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A simple Technique for contrast stretching by the Addition, subtraction& HE of gray levels in digital image

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Abstract: The aim of image enhancement is to improve the visual appearance and quality of an image. Many images like medical images, satellite images, aerial images, images obtained from digital camera and even real life photographs suffer from poor contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality and to retrieve hidden information in the image. A digital image is an aggregate of large number of picture elements which represents the brightness of different pixels .Our aim is to study various techniques used for the enhancement of images. In this paper, we present a new technique for the increase in its dynamic range by the addition and subtraction of some number from the image gray levels, followed by the histogram equalization. The technique is very simple to implement and produces good result in image quality enhancement.

Keywords: Digital camera, Digital image, Frequency domain enhancement, Histogram Equalization, Image Enhancement, Spatial domain enhancement.

I. INTRODUCTION

The purpose of image enhancement is to produce a high quality image from a low quality raw image. For this, we have to use some image enhancement techniques which can bring about the desirable transformations in the given image. The survey of image enhancement techniques implies two broad classes of techniques: (1) Spatial domain transformation techniques; and (2) Frequency domain transformation techniques. Spatial transformation techniques operate directly on the picture elements. We can have global & local transformation techniques. In global techniques, we generate some transformation functions which operate on all the pixels at the same time. In local transformation, we take each element one by one and operate a suitable spatial filter on these pixels and continue this process for all the pixels. We can produce some specific effects on the image like revealing its finer details, or highlighting some specific portion of the image in which we can find some specific information. Image is captured by different equipment like a digital camera, mobile phone, astronomical telescope, X-rays, satellite images etc. This image is converted to digital form by sampling, quantization & A/D conversion. In this image, we have large number of picture elements in a frame (picture plane), which may be a square or rectangle of different aspect ratio. Each picture element in the image has some specific value of brightness or light intensity, and such an image may be represented by an array of elements of dimension m x n and each element has some value of light intensity represented by a 8 bit or 16 bit memory , register in gray scale and by 24 or 48 bits data for colored image. Each color i.e. red, green, blue is represented by individual color channel, each has 8 bits or 256 gray levels In this paper ,we describe a simple technique whose detail is given in section 4 Section- 1 describes different techniques used for image enhancement. Section -2,explains histogram method,section-3 explains frequency domain method ,section -4 describes proposed method ,results and conclusion

A. Image Capturing:

A digital image is an image obtained through certain sensors which are light-sensitive, like charge coupled devices (CCD's) or CMOS devices which are used normally in digital cameras. Digital images obtained by digital camera is an aggregate of different picture elements which are present in a rectangular or square frames that are represented by a matrix or an array of size M x N, where M & N are the number of pixels along X & Y directions and these are the dimensions of light sensitive sensors in the camera which carry small cells (sensors). These cells are sensitive to light intensity. When light falls on these cells, displacement of charge takes place and develops some voltage in proportion to the light intensity falling on the cells. This voltage is converted to digital form by sampling and A/D conversion. The voltage is stored in the form of 8 bit word and saved in the memory of digital camera for a gray scale image. The number of gray levels in a 8 bit picture element are 256, which have values from 0 to 255, while for a colored image, we need 24 bits for the representation of picture elements. Each 8 bits represents red, green and blue colors which are the primary colors. We can generate very large number of colors by the combinations of these primary colors i.e. 2^{24} colors.

The proposed paper presents a simple technique for increasing the contrast of the image by the partitioning of histogram by the addition and subtraction of some well defined values from the gray levels of the image present in the histogram. By recursively using this technique, we may bring about contrast increase in the image. The details of the technique are explained in the section 4.0 and Section 4.1 describes the results of this technique and its comparison with other techniques. The conclusion is given at 4.2

B. Processing of the digital image:

When we capture any image, the image may have some drawbacks due to various reasons such as insufficient light while capturing the image by a digital camera, unfavorable weather conditions like fog, rain, excessive or insufficient sunlight condition, or less resolution power of the sensors used in camera. Due to these adverse conditions, the quality of the image taken by a camera may be poor, but the quality can be improved by using some specific techniques for image enhancement.

