Enhancing Diagnostic Viewing of Medical Images with Histogram Equalization

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***Abstract*—This paper addresses the low contrast problem of medical images. The low contrast medical images are unable to process for effective diagnosis. This problem can be overcome with this proposed novel histogram based image enhancement technique. The enhancement process starts with computing histogram values of an image. These histogram values are further used to remap the low contrast image intensity values with enhanced pixel values. The resultant enhanced image is compared with standard (basic) enhancement techniques to check the high visual clarity of the proposed algorithm.**

Keywords—Image Enhancement, Histogram processing, intensity mapping.

I. Introduction (*Heading 1*)

The Digital image processing is the processing of the digital images (two dimensional images) by a digital computer or processor. This processing is used to remove noise & blurring which is introduced by the movement of the camera (Mohamed H.S.S, et.al., 2011).Image enhancement algorithm is one technique that yields (Vimal, 2000) better quality image by suppressing the noise information (ColtucD 2006) so that it improves the interpretability of information for human viewers in images.

Histogram equalization is one of the techniques in image enhancement that can improve the contrast and brightness for the low contrast and dark images. For example, if the image is very low contrast then the histogram equalization can improve the contrast in all parts of the image. Histogram equalization works well with the poor contrast images (Peli 1990).

Mohamed Y. Adam, 2011, proposed a method which is the most popular and strong program called histogram equalization to enhance medical images which is implemented without using the function histeq.

Soong Der Chen, 2003, proposed Bi-histogram equalization (BBHE) that increases the brightness of original image to a certain extent and also analyzed mathematically. Debashis Kadhum Z.A.I, 2012, proposed contrast enhancement of an image with histogram equalization technique. Stark, 2000, generalized histogram equalization for adaptive image-contrast enhancement. Duerk, 1993, designed waveform for gradient moment nulling and motion encoding efforts in low contrast MRI images. Cobra, 2005, discussed modified histogram for image enhancement with visual system model. Georgeson, 2005, measured visual contrast by subjective contrast-matching, and contrast sensitivity techniques. Rovamo, 1999, modelled image contrast sensitivity with eye illumination and grating area.

Rest of the paper is framed as: Section II describes techniques in image enhancement Section III addresses the proposed work with histogram base Section IV describes flowchart of proposed algorithm In Section V, the discussion is on the experimental results and finally concluded in section VI.

II. Image Enhancement

Image enhancement is employed for sharpening or smoothing image features (Jain.R.K. 2001).

The spatial domain method can be expressed using an equation given as

$$S(x , y) = T [I(x , y)] \tag{1}$$

Where I(x, y) and S(x, y) are the input and enhanced images respectively, and T is an operation performed on input image I defined over a specified location at point (x, y).

The spatial domain technique operates directly by the manipulation of pixels values and is broadly classified as

A. Point operation or processing

B. Mask processing

C. Histogram processing

A. Point operation or processing

Point operation is performed by an equation and in which a pixel value does not depend on other pixel value, is given as follows:

$$S(x , y) = T[I(x , y)] \tag{2}$$

Here exists a one to one mapping between the input I(x, y) and output S(x, y) images respectively.

1. Linear point processing

A linear transformation technique (Jain.R.K. 2001) maps input pixel value to another enhanced pixel value at the same location using a linear equation (3).

- Brightness modification
- Contrast adjustment
- Image negative transformation

2. *Brightness modification*

In the brightness modification of an image a constant is added or subtracted from the luminance (Sen.D.2009) of all sample values. Here K is the integer value.

$$S(x,y) = I(x,y) \pm k \tag{3}$$

3. *Contrast adjustment*

Contrast adjustment is done by scaling all the pixels of the image by a constant K, is given by

$$S(x,y) = I(x,y)*K \tag{4}$$

4. *Image negative or image transformation*

The image negative is the negative transformation of an input image (Shanon, 2008) and is given by the expression. 'r' is intensity value of the image. 'L' is the graylevel of the image.

$$S = L - 1 - r \tag{5}$$

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B. Mask processing

In mask processing, each pixel is modified according to the values in a neighbourhood. In the mask processing, the operator T operates on the neighbourhood of pixels. Here the neighbourhood of pixel value can be changed by multiplying each pixel with masking matrix. To be enhanced pixel must be placed in centre of the matrix. It is possible of the mask size is "odd*odd" multiply each pixel with mask. In mask processing there are two types linear and non-linear mask processing.

