

# Different techniques of gray level transformation for image enhancement

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**Abstract** - In this paper we are analyzing different Gary level transformation techniques for image enhancement, enhancing an image provides the better quality if image as compare to non enhanced image. Image enhancement is used to enhance medical images, images captured in remote sensing, images from satellite etc. We discuss here some basic transformation techniques of gray level images. In this paper we are discussed about the techniques like negative transformation, contrast stretching, exponential transformation, power law transformation and gray level slicing

**Keywords** — contrast stretching, exponential transformation, gamma correction, gray level slicing, gray level transformation, histogram, log transformation, negative transformation, power law transformation.

## I. IMAGE REPRESENTATION

It is the mathematical analysis of the image as the image are of various type like Black and white image, Gray scale image ,color image, indexed color image, compressed image etc. To represent the image we consider the mathematical characterization in that basic two types are as deterministic image representation & statistical image representation. Mostly the image represent in two dimensional system is nothing but mapping of input set of two-dimensional functions  $F1(x, y), F2(x, y), \dots, Fn(x, y)$  to set the output two-dimensional functions  $G1(x, y), G2(x, y), \dots, GM(x, y)$  where  $(-\infty < x, y < \infty)$ . Now we have use the operators  $Om\{\}$  for  $m=1,2,3, \dots, M$ , which relate the input to output set of functions by the set of equations

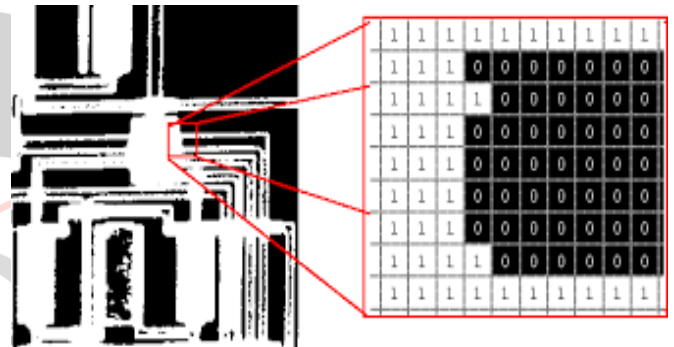
$$\begin{cases} G1(x, y) = O1\{F1(x, y), F2(x, y) \dots FN(x, y)\} \\ \vdots \\ Gm(x, y) = Om\{F1(x, y), F2(x, y) \dots FN(x, y)\} \\ \vdots \\ GM(x, y) = OM\{F1(x, y), F2(x, y) \dots FN(x, y)\} \end{cases}$$

The one to one mapping is defined as  $G(x,y)=O\{F(x,y)\}$

## II. BASIC TYPES OF IMAGE

### a. Binary Image

The binary image of having only two values 0 and 1 it also called 1 bit image it takes only 1 binary digit to represent a pixel[1].



**Fig1: Binary Image**

**b. Gray scale image-** it also called as monochrome image, normally it contains 8 bit/pixel data , which as 256 different gray levels. Gray scale images are widely used in medical & astronomy applications.



**Fig 2: Gray Scale image**

**c. Color image-** It contains the different colors of spectrum like RGB generally it is of 8bit/pixel,24bit/pixel. There are numerous applications of a measure for gray scale image. A

useful applications we can compare the different gray level transformation for the image enhancement.



Fig. 3 Color image

#### IV. GRAY LEVEL IMAGE

The basic idea for presenting a gray level image is let  $A=\{a_{ij}\}$  be an image, where  $a_{ij}$  is the gray value of the pixel with coordinates  $(i,j)$  in the range  $[0, \dots, \dots, N_g]$  and  $1 \leq i$  (and  $j$ )  $\leq N$ . We have a binary image if  $N_g$  greater than 1.

The image contains only black, white and gray colors in which gray has multiple levels. grayscale means that the value of each pixel represents only the intensity information of the light. Such images typically display only the darkest black to the brightest white.