Broadly speaking these techniques can be divided into two categories:-

a. Spatial Domain Transformation Techniques
b. Frequency Domain Transformation Techniques

C***. Spatial Transformation Techniques:***

In spatial transformation, we operate directly on pixels. We can have different types of spatial transformation techniques

a. Contrast Stretching:
b. Negative image or complimentary image transformation
c. Log and power law transformation (Non-linear transformations)
d. Linear and Piecewise-Linear Transformations
e. Gamma correction
f. Histogram Processing
g. Spatial filtering for smoothing of image involving convolution techniques

D. Contrast Stretching: Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values. For an 8 bit image, there are 256 gray levels. Level 0 or close to zero represent dark portion of the image and gray level 255 or close to it represents the bright portion of the image. The difference between maximum and minimum values of gray levels is called its dynamic range. If this dynamic range is confined to a narrow range, the contrast of the image would be low. As a result, the quality of the image would be poor and we need to increase the dynamic range. We can apply a *linear* scaling function to the image pixel values. So, contrast stretching is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values.

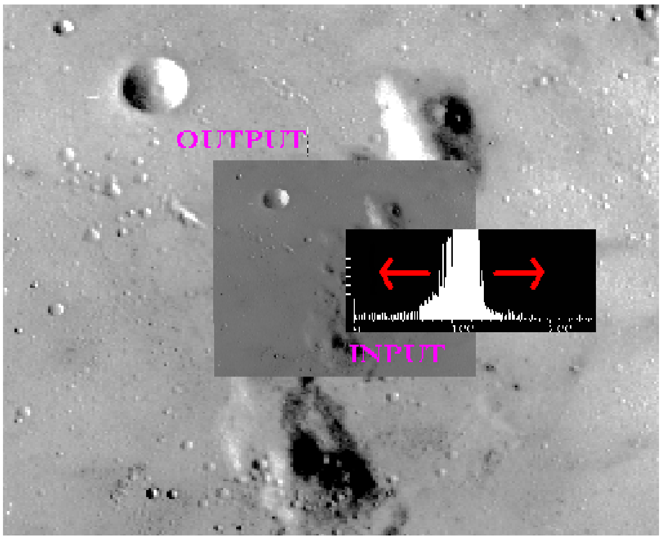


Figure 1: Contrast stretching for histogram spreading

Before the stretching can be performed, it is necessary to specify the upper and lower pixel value limits over which the image is to be normalized. For example, for 8-bit gray level images, the maximum and minimum values of gray levels would be 0 and 255. But in the actual given image, let the lower and the upper limits up to which we want to extend the contrast be, say *a*&*b* respectively.

The simplest sort of normalization then scans the image to find the lowest and highest pixel values currently present in the image. Let us call these values as *c* and *d*. Then each pixel *P* is scaled using the following function:

$$P_{out} = (P_{in} - c)\left(\frac{b-a}{d-c}\right) + a$$

Where *P* is the input pixel value and *Pout* is the output pixel values. Values below 0 are set to 0 and values above 255 are set to 255. By putting the values of *Pin* in the relation (1) we can calculate the values of *Pout* and achieve the objective of contrast extension. This is a linear extension.

E. Negative image: Sometimes negative images are required in medical investigations .These can be obtained by using the transformation s= [(L-1) –r], where the level is in the range [0, L-1]. It can be seen that every pixel value from the original image is subtracted from the figure 255. The resultant image becomes negative of the original image. Negative images are useful for enhancing white detail embedded in dark regions of an image.

F. Thresholding: Another technique is Image thresholding transformation in which we have only two values of pixels. These can be termed binary transformation as pixel values of thresh-hold images are either 0's or 1's. (0 or 255 in 8 bit gray scale)

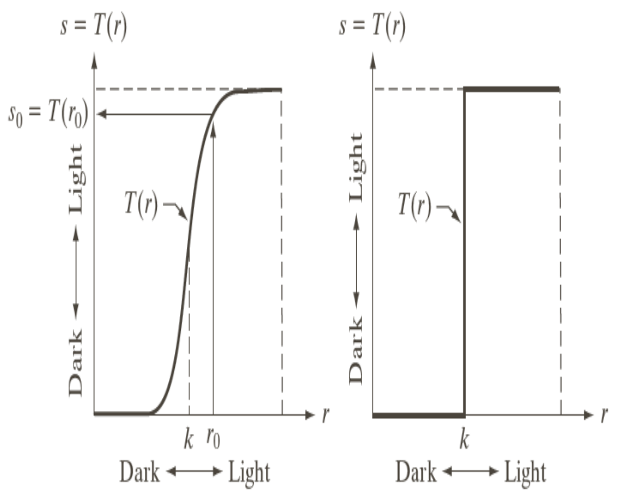


Figure 2: (a) Nonlinear-stretching (b) Image thresholding

G. Linear and Nonlinear Transformations: We can have some linear and non-linear transformations in image processing, like log transformations, power transformations, anti-log transformations, and nth root transformations. These are shown in figure below. We can adjust the transformation variables according to our requirement so as to get a good quality image.

