ISSN: 2455-1848
International Journal of Innovative Research & Growth
A Peer Reviewed & Referred International Journal
Volume-8 Issue-6 April-2019
Impact Factor-3.0
www.ijirg.com, editor@ijirg.com

A Comprehensive Review Of Image Enhancement Techniques

[1]Ankit Chourasiya, [2]Neha Khare
[1,2]Takshshila Institute of Technology Jabalpur, Madhya Pradesh, India
Email: - chourasiyaji11@gmail.com, nehakhare@takshshila.org

Abstract
Main objective of image enhancement is to process an image in order that result is more appropriate than original image for specific domain. To increasing the visual quality of image, image enhancement technique provides the large number of choices or methods. Application selection of such techniques is greatly influenced by the imaging modality, task at hand and viewing condition. This paper can give a summary of underlying ideas, together with algorithms commonly used for image enhancement. The paper focus on spatial domain method for image enhancement with explicit respect to point processing method and histogram processing method.
Keywords: - *Digital image processing, image enhancement, histogram equalization.*

1- INTRODUCTION

The aim of the image enhancement techniques is to processes the input image such a way that the output image should be more suitable then the input image for certain application. The technique use for image enhancement is depends upon the application i.e. different application uses different kind of image enhancement technique for example the technique use for image enhancement in x-ray image may not be best suitable for enhancement of microscopy images.

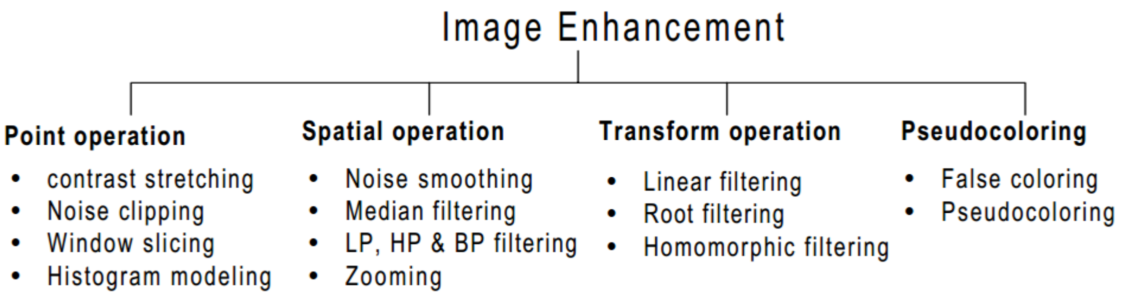

Fig.1: Different image enhancement methods

Image enhancement can be done based on two technique and they are spatial or frequency domain techniques [1][2].Let us review some of the spatial domain technique.

2- SPATIAL ENHANCEMENT METHODS

- Spatial domain operation try to directly manipulate the pixels in image plane itself or we can say that the operation which are perform directly on pixel in image is known as spatial domain filtering. Filtering is technique which can be performing in image enhancement [1].
- The operation perform by spatial domain filtering formulated as g(x,y) = T(f(x,y)), where g is the output image i.e. enhanced image, f is input or raw image and T is operation perform on the input

image f including some neighborhood (x,y).

- It has three different form namely point processing, histogram based processing and mask processing.

3- FREQUENCY DOMAIN ENHANCEMENT METHODS

In Frequency Domain operation image first converted to mathematical function and that function is Fourier transform of the input image and then all the image enhancement related operation are perform in input image then inverse Fourier transform of image is computed to obtain the desired or enhanced image [1][2].

$$g(x) = T[f(x)] \quad (1)$$

$$g(x, y) = T[f(x, y)] \quad (2)$$

So, in this case f(x,y) is original image. T is the transformation which is applied on this original image to give us the processed image g(x,y).

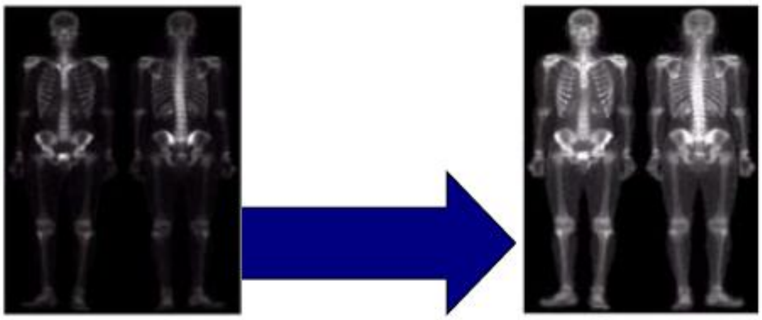

Fig.2 Example of enhancement of an image using frequency domain

Above example show the enhancement of x-ray image which is gray level image and same example is suitable for color image also. Gray image can have pixel value in the range of 0 to 255. There are many different kind of methods are available for image enhancement which improve the quality of image in some sense. In this paper basic fundamental and mathematical understanding behind the image enhancement methods have been discussed.

4- ENHANCEMENT BY POINT PROCESSING METHODS

[3] In point processing methods neighborhood is pixel itself that means size of neighborhood is 1x1. In this case transformation function directly works on the single pixel location. So it work on particular pixel location (x,y) and depending upon the value and intensity of location (x, y) it determine what will be the intensity in the corresponding location in the processed image g. so in such case transformation function of point processing operation is written as

$$S = T(r) \quad (3)$$

Where r represent pixel value of original image, S indicate the pixel value in the corresponding location in the processed image and T refers to the gray level transformation function or point processing operation.