In grayscale images, the value of each pixel is related to the number of bits of data used to represent the pixel. The value of the gray image is usually represented by 8 bits, that is, the combination of eight binary numbers represents the pixel value of a pixel. Therefore, the value range of pixels of 0-255(00000000-11111111), with a total of 256 grayscale levels. If a 16 bit number is used to represent the pixel value of a pixel, the value range will be 0---65,535 with a total of 65536 grayscale levels[6][7].

#### Why gray level images are the most preferred image type?

Gray level image is a one layer image from 0-255 where as RGB have 3 different layer image. Color increases the complexity of the model one may want to introduce an image processing tool using gray level images as opposed to color, not because of the "format" of gray level images, but because the inherent complexity of gray level images is lower than that of color image. We can analyze the image with the means of its contrast, edges, shapes, counters, texture, perspective, brightness, and shadows and so on, without addressing the color. After presenting a gray level image model/method, in most cases it can be afterwards be extended to color images.

The gray scale images are preferred over colored ones to simplify mathematics. It is relatively easier to deal with (in terms of mathematics) a single color channel (shades of white/black) than multiple color channels. For simple denoising application of a color image it means you will need to denoise every channel, color in many cases are meant for visual appeal of humans, but image processing deals with applications where machines are the main subject like in computer vision. An application like object detection would barely require information at the edges of an image, which can as well be obtained in gray scale image.

In addition, grayscale images are entirely sufficient for many tasks and so there is no need to use more complicated and harder-to-process color images.

#### V. HISTOGRAM

A histogram is the estimation of the probability distribution of a particular type of data. An image histogram is a type of histogram which offers a graphical representation of the tonal distribution of the gray values in a digital image. By viewing the image's histogram, we can analyze the frequency of appearance of the different gray levels contained in the image.

In Figure 4 we can see an image and its histogram. The histogram shows us that the image contains only a fraction of the total range of gray levels. In this case there are 256 gray levels and the image only has values between approximately 25-150. Therefore this image has low contrast. In image histogram, the x axis shows the gray level intensities and the y axis shows the frequency of these intensities[4][5].

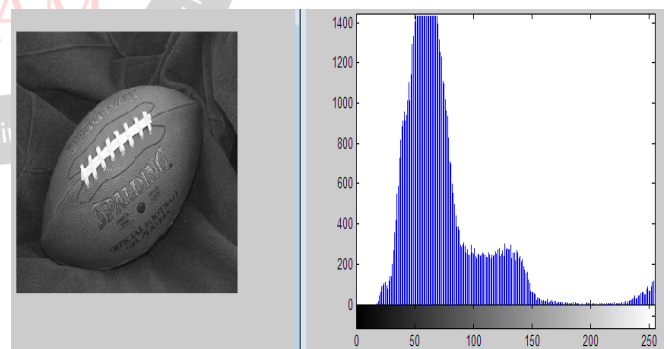


Fig.4 An image and its histogram

Histogram equalization is a straightforward image-processing technique often used to achieve better quality images in black and white color scales in medical applications such as digital X-rays, MRIs, and CT scans. All these images require high definition and contrast of colors to determine the pathology that is being observed and reach a diagnosis. However, in some type of images histogram equalization can show noise hidden in the image after the processing is done. This is why it is often used with other imaging processing techniques.

Histogram equalization is used for equalizing all the pixel value of an image. Transformation is done in such a way that uniform flat end histogram is produced. Histogram equalization increases the dynamic range of pixel values and makes an equal count of pixels at each level which produce a flat histogram with high contrast image[9].