- Linear mask processing
- Non linear mask processing

1. *Linear mask processing*

In linear mask processing the mask consists of nonzero values as mask. These are two types:

- Smoothing filters
- Sharpening filters

Smoothing filters with mask can reduce noise and blur where as sharpening filters with mask will enhance the intensity value of images in pixels. For out of the image boundaries the pixels are replaced with: Zero padding or replica. Zero padding refers to adding zero at the end to increase the length of a time domain signal. The resulting output image (Cobra, 2005) is smaller than the input image. Pixel replica is simply refers to adding replicates at the end to increase the length of a time-domain signal. The resulting output image is greater than the input image.

2. *Non- linear mask processing*

In non linear mask processing, the empty mask is selected (mask is not having any coefficient values).The purpose of non linear mask processing is the neighbouring pixels values are selected directly, for enhancement procedure. This method is used for removing salt-and-pepper noise from corrupted images. There are three techniques,

- Median
- Maximum
- Minimum

By using minimum filter we can remove salt noise. By using maximum filter we can remove pepper noise. By using median filter we can remove salt and pepper noise.

C. Histogram processing

Histogram processing of a digital image is a discrete function and a plot that gives intensity information with gray levels in the range [0, L-1]

$$h(r_k) = n_k \tag{6}$$

Where r_k is the k^{th} pixel value and n_k is the count of the k^{th} pixel in an image.

III. Proposed Methodology

The proposed methodology of medical image enhancement process drawn in figure 1. The mathematical part of the algorithm is referred from (Shannon, 2008). The detailed step by step analysis is given below:

Given an image with dimensions m X n pixels, with L possible gray values {0 to L-1}

1. Read the original image I(m.n) with dimensions mXn.

2. Compute the count of the common pixels in an image:

$$f(I(i,j)) = \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} f(I(i,j)) + 1 \tag{7}$$

3. Calculate the running sum of the above computed values:

Initialize s=0. f(i) values are is from equation (7)

$$c(i) = \sum_{i=0}^{L-1} s + f(i) \tag{8}$$

4. Calculate y= (m X n)/ L. Here L is the highest gray value in an image

5. Calculate the new gray values according to the following expression: c(i) is from equation (8).

$$g(i) = \sum_{i=1}^{L-1}\left[\frac{c(i)}{y} + 0.5\right] - 1 \tag{9}$$

6. Map the pixel values using the below equation:

$$u(i, j) = \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} g(I(i, j)) \tag{10}$$

7. Replace the pixel values using following equation

$$h(i, j) = \begin{cases} u(i, j) & \text{if} \quad u(i, j) \geq 0 \\ 0 & \text{else} \end{cases} \tag{11}$$

IV. RESULTS & DISCUSSION

The proposed work has been executed and verified with Matlab software. The low contrast images are downloaded from the medical doctorial databases and reference publications (Ginneken,2001; Bomans M, 1990; Rodieck, R.W.2005). The proposed method output is verified with standard enhancement techniques like contrast enhancement, brightness enhancement, mask processing (linear & nonlinear), etc. The following figures (from fig 2-4) describes the resultant image with proposed method with standard methods.

V. CONCLUSION

In the proposed work image enhancement techniques are verified and analysed on several medical images. The novel algorithm with histogram base is proposed and the effectiveness of the algorithm is compared with the techniques like point processing, mask processing, and spatial filtering. With the proposed work the fine and course details are very clear in visual representation. The proposed algorithm has proven the efficiency in both qualitative and quantitative analysis. Finally the medical images are enhanced with better visual quality and can be diagnosis easily by the physician.