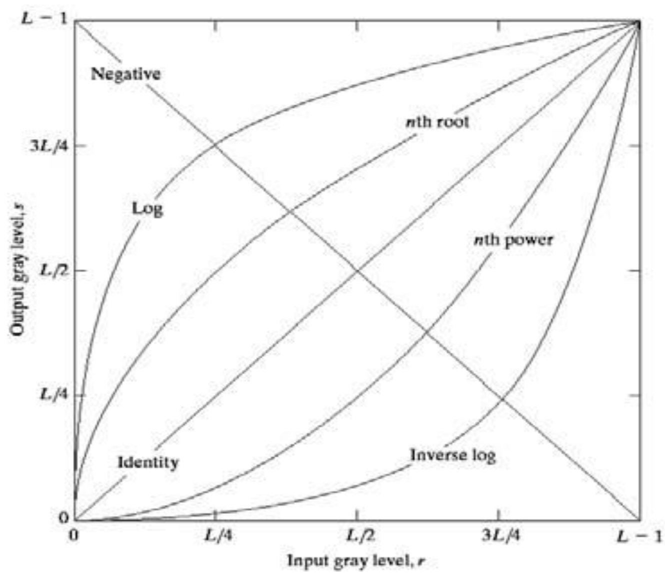


Figure 3: Log-transformation, Non-linear curves &Negative image transformation curve

H. Transformations: The general form of the log transformation is *s = c * log (1 + r).* Log functions are particularly useful when the input gray level value have an extremely large range of values, and due to which some portion of the image are washed out, so dynamic range can be compressed as per our requirement. On the other hand, when the dynamic range is limited, it can be enlarged through anti-log transformation.

I. Powers-Law Transformations & Gamma corrections: The *nth* power and *n*th root curves are shown in Figure 4. It is given by the expression, $s = cr^{r}$ where c and r are the positive constants and γ is another constant which can be suitably selected as per the requirement of the image. This transformation function is also called as *gamma* correction. For various values of γ, different levels of enhancements can be obtained. This technique is commonly called as *Gamma Correction.*

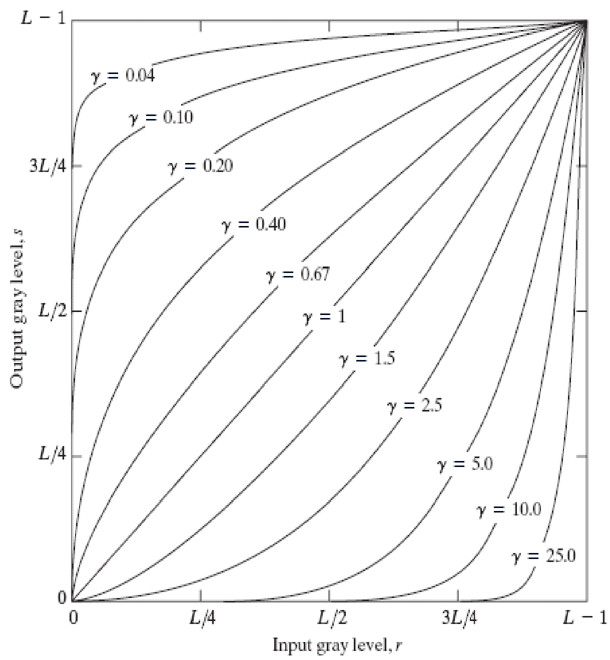


Figure 4: Curves for Gamma correction

Figure 5: Effect of contrast enhancement

We can notice that, different display monitors, display images at different intensities and clarity. That means, every monitor has built-in gamma correction in it with certain gamma ranges. A good monitor automatically corrects all the images displayed on it for the best contrast to give user the best experience.