## VI. GRAY LEVEL TRANSFORMATION TECHNIQUES

- a. Negative Transformation
- b. Contrast stretching
- c. Log transformation
- d. Exponential transformation
- e. Power law transformation
- f. Gray level Slicing

### a. Negative Transformation

The negative of an image is achieved by replacing the intensity 'i' in the original image by 'i-1', i.e. the darkest pixels will become the brightest and the brightest pixels will become the darkest. Image negative is produced by subtracting each pixel from the maximum intensity value. For example in an 8-bit grayscale image, the max intensity value is 255, thus each pixel is subtracted from 255 to produce the output image. The transformation function used in image negative is :

$$s = T(r) = (L - 1) - r$$

Where L - 1 is the max intensity value, s is the output pixel value and r is the input pixel value

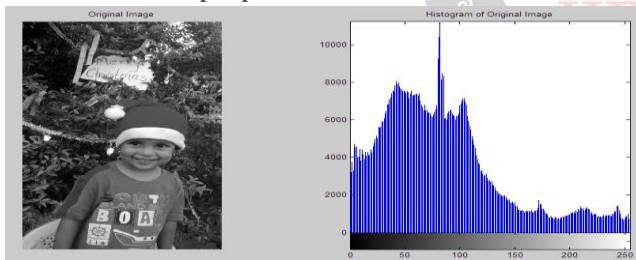


Fig.5 Original image and its histogram

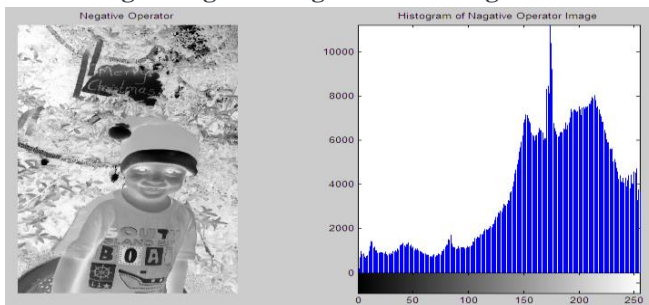


Fig.6 Image after Negative transformation and its histogram

### b. Contrast Stretching

Contrast stretching is also known as normalization. It is a simple image enhancement technique. The quality of image

is enhanced by stretching the range of intensity values[2]. If the minimum intensity value( $r_{min}$ ) present in the image is 100 then it is stretched to the possible minimum intensity value 0. Likewise, if the maximum intensity value( $r_{max}$ ) is less than the possible maximum intensity value 255 then it is stretched out to 255. (0-255 is taken as standard minimum and maximum intensity values for 8-bit images) General

Formula for Contrast Stretching:  $S = (r - r_{min}) \frac{(I_{max} - I_{min})}{(r_{max} - r_{min})} + r_{min}$

For  $I_{min} = 0$  and  $I_{max} = 255$  (for standard 8-bit grayscale image)

$$S = 255 \frac{(r - r_{min})}{(r_{max} - r_{min})}$$

where, r = current pixel intensity value

$r_{min}$  = minimum intensity value present in the whole image

$r_{max}$  = maximum intensity value present in the whole image

Using the Matlab code we are getting the contrast stretching with the threshold values like 10,20 and slope like 0.5,0.9,1.5 and another example of contrast stretching with the threshold values like 50,20 and slope like 0.6,1.5,3.5, so we can see the difference between these two outputs of contrast stretching as well as we can compare it with original image[3].