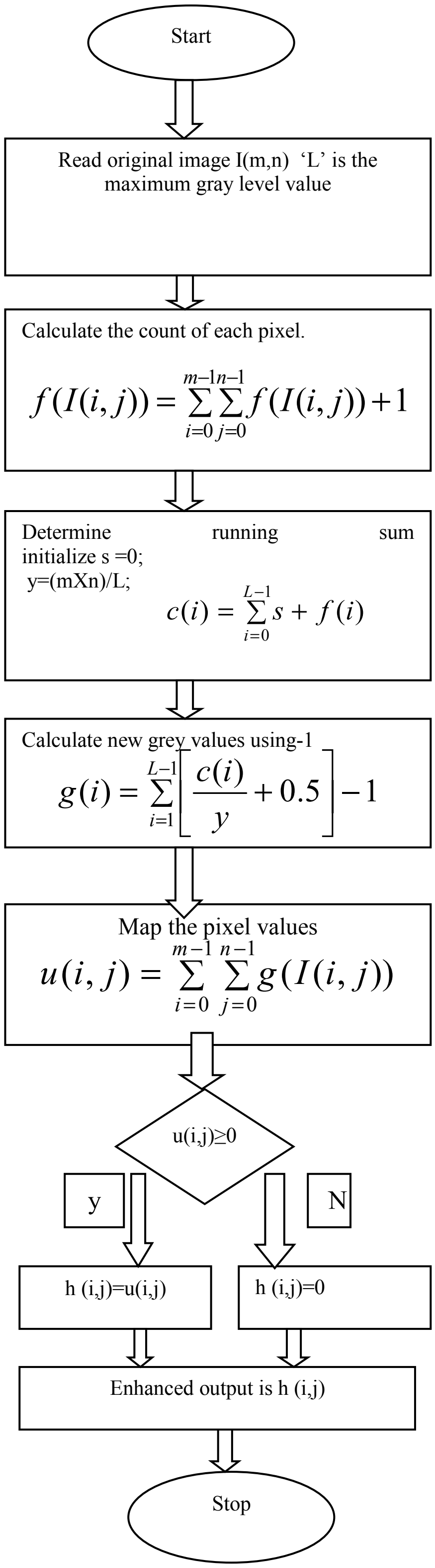

Fig.1Flow of Proposed Work

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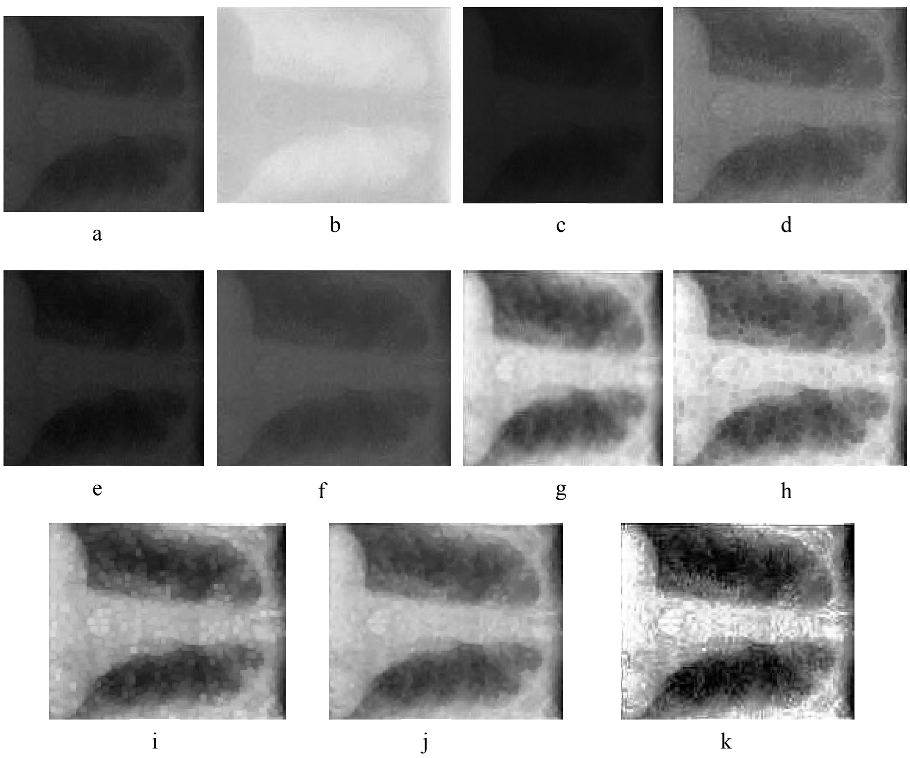

Fig 4 (a) original image, (b) negative image, (c) contrast decrease, (d) contrast increase, (e) brightness decrease, (f) brightness increase, (g) linear mask output, (h) minimum filtering, (i) maximum filtering