II. HISTOGRAM EQUALIZATION

Histogram is the graph between gray levels and the number of pixels corresponding to that gray level (i.e. frequency). It can be drawn by using MATLAB program or other software programs. The main purpose of drawing histogram is to know about the dynamic range of the image so that we may device some techniques for the proper modification of its contrast**.** There are many image enhancement techniques which have been proposed and developed. One of the most popular image enhancement methods is histogram equalization (HE). H E is a popular technique for contrast enhancement because this method is simple and effective. HE technique can be applied in many fields such as in medical image processing, radar image processing, and sonar image processing. The basic idea of HE method is to re-map the gray levels of an image based on the image's gray levels cumulative density function (CDF). HE flattens and stretches the dynamic range of the resultant image. In H E, we obtain approximately a uniform probability density function (PDF). However, HE is rarely employed in consumer electronic applications such as video surveillance, digital camera, and television, since HE tends to introduce some annoying artifacts and unnatural enhancement, including intensity saturation effect. One of the reasons for this problem is that HE normally changes the brightness of the image significantly, and thus makes the output image to become saturated with very bright or dark intensity values.

In order to overcome the afore-mentioned problems, mean brightness preserving histogram equalization based techniques have been proposed in the literature. Generally, these methods separate the histogram of the input image into several sub-histograms, and the equalization is carried out independently in each of the sub-histograms. For example, brightness preserving bi-histogram equalization (BBHE) [3], divides the input histogram into two subsections based on the mean value. Later, minimum mean brightness error bi-histogram equalization (MMBEBHE [4]) has been proposed by Chen and Ramli to preserve the brightness optimally. MMBEBHE also separates the histogram into two subsections. However, MMBEBHE performs the separation based on the threshold level which would yield a minimum difference between the input mean and the outputs mean [MMBE]. Another technique is the Dualistic sub-image histogram equalization (DSIHE) [5], which has been proposed by Wang et al. [7], that also separates the input histogram into two sub sections. But separation is based on the median value. Wadud and Kabir [11] proposed a new class of histogram partitioning named as dynamic histogram equalization (DHE). The DHE partitions the original histogram based on local minima and then assigns a new dynamic range to each sub-histogram. Ibrahim and Kang [12], proposed a method which is brightness preserving dynamic histogram equalization (BPDHE) similar to DHE, which is an extension of the DHE. BPDHE applies Gaussian-smoothing filter before the histogram partitioning process is carried out. The BPDHE uses the local maxima as the separating point rather than the local minima used in DHE.

Ibrahim and Kang claimed that the local maxima are better for mean brightness preservation. Quadrants dynamic histogram equalization (QDHE) [13-14] method was proposed by Ooi and Nor for better contrast enhancement. QDHE partitions the histogram into four sub-histograms using the median value of intensity and then clips the histogram according to the mean of intensity occurrence of the input image and finally a new dynamic range is assigned to each sub-histogram before each sub histogram is equalized. Ooi and Nor [14] also proposed *Adaptive Contrast Enhancement Methods* with brightness preserving which comprised of two methods named as Dynamic Quadrants Histogram Equalization Plateau Limit (DQHEPL) and Bi-Histogram Equalization Median Plateau Limit (BHEPL-D). DQHEPL is an extension of RSIHE. It divides the histogram into four sub- histograms, and then assigns a new dynamic range and finally implements clipping process. BHEPL-D is the extension of the BHEPL except that it clips the histogram using the median of the occupied intensity. Chang and Chang [15] presented a simple approach for contrast enhancement named as Simple Histogram Modification Scheme (SHMS). This method modifies the histogram by changing the values of two boundary values of the support of the histogram. A new method named as Background Brightness Preserving Histogram Equalization (BBPHE) [16] has been proposed by Tan et.al. The partition method used by BBPHE is based on background levels and non-background levels range. After partition, each sub-image is equalized independently and then combined into the final output image. It is claimed that the background levels are only stretched within the original range. Hence the over-enhancement can be avoided by BBPHE.