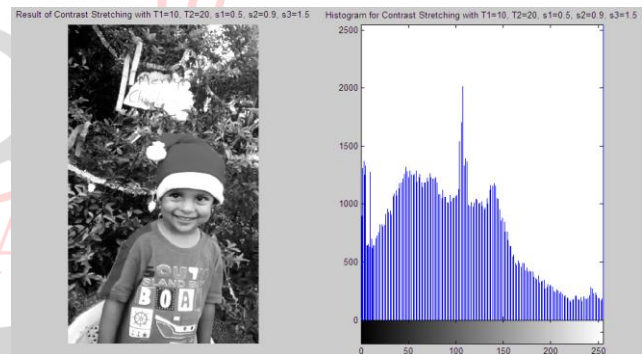


Fig. 7 Result1 for contrast stretching

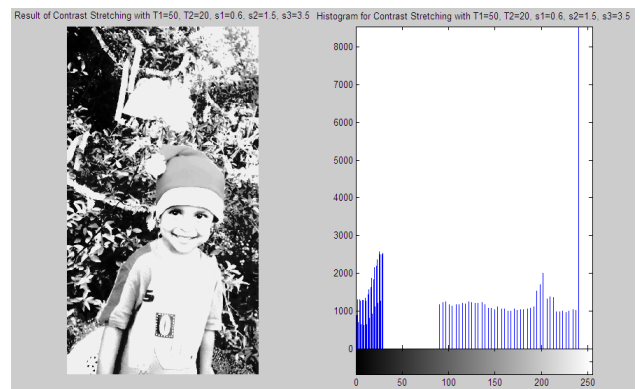


Fig.8 Result 2 for contrast stretching

### c. Logarithmic Transformation

It is mathematically defined as,  $S=C \log(1+r)$  where C is any constant and r, s are input and output pixel values. LOG

transform enhances small magnitude input values into wider range of output pixel values and compresses large magnitude input values into narrow range of output values. It is useful to display Fourier Transformed images, the drawback for this transform is that the transformation function is fixed and cannot be changed as per requirement. During log transformation, the dark pixels in an image are expanded as compare to the higher pixel values. The higher pixel values are kind of compressed in log transformation.

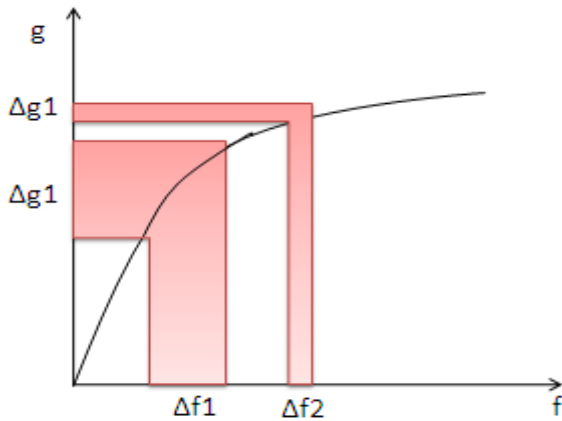


Fig.9 Graphical representation of Logarithmic Transformation

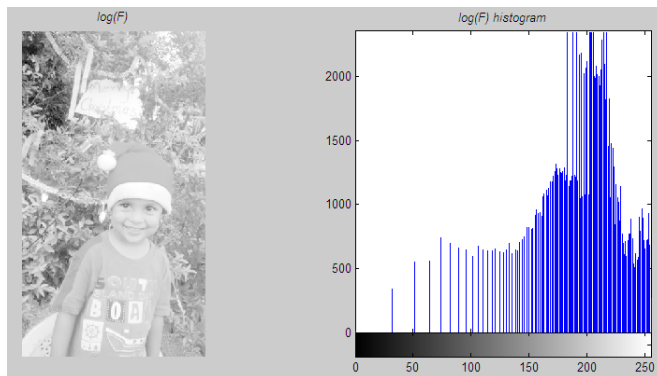


Fig10. Image and its histogram after logarithmic transformation

**d.Exponential transformation**

The exponential transform is the inverse of the logarithmic transform. Here, the mapping function is defined by the given base e raised to the power of the input pixel value

$$I_{outout}(i, j) = e^{I_{input}(i, j)}$$

Where I(i,j) is the value of a pixel at a location (i,j) in image I. This transform enhances detail in high value regions of the image (bright) whilst decreasing the dynamic range in low value regions (dark) - the opposite effect to the logarithmic transform. The choice of base depends on the level of dynamic range compression required. In general, base numbers just above 1 are suitable for photographic image enhancement.

$$I_{outout}(i, j) = c[(1 + \alpha)^{I_{input}(i, j)} - 1]$$

Here  $(1 + \alpha)$  is the base and c is the scaling factor required to ensure the output lies in an appropriate range. As is apparent when  $I_{outout}(i, j) = 0$ , this results in  $I_{outout}(i, j) = c$  unless we add in the -1 to counter this potential offset appearing in the output image[8].