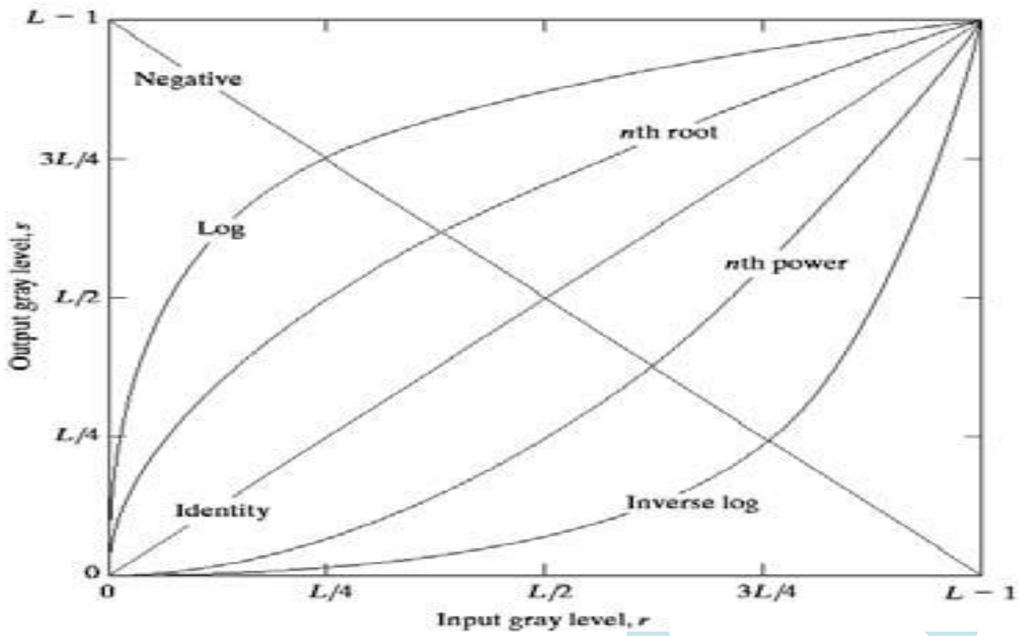

Fig.3 Basic gray level transformation

In above diagram the range of the resultant value of location is [0, L-1], where $L=2^K$, Where k is number of bet in image

A- Create Negative of an Image

The input images are containing white or gray level information embedded in many cases.[4] It is very hard to obtain the information from the very dark or black pixel where very few white or gray level information is present. So in such cases finding out the information from the raw image or input image become very difficult. In that case instead of taking raw image as a input image, it is good for taking negative of an image. Now the question is that how negative of an image is created? For creating negative of an image the all the white pixel which is present in raw or input image or the intensity value of an input image we make them darker and same thing is done with the dark intensity value by making them brighter which create the negative of the image. After creating the negative of an image, extracting information from the input image is become more convenient than the original image.[4] For performing such kind of task the transformation function needed is shown in figure .

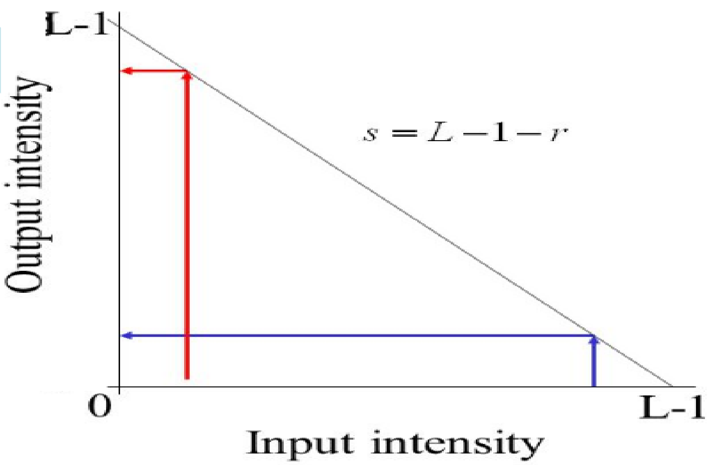

Fig.4 transformation function of negative of an image

Here L is maximum intensity value and r is the pixel value in the original image.

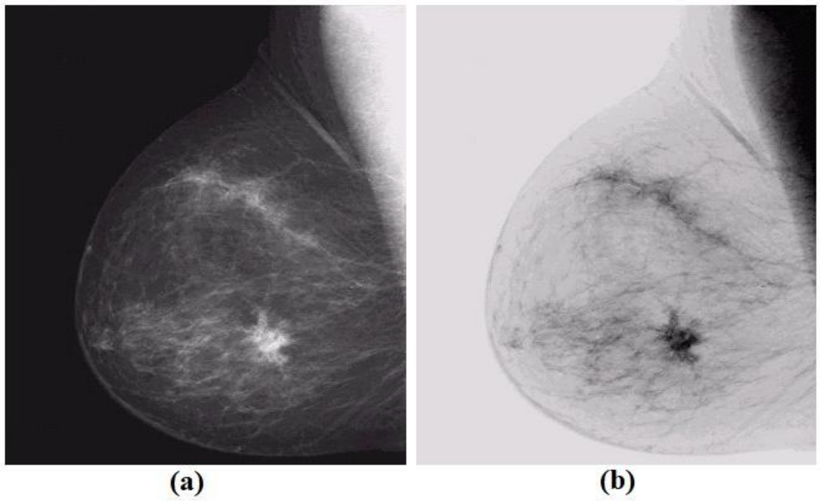

Fig.5 (a) Original mammogram image, (b) negative of an image obtain using negative transformation

B- Contrast Stretching

It improves the quality of dark image by increasing or expanding the dynamic range of an image. Some time the input image is become darker because of various factors. This factor may be illumination of object was very poor or because of dynamic range of sensor, aperture of the lens of the camera was not properly set. the transformation function of this shown below [5].