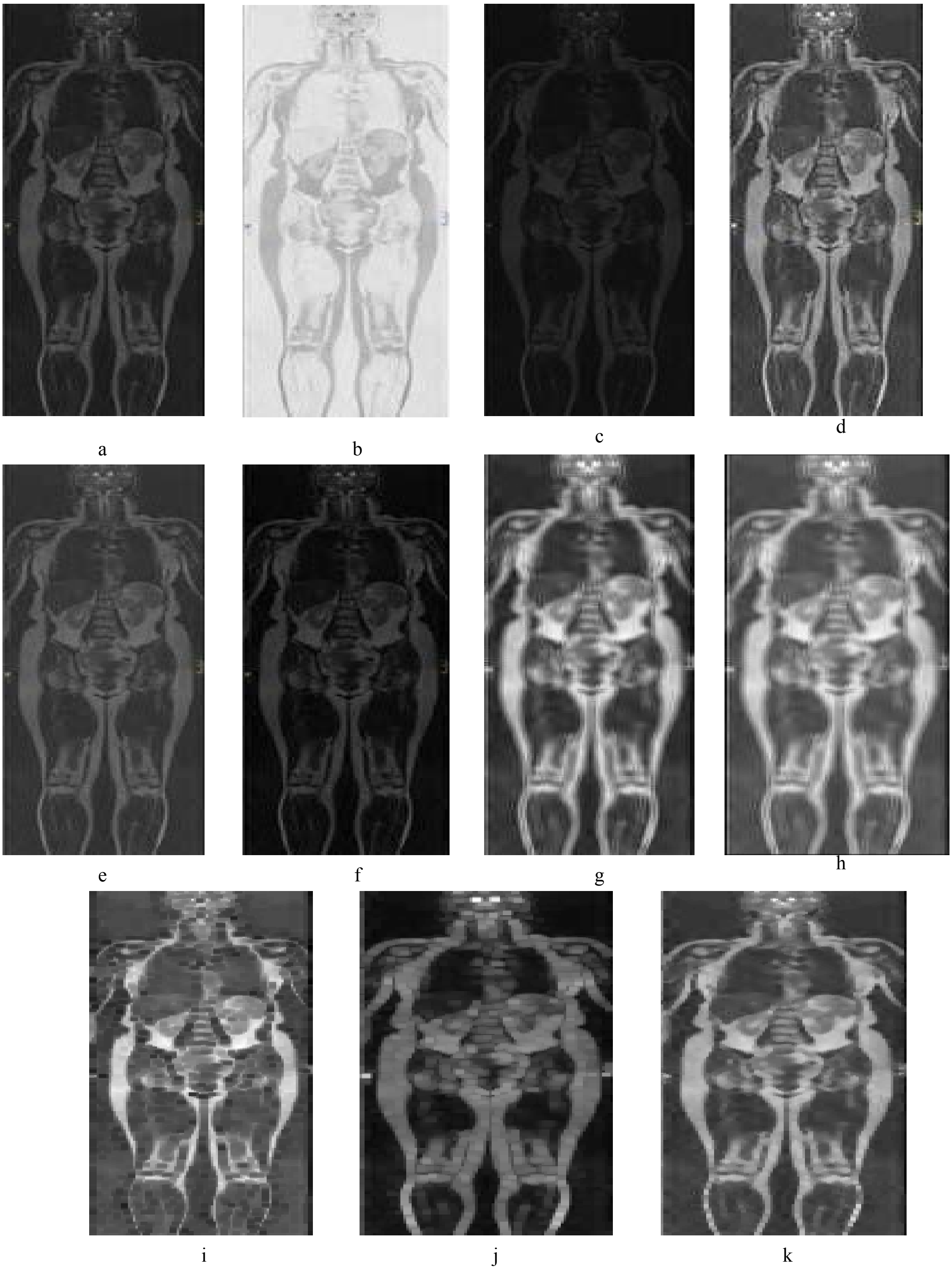

Fig 3 (a) original image, (b) negative image, (c) contrast decrease, (d) contrast increase, (e) brightness decrease, (f) brightness increase, (g) linear mask output, (h) minimum filtering, (i) maximum filtering (j) median filtering, (k) proposed method.