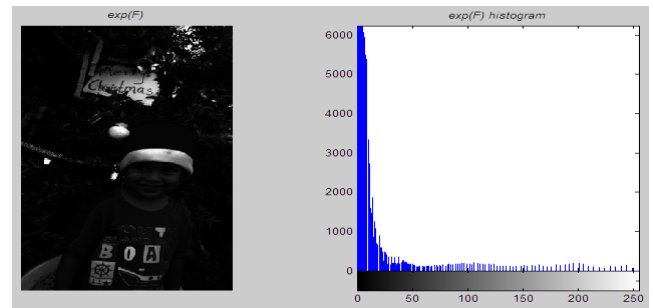


Fig.11 exponential transformation of image

**e. Power Law Transformation**

**Concept of Gamma correction**

There are two transformation is in power law transformations, that include nth power and nth root transformation. These transformations can be given by the expression  $S = Cr^\gamma$  this symbol  $\gamma$  is called gamma, due to which this transformation is also known as gamma transformation. Variation in the value of  $\gamma$  varies the enhancement of the images. Different display devices/monitors have their own gamma correction, that's why they display their image at different intensity, where c and g are positive constants. In Fig that curves generated with values of  $\gamma > 1$  have exactly the opposite effect as those generated with values of  $\gamma < 1$