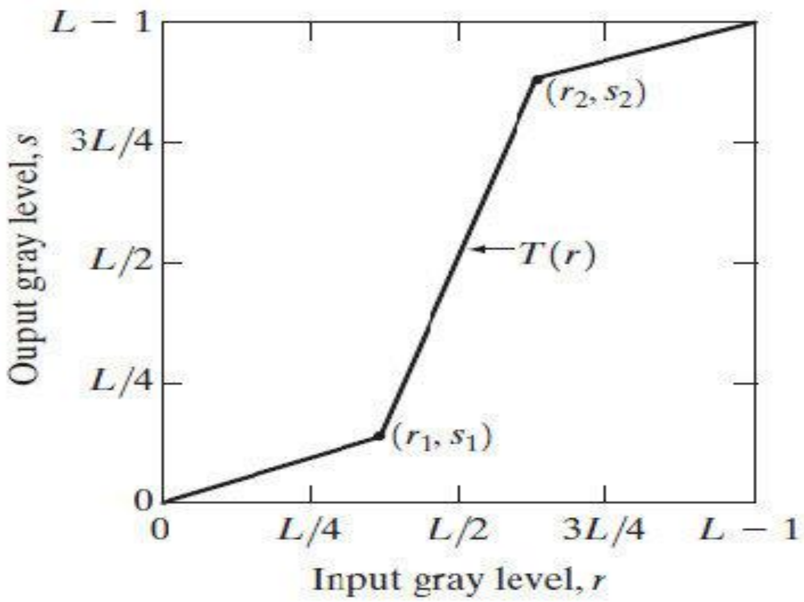

Fig.6 Transformation function of contrast stretching

Here (r1, r2) and (r2, s2) are two different point which control the shape of the transformation. If r1 = s1 and r2 = s2 the transformation function become straight line with slope equal to 45 degree.

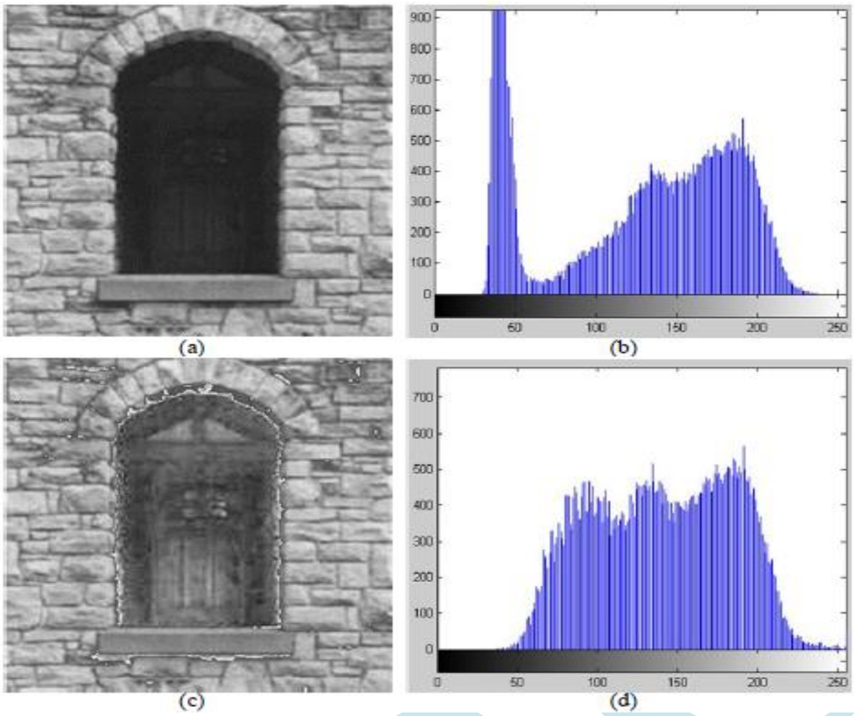

Fig.7 Example of contrast stretching (a) Original image, (b) Histogram of original image, (c) result of contrast stretching, (d) histogram of resultant image

C- Logarithmic Transformations

To perform the logarithmic transformation, first input image sho uld be converted into the gray scale image so that effect of logarithmic transformation understands. Dynamic range is difference between the high and low pixel value[6]. By applying logarithmic transformation in dynamic range the enhancement of an image is done by increasing the values of dark pixels in an input image. This is done while compressing the higher-level pixel values.

$$s = c.\log(1+r) \qquad (4)$$

The logarithmic transformation function is shown above. Where c is constant and $r \geq 0$.

