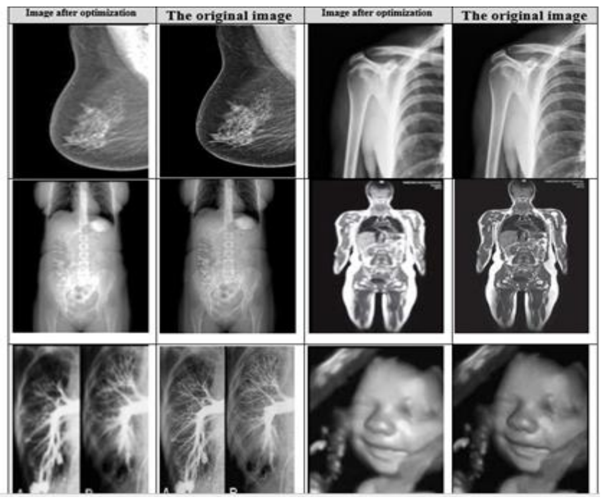
By substituting equations (7) into the Newton-Raphson equation (6) and substituting the value of the central pixel CJ=X=1 From there, we find the value of the adjacent pixel Cj and then we consider the adjacent pixel that we obtained as the central pixel. In the same way, we find the adjacent pixel for it, we put the results in a matrix (3 × 3) and we get the filter NR1 And shown in Table (3).

Table (3) The filters resulting from solving equations (7) and (8) using the Newton-Raphson method

Equation filter (3x3)			The mathematical formula of the equation	Filter icon	Number Equation
0.739112891	0.750363868	0.739112891	f (x)= x- cos (x)	NR1	1
0.750363868	1	0.750363868			
0.739112891	0.750363868	0.739112891			
0.893514757	0.683939721	0.893514757	f (x)= x exp (x)-1	NR2	2
0.683939721	1	0.683939721			
0.893514757	0.683939721	0.893514757			

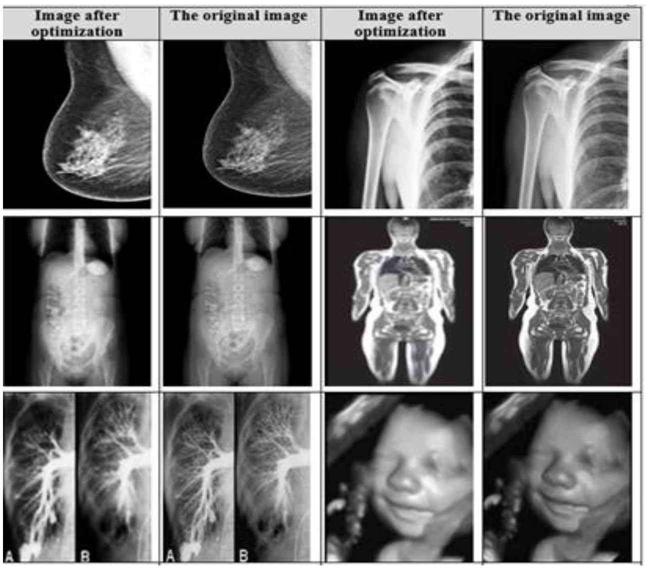
The NR1 filter used Equation (1) to optimize images, and the results were obtained in Table (4).

Table (4): Results of applying the NR1 filter to the study images and the results of their improvement.



The 2 NR filter was used to improve images, and the results are obtained in Table (5).

Table (5) Results of applying the 2NR filter to images and results of their improvement



4-3 Statistical Results:

Table (6) represents the PSNR, MSE, and RMSE values for the images whose brightness and contrast are optimized by the NA equation.

Table (6) PSNR values and MSE RMSE images optimized by the NA equation.

PSNR	MSE	RMSE	ت	Imaging technique
86.5979	3.3580772	1.8325057	1	x-ray
90.3054	2.7898659	1.6702892	2	MRI
93.7578	2.3475531	1.5321727	3	Ultrasound
22.3856	83.261274	9.1247616	4	Mammography
57.1775	14.619972	3.8236072	5	CT
52.1751	18.774669	4.3329746	6	Angiography and Interventional
68.94	8.1194592	2.8494665	7	Fluoroscopy

Table (7) represents the PSNR, MSE, and RMSE values for the NR1 filter (3x3), and comparing them with the values of the modified filter (Average 3x3).

Table (7) PSNR, MSE and RMSE values for filter NR1 (3x3) and modified filter (Average 3x3)

NR1(3X3)filter			(Average 3x3) filter			ت	Imaging technique
PSNR	MSE	RMSE	PSNR	MSE	RMSE		
61.5742	11.7347	3.4256	52.8255	18.1739	4.26309	1	x-ray
58.1337	13.9374	3.73328	57.4334	14.4341	3.799224	2	MRI
46.8922	24.4505	4.94475	47.064	24.2414	4.92356	3	Ultrasound
39.5413	35.3111	5.94231	29.5622	58.1574	7.626102	4	Mammography
49.7342	21.2117	4.60561	45.175	26.6426	5.161652	5	CT
46.596	24.8153	4.98150	40.6903	33.3396	5.774053	6	Angiography and Interventional
47.3682	23.8755	4.88625	36.4432	41.2274	6.420858	7	Fluoroscopy

Table (8) represents the PSNR, MSE, and RMSE values for the NR2 filter (3x3), and comparing them with the values of the modified filter (Average 3x3).

Table (8) PSNR, MSE and RMSE values for filter NR2 (3x3) and modified filter (Average 3x3)

filter NR2 (3x3)			(Average 3x3) filter			ت	Imaging technique
PSNR	MSE	RMSE	PSNR	MSE	RMSE		
61.5978	11.7209	3.42358	53.0837	17.94082	4.23566	1	x-ray
58.0399	14.002957	3.742053	59.2769	13.16311	3.6281	2	MRI
46.7332	24.645727	4.964446	38.1385	37.87679	6.15441	3	Ultrasound
35.510	43.196676	6.572418	34.0326	46.50843	6.81970	4	Mammography
49.9624	20.971063	4.579417	38.413	37.36048	6.11232	5	CT
46.3847	25.078942	5.007888	35.2177	43.83263	6.62062	6	Angiography and Interventional
46.7637	24.608171	4.960662	55.6862	15.75178	3.96885	7	Fluoroscopy

5- CONCLUSION

In this work, a new model with a hybrid method to improve the brightness and contrast of medical images is developed from the NA equation and the Newton-Raphson method. The results of PSNR, MSE, and RMSE showed the efficiency of the novel NA equation to improve brightness and contrast of medical images, especially for computed tomography scan (CT) and angiography and interventional and x-ray pictures fluoroscopy and the statistical results showed the efficiency of the novel equations NR1 and NR2 to enhance the brightness and contrast of images of computed tomography scanning (CT), venography and interventional radiology (Angiography and interventional) and fluoroscopy imaging compared with the statistical results to improve Brightness and contrast of the same images with the average filter.

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