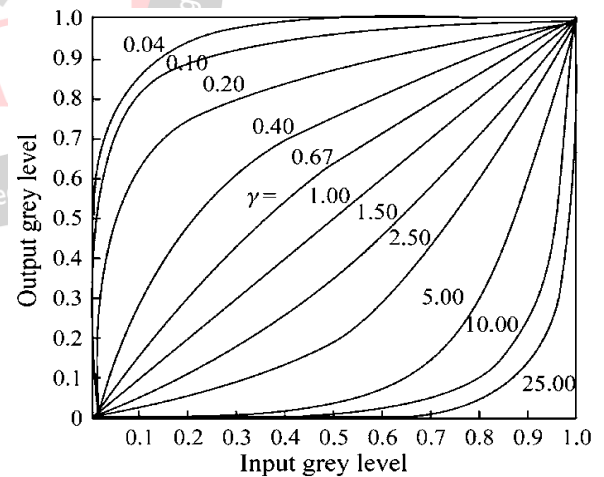


Fig.12 Plot of the equation  $S = Cr^\gamma$  for various values of  $\gamma$

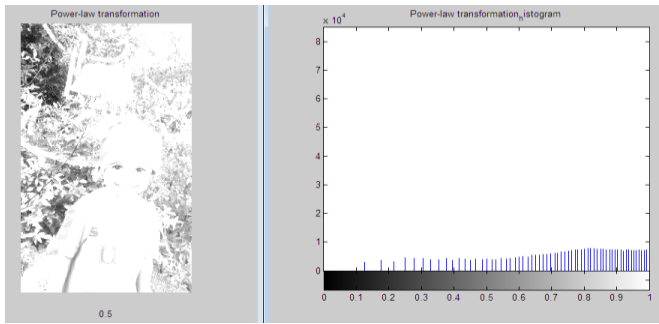


Fig.13 Power law transformation result with  $\gamma=0.5$

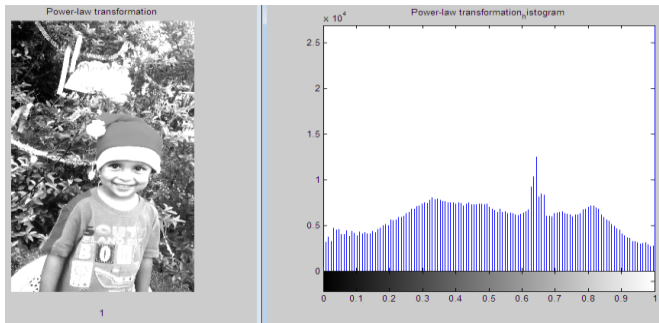


Fig.14 Power law transformation result with  $\gamma=1$

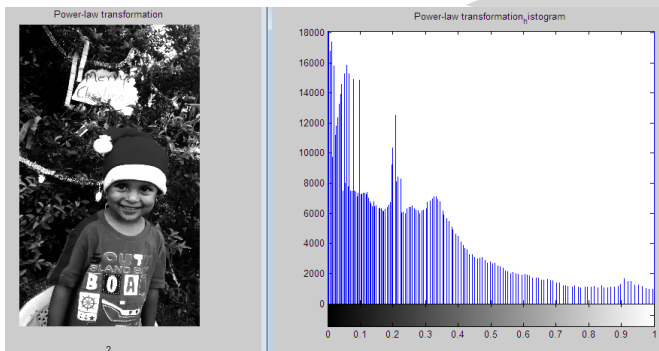


Fig.15 Power law transformation result with  $\gamma=2$

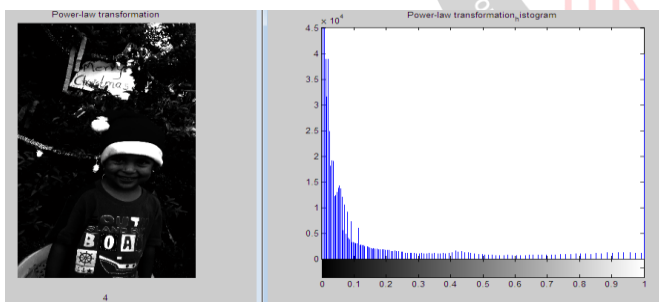


Fig.16 Power law transformation result with  $\gamma=4$

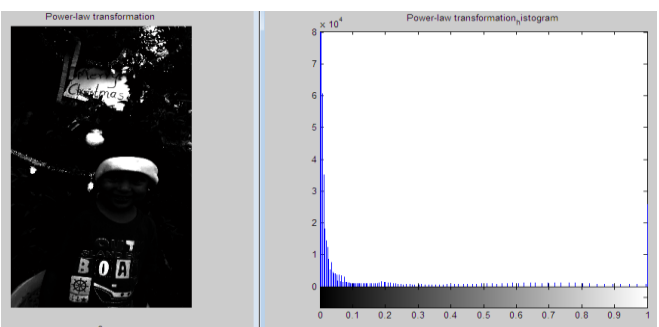


Fig.17 Power law transformation result with  $\gamma=6$

### F. Gray level Slicing

This technique is used to highlight a specific range of gray levels in a given image. – Similar to thresholding – Other levels can be suppressed or maintained – Useful for highlighting features in an image It can be implemented in several ways, but the two basic themes are: One approach is to display a high value for all gray levels in the range of interest and a low value for all other gray levels. The second approach, based on the transformation brightens the desired range of gray levels but preserves gray levels unchanged[10].



Fig.18 Gray level sliced images for intensity a)150 onwards b)50 onwards c)200 onwards

### VII. CONCLUSION

This paper represents different techniques for gray level image transformation for image enhancement. We have explained the concept of image histogram. Negative transformation of gray level image is helps in finding the details from the darker regions of the image it has its applications in the area of medical imaging, remote sensing and others log transformation is used for image enhancement as it expands dark pixels of the image as

compared to higher pixel values. As like log transformation exponential transformation are used to change the dynamic range of an image, they enhance the high intensity value, Power law transformation is used for enhancing image of different type of display devices. The gamma of different display devices is different. Gray level slicing technique manipulates group of intensity level in an image up to specific range by diminishing rest or by leaving them alone. It is applicable in medical images & satellite images such as X-ray flaws, CT scan.

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