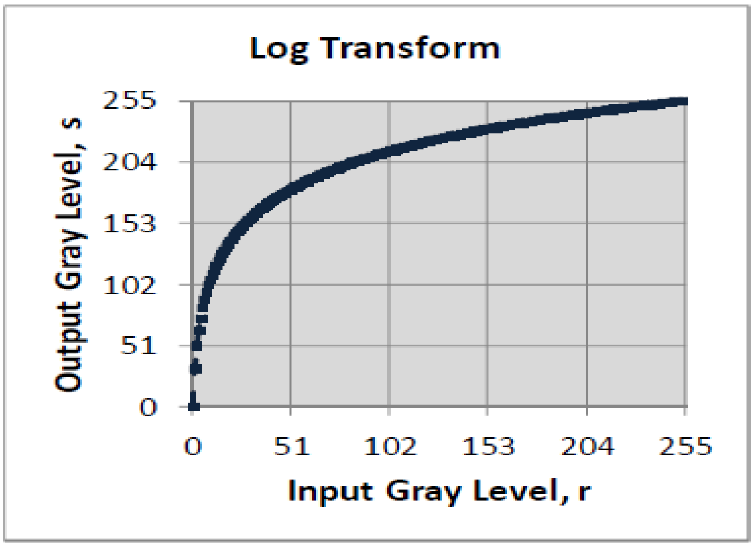

Fig.8 Form of logarithmic transformation

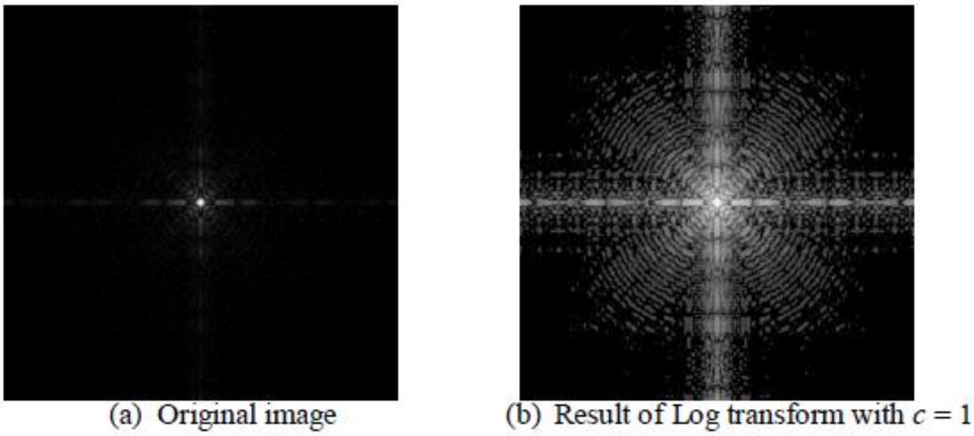

Fig.9 Applying log transformation

D- Power-law Transformation

It is used for several imaging devices. The device can be, it is used for image capturing devices, image printer, image acquisition and so on because by nature all these devices provides a power law transformation of the image that need to be produced [6]. The power law transformation function between the input image intensity values and output image intensity value is written as

$$s = T(r) = C.r^{\gamma} \qquad (5)$$

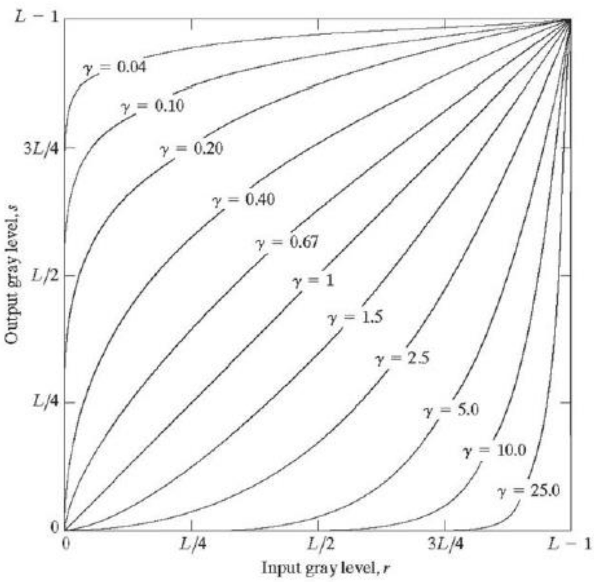

Fig.10 Form of power law transformation with various gamma values (c = 1 in all case)

The above plot represents the different value of gamma where c = 1.

There are some point which need to be focus and these point are listed below

- If the value of gamma is less than 1 the transformation function is usually lower intensity side.
- If the value of gamma is greater than 1 then the transformation function is usually higher intensity side.

It starch the dynamic range of very small intensity range in the input image whereas, for a higher intensity side, a higher range of input intensity is mapped to a lower range of intensity value in processed image and the reverse is true if the value of gamma is more than 1. For such kind of transformation exponent is refer by the symbol gamma that's why this transformation function is also called gamma correction.

[8] For understanding this concept in more detail, here is the explanation of image

display device (CRT Monitor) to know how gamma correction is work. The image which is display in the CRT is darker than the original image. So in that case some kinds of correction measurements are perform before displaying the image to CRT, so that input image display properly and the correction which here is going to perform is nothing but gamma correction. The same kind of power law transformation can also be apply for image enhancement also. Below are the image which so the gamma correction perform on it with different value of gamma.