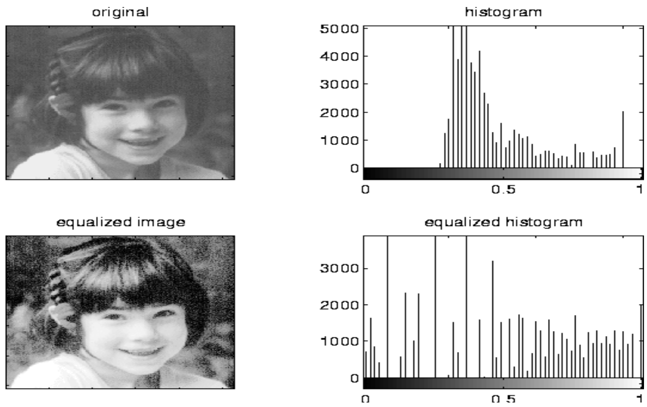


Figure 6: Original low contrast image &after HE, change in contrast

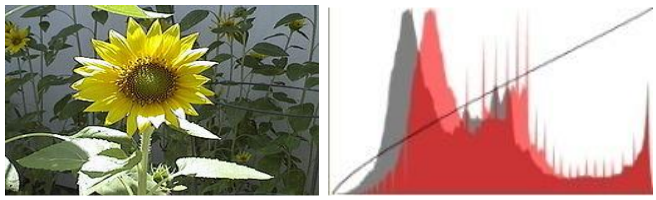


Figure 7: Illustrating the histogram of a flower

III. FREQUENCY DOMAIN METHODS

In an image, as we move from one pixel to the next, there would be a change in its gray levels. If the change is fast, the image would have more high frequency components. If there is slow variation in gray levels, the image would have more low-frequency components. So in an image, we have a band of frequency components. By using some filters, we can change some frequency components of the image as per our requirement. Image enhancement in the frequency domain is straight forward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter transfer function (rather than convolve as in the spatial domain), and take the inverse transform to produce the enhanced image

IV. PROPOSED METHOD OF IMAGE ENHANCEMENT

We obtain the histogram of the image and it is divided into two parts by taking its median. The two parts of the image histogram are then subjected to contrast stretching in the lower and upper part of the histogram by the addition and subtraction of some numbers from the upper and lower part of the histogram. For this, following steps are taken:

a. Obtain the histogram of the image
b. From the histogram, find the lower and upper limits of the gray levels
c. Let the lower limit be ‘a’ and let the upper limit be ‘b’
d. Subtract a from the median value obtained by Mat lab
e. Now add a number (255-b) in the median
f. Obtain the new histogram. There would be a gap around the median in the histogram as the gray levels have been shifted towards the lower portion and higher portion across the median
g. Now take the image histogram Equalization of the image and find the final image.

Algorithm for this is given below

a. Calculate the median of the image denoted as an intensity value $X_e$where the cumulative density function is 0.5.
b. Divide the histogram in two parts ranging from 0 to $X_e - 1$ and $X_e$to$L$; L being the highest gray level in image.
c. Subtract a number ‘a’ in each gray level in the lower histogram below the median value X_e and add a number (255-b) in upper histogram. i.e. if the dynamic range of image is $a\ to\ b$ then new range shall be 0 to 255 with a gap of [(a)+(255-b)] in the centre
d. Obtain the histogram of this image
e. Take the histogram equalization of the previous image
f. Obtain the final image.

V. RESULTS

The above technique was implemented using Mat lab on different 8 bit depth images and the processed images were obtained which are shown in the following figures i.e. in fig 8 to 13 .From the processed images we can observe that there is enough improvement in image contrast & image quality as compared to the original image. Also the results obtained from other techniques were found for comparison

Figure8: Processed images using different techniques proposed is our technical paper which reveals more fine details

Figure9: Processed images using different techniques proposed is our technical paper which reveals more fine details

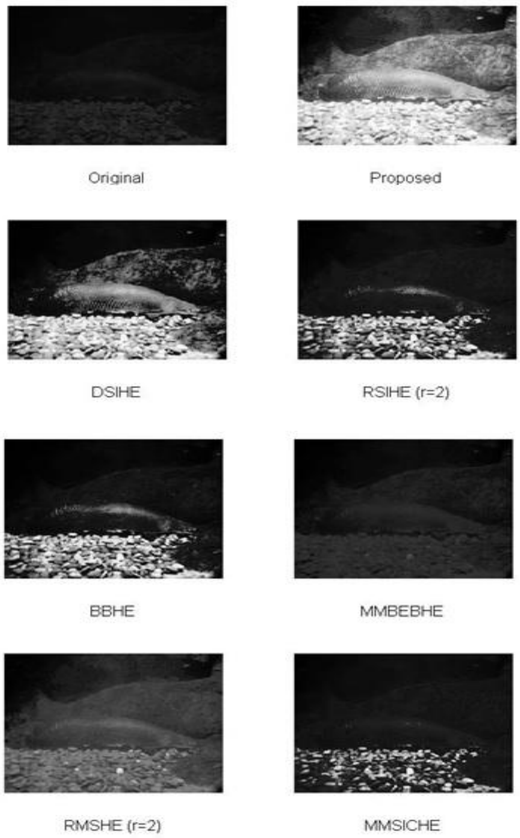


Figure10: Processed images using different techniques proposed is our technical paper which reveals more fine details