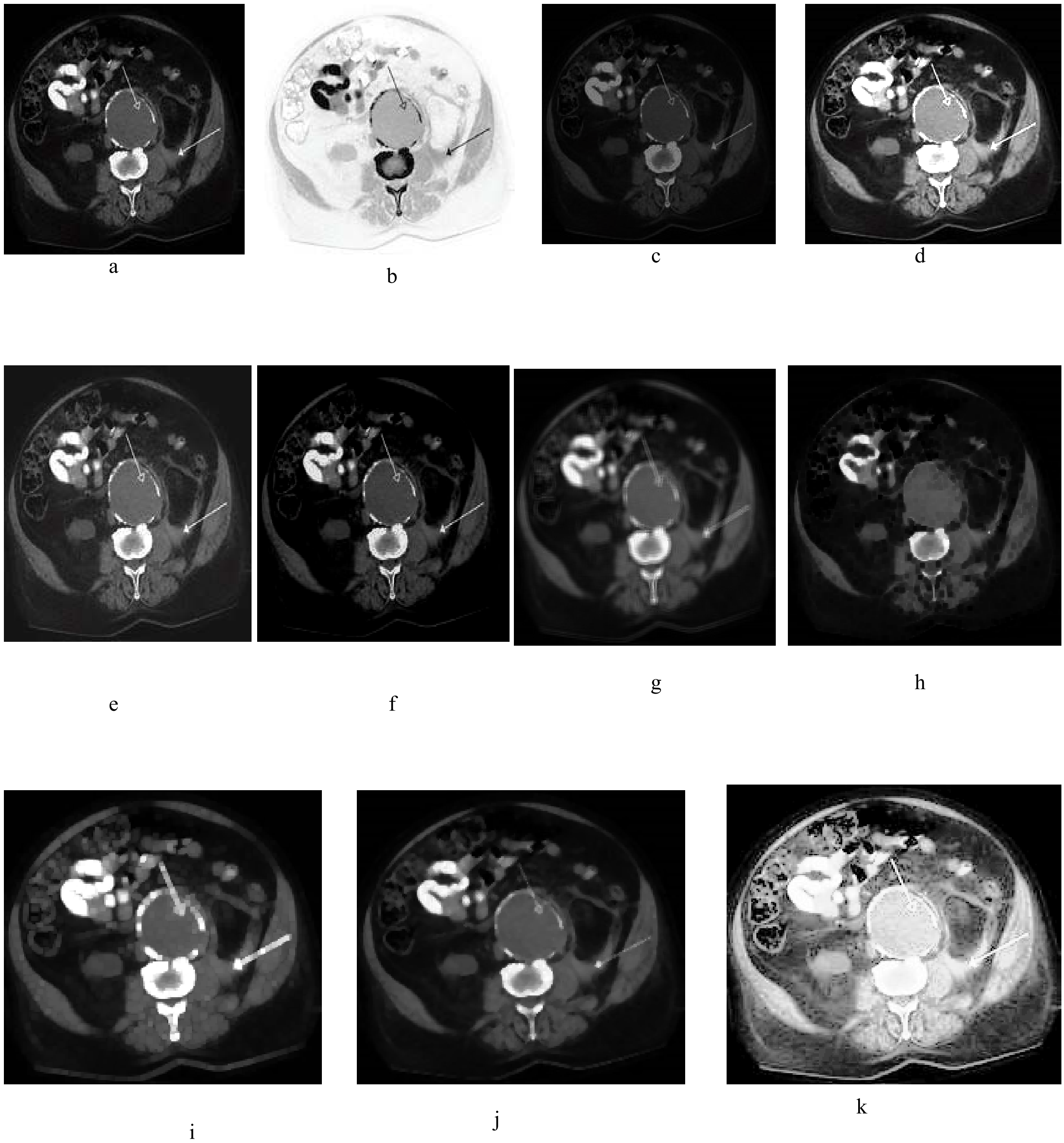

Fig 2 (a) original image, (b) negative image, (c) contrast decrease, (d) contrast increase, (e) brightness decrease, (f) brightness increase, (g) linear mask output, (h) minimum filtering, (i) maximum filtering
(j) median filtering, (k) proposed method.