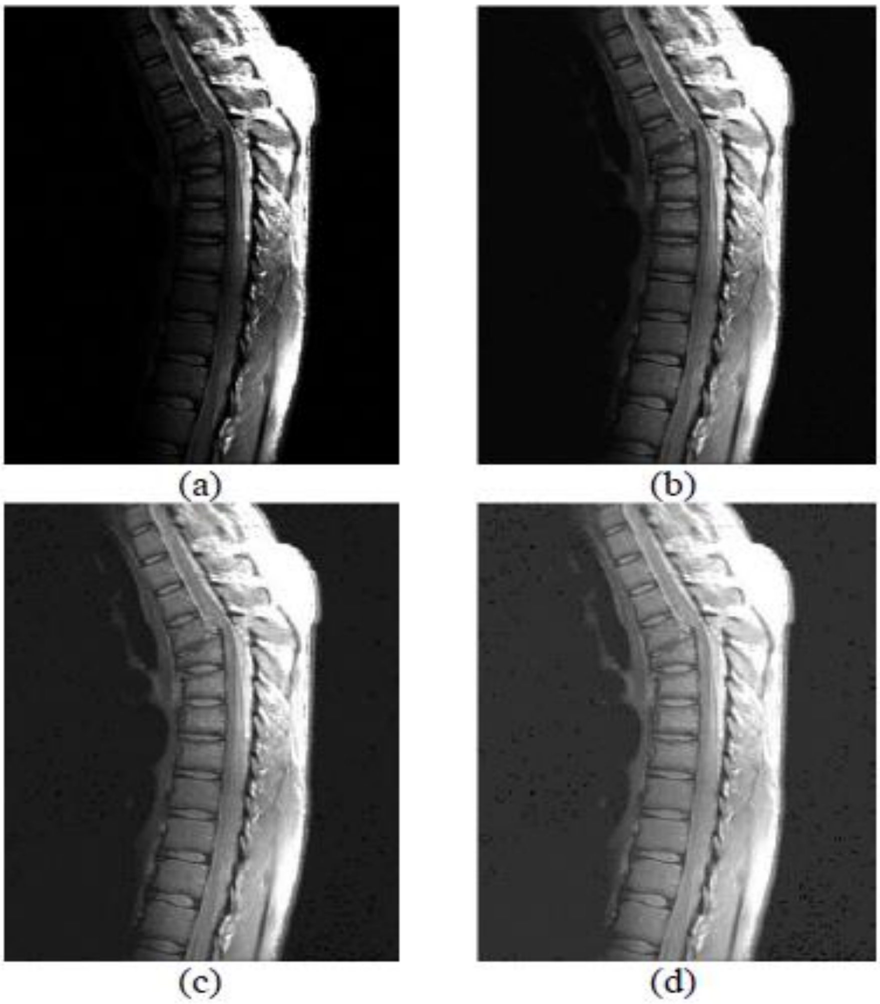

Fig.11 (a) Original MRI image of human spine. (b)-(d) result of applying power law transformation with c=1 and y = 0.6, 0.4 and 0.3 respectively

By using different value of gamma different power law transformation can be perform on the in same image that means image enhancement in our control. By increasing the value of gamma image become more and more dark.

E- Gray Level Slicing

In some cases application domain may not interested in highlighting the all intensity level of input image. It may interested in highlighting the certain intensity level of an image so in such cases gray level slicing is going to use. It enhances the specific feature of image [6].

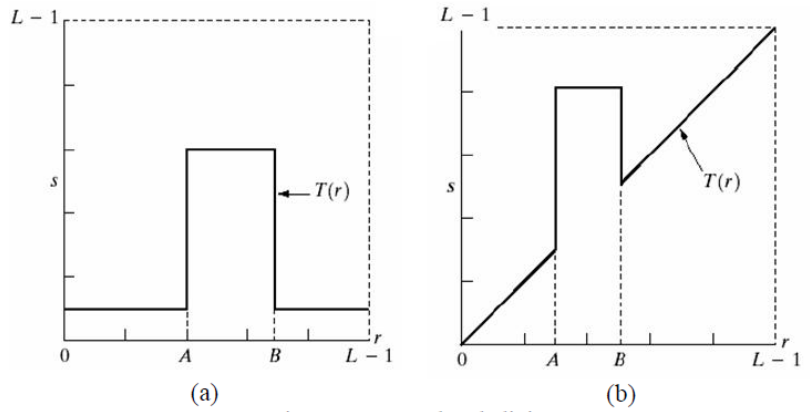

Fig.12 transformation function (a) highlight the intensity range [A, B] set all other intensity values to 0. (b) Highlight intensity range [A, B] and not change other intensity values.