Figure 11: Processed images using different techniques proposed is our technical paper which reveals more fine details

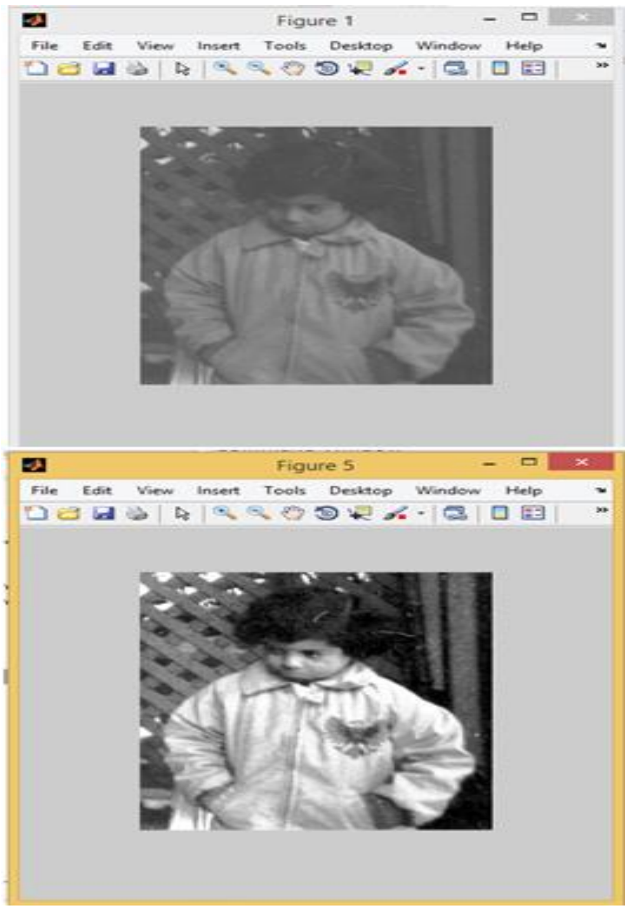


Figure12: Demonstration of original image (above) of pout.tif and after applying the proposed technique (below) to see the enhancement in image.

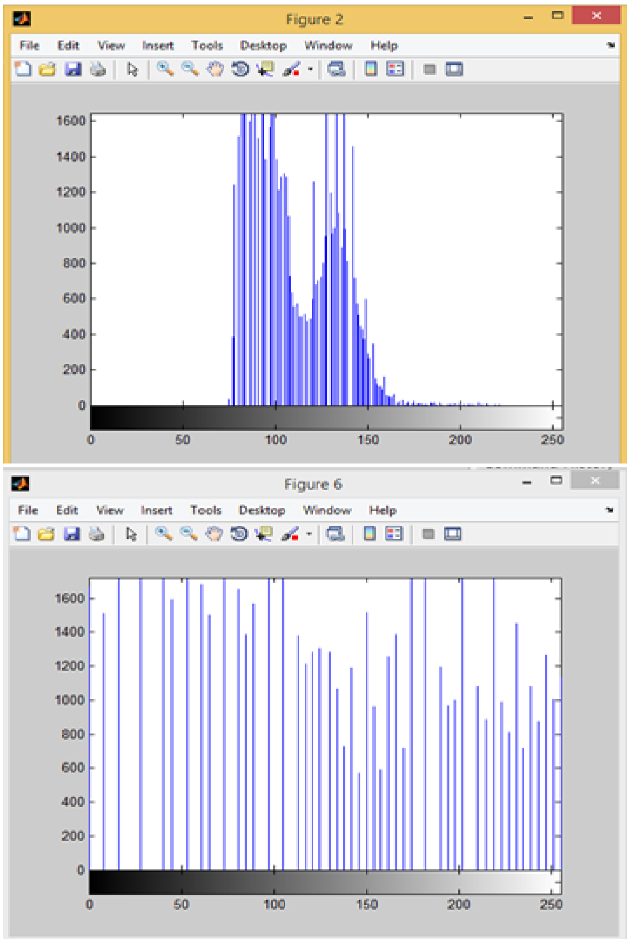


Figure13: Demonstration of the histogram for the original image (above) of pout.tif and the histogram of the enhanced image (below) from Figure 12.