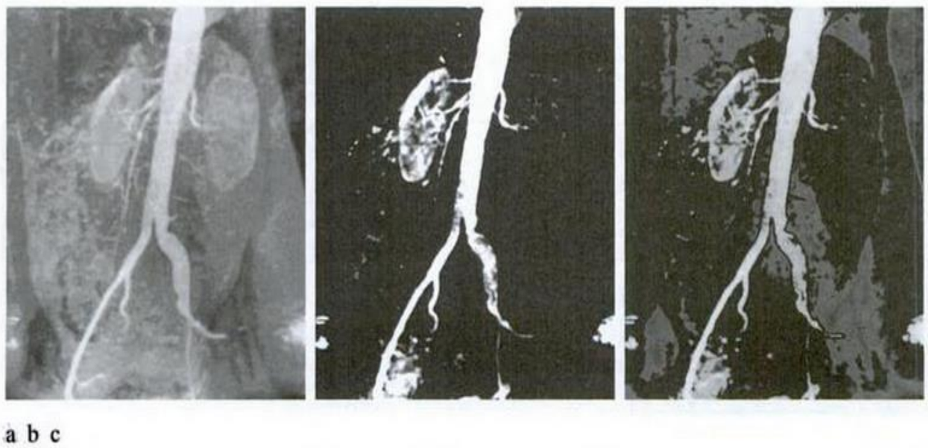

Fig.13 (a) is original image and (b) and (c) are the output image which we get after applying the above transformation function on original image

5- HISTOGRAM PROCESSING

The aim of histogram to provide the global description of an image. Histogram is discrete function with gray levels in the range of [0, L-1]. The function is represented as:

$$h(r_k) = n_k$$

k^{th} intensity value — Number of pixels in the image with intensity r_k

So, the number of pixel having an intensity value r_K and if these value are plotted, the number of pixel having different intensity value against the intensity value of those pixels then the plot that be get is known as histogram [7]. Here considered image is discrete so the function $h(r_k)$ is also be the discrete function and r_k is a discrete intensity levels. The normalized histogram represented as

$$p(r_k) = \frac{n_k}{MN}, \quad k = 0,1,\ldots L-1 \qquad (6)$$

As before, n_k is the number of pixels having intensity value r_k and here M×N refer to the total number of pixel in digital image and image is the collection of pixels. $p(r_k)$ is the probability of occurrence of a pixels having intensity value equal to r_k. The global description of the image is given by such type of histogram.

Most of the histogram based image enhancement techniques they try to improve the contrast of the image wither it is histogram equalization or the histogram modification techniques.

A- Histogram Equalization (HE)

Here the assumption is the transformation function are in the form of $s = T(r)$ where r is the intensity value in the orignal image and s is intensity in a processed image[7]. Here transformstion has to satisfied two condition which are:

1. T(r) must be singled value and monotonically incresing in the range of $0 \leq r \leq 1$ with in gary scale. It maintain the order of the gray levels in the processed image.
2. T(r) must be satisfied $0 \leq T(r) \leq 1$ for $0 \leq r \leq 1$, it ensure that the intensity value in the processed image should be in the range.

If these condition are satisfied by T(r) then $r = T^{-1}(s)$ also satisfied these two condition. Now how histogram help to get this transfromation function.

Now ,

$P_r(r)$ is probability density function (PDF) of r

$P_s(s)$ is probability density function (PDF) of s

Now from the elementry probability theory if $P_r(r)$ and T(r) are known and $T^{-1}(s)$ satisfied above two condition then PDF of s is can writen as

$$Ps(s) = \Pr(r)\frac{dr}{ds}\bigg|_{r=T^{-1}(s)} \qquad (7)$$

All the histogram processing techniques try to modify the PDF $P_s(s)$ so that the image gets the particular appearance is obtain by the transformation function T(r).

$$s = T(r) = \int_0^r \Pr(w)dw \qquad (8)$$

So, the integral gives the cumulative distribution function of variable r. if T(r) in this particular form then it definaty satisfied the all the conditions. From this compute $\frac{ds}{dr} = \Pr(r)$ by substitution.

$$P_s(s) = P_r(r)\left|\frac{dr}{ds}\right|$$

$$= P_r(r).\frac{1}{\Pr(r)}$$

$$=1$$

So find that this transformation function is nothing but commulative distributed function of r. then using T the transfrom that. Image generated by this transformation function has uniform density function of the intensity value s. whatever discussion done now it is with respect to continueous domain but the image which are going to be input is digital image and idigital image are discrete in nature. So for this discrete formulation of all this procedure the comulative distributed function (CDF) is

$$\Pr(r_k) = \frac{n_k}{MN} \qquad (9)$$

And

$$s_k = T(r_k) = \sum_{j=1}^{k}\frac{n_j}{MN} \qquad (10)$$

Where k varies in the range form 0 to L-1. After perfoming this transformation function the operation is an histogram equalization. It basically give the transform image where the intensity value have unform distribution and because of this the processed image that appear is high contrast image.

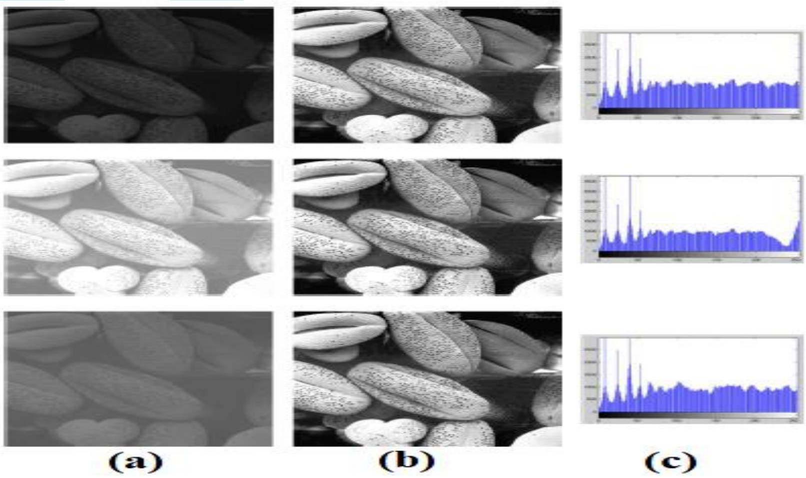

Fig.14 Example of histogram equalization (a)Original images (b) histogram equalization of original image (c) histogram of an image in (b)

B- Limitation of Histogram Equalization

The image which produced by after histogram equalization is fixed that means further operation on processed image or output image cannot be possible. Suppose application required to perform on processed image and try to manipulate the specific feature of an image is not possible. So histogram equalization processed generate only single processed image. Now to overcome this technique that use is known as histogram matching or target histogram [7].

6- ADAPTIVE HISTOGRAM EQUALIZATION (AHE)

Adaptive histogram equalization (AHE) give more power to image enhancement as compare to histogram equalization [8]. It is used to improve contrast in the images. Using adaptive method several histogram of an input image is computed by AHE and each histogram which is computed is coincide to a different area of the image and the computed histogram is used for redistribution them to estimating of the image. It is suitable for enhancing the nearby complexity and not only improving the contrast it also enhance the each region of an image.

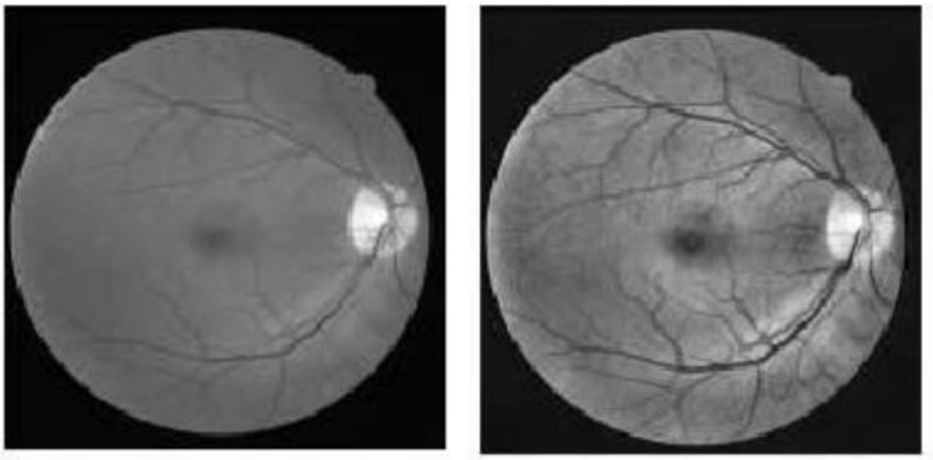

Fig.15 Example of AHE (left side original image and right AHE image)

A- Properties of AHE

The parameter of this image enhancement technique is shape of the precincts regions. It composes the trait length scale. In this technique contrast at miniature scale is enhanced, while the contrast of major or bigger scale is down.

The resultant value of picture element of image under AHE is well-proportional to its rank among the picture element in its neighborhood this is because of histogram equalization. So this allows a dexterous implementation on pro hardware that performs the comparison of central picture element to all other picture element in its neighborhoods. An unnormalized output value figured by adding 2 for each picture element with lower value then the center picture element and add 1for same picture element with same value.

7- HISTOGRAM MATCHING

[9] Assume $P_r(r)$ is the histogram of given image and $P_z(z)$ is the targeted histogram. Where r refer continuous gray level in input image and z represent the intensity value in a processed image and they are specified as a probability distributed function. Now by equalizing the input image using transformation function

$$S=T(r)=\int_0^r Pr(w)\, dw \qquad (11)$$

Now using $P_z(z)$ computing the transformation function G(z)

$$G(z)=\int_0^z Pz(t)\, dt \qquad (12)$$

By using equation (5) and (6)

$G(z) = T(r) = S$

$Z = G^{-1}(s) = G^{-1}[T(r)]$

So the operation that perform here is firstly equalize the given image using the histogram equalization and then find out the transformation function G (z) form the target histogram that has been specified and the perform the inverse transform of equalize image using inverse transformation on G. after all such operation the resultant image that produce is likely to have an histogram which is given by $P_z(z)$. Again all this operation are related to the continuous domain, so let's formulate all this to discrete domain.

$S_k = T(r_k) = \sum_{i=0}^{k} \frac{n}{MN}$ (13)

$V_k = G(Z_k) = \sum_{i=0}^{k} pz(zi) = S_k$

Where k = 0,1,…..L-1

$Z_k = G^{-1}\,[T(r_k)]$ (14)

So this is the discrete formulation of continuous domain.