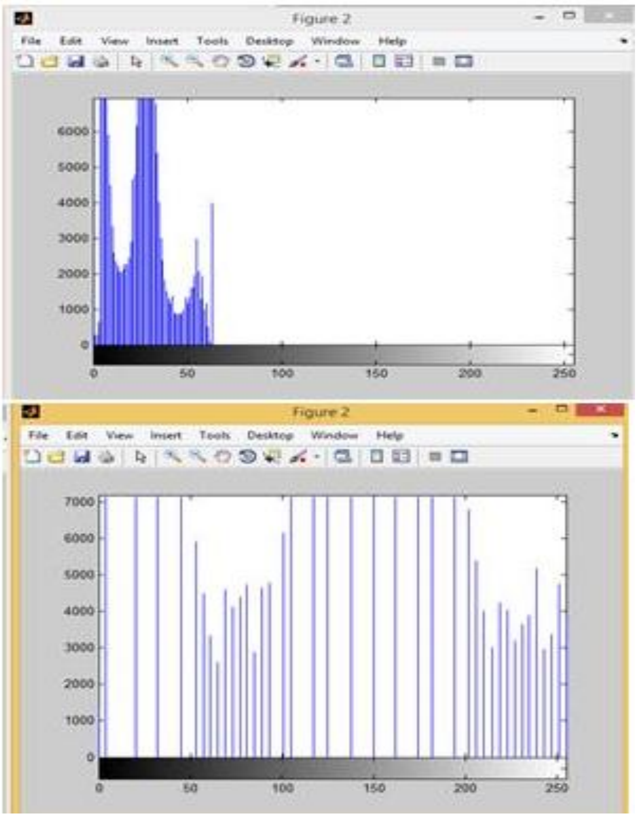
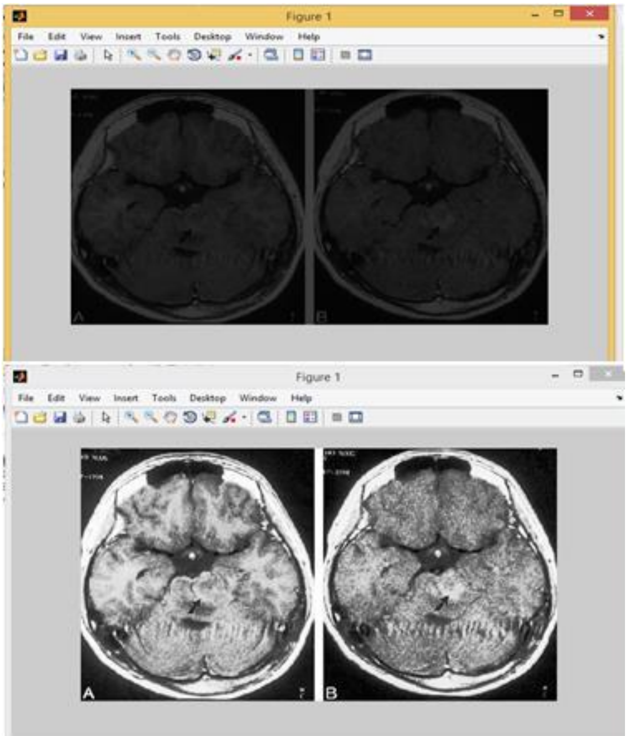


Figure 14: Original image (above) and the processed image (below) showing the enhancement in image quality achieved by applying proposed technique, and the histograms of the images respectively.



VI. CONCLUSION

The proposed technique is a simple technique involving only few steps used for the improvement in image contrast, but gives very good results in improving the quality of the image as compared to other techniques which use complicated algorithm for implementation. It is also less time consuming. In fact, in a digital image, there are so many variations and a single technique cannot produce proper enhancement of all types of images. So we may use suitable technique for different types of images and there is always enough scope for improvement in the future.

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