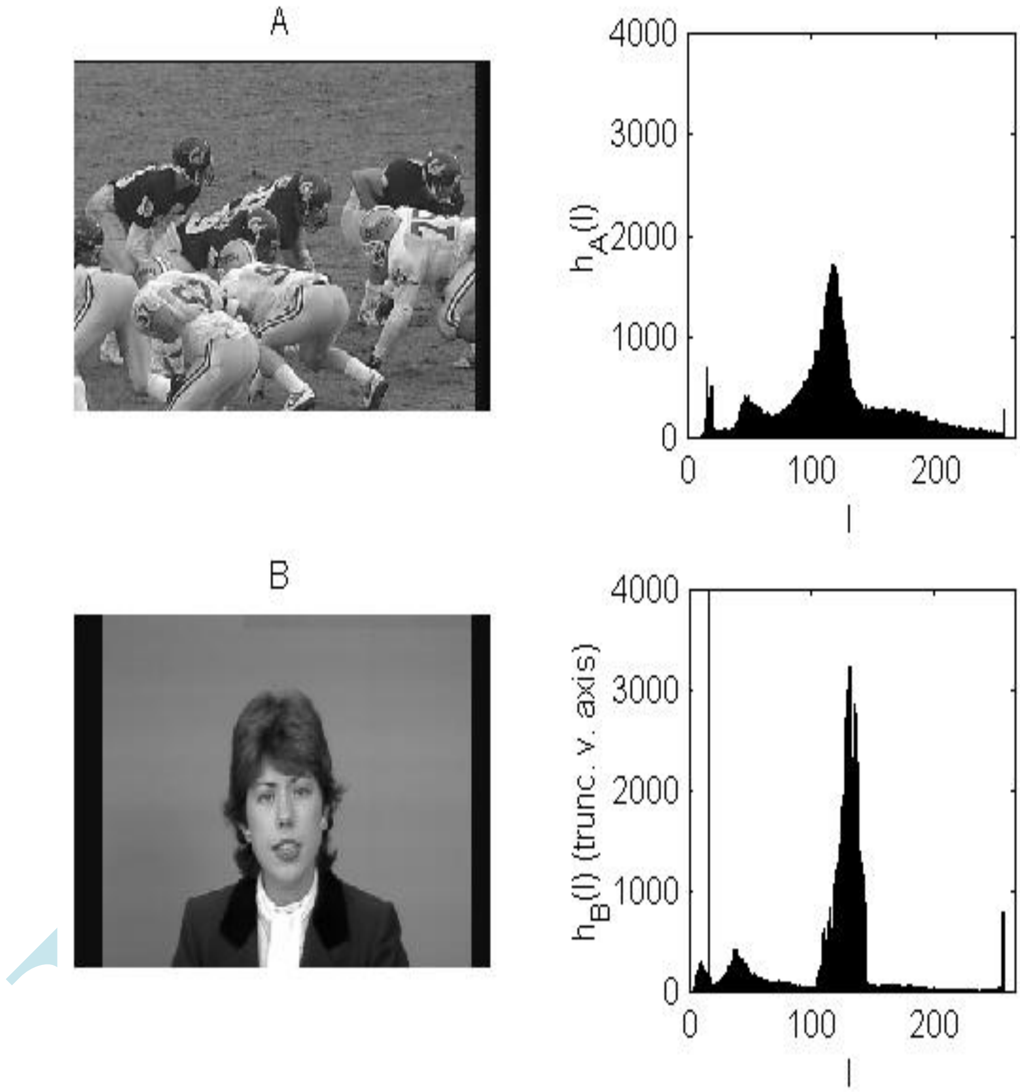

Fig.16 Example of histogram matching of different image

8- CONCLUSION

This paper provides the review of various image enhancement methods that used in the various domains. After investigation various technique it is observe that image enhancement technique offer a wide assortment of methodologies for changing image to accomplish outwardly worthy image. The decision of such procedure is an element of the particular undertaking, image content, spectator qualities, and review conditions. The point processing techniques are most crude, yet fundamental image processing tasks and are utilized fundamentally for complexity improvement. Image negative is appropriate for upgrading white detail implanted in dim or dark areas and has application in medicinal imaging. Power-law transformations are helpful for general purpose contrast manipulation. For a dull image, a development of gray level is cultivated utilizing a power-law transformation with a fractional exponent. Log transformation is useful for improving detail in dim or dark regions of the image at the expense of detail in the brighter regions the higher-level values. For a image having a washed-out appearance, a pressure of gray levels is acquired utilizing a power-law change with γ more prominent than 1. The histogram of image (i.e. a plot of gray level frequencies) gives imperative data with respect to the contrast of a image. Histogram equalization is a transformation that stretches the contrast by redistributing the gray-level values uniformly. Only the global histogram equalization can be done completely automatically.

9- REFERENCES

i. A.C. Bovik, Digital Image Processing Course Notes, Dept. of Electrical Engineering, U. of Texas at Austin, 1995
ii. B. Chanda and D.D. Majumder, 2002, Digital Image Processing and Analysis.
iii. R.W.Jr. Weeks,(1996). Fundamental of Electronic Image Processing. Bellingham: SPIE Press
iv. A. K. Jain, Fundamentals of Digital Image Processing. Englewood Cliffs, NJ: Prentice Hall, 1989.
v. https://staff.fnwi.uva.nl/r.vandenboomgaard/IPCV20162017/LectureNotes/IP/PointOperators/ImageStretching.html Accessed on January 20, 2019
vi. http://uotechnology.edu.iq/ce/lecture%202013n/4th%20Image%20Processing%20_Lectures/DIP_Lecture4.pdf
vii. https://in.mathworks.com/help/images/histogram-equalization.html Accessed on February 11, 2019
viii. https://en.wikipedia.org/wiki/Adaptive_histogram_equalization Accessed on February 11, 2019
ix. J.C. Russ, the Image Processing Handbook, CRC Press, Boca Raton, FL., 1992.