

Study and Analysis of Various Image Enhancement Method using MATLAB

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Abstract— The main objective of image enhancement is to process the input image so that the processed image will look much better. Image enhancement refers to accentuation, or sharpening of image features such as edges, boundaries, or contrast to make a graphic display more useful for display and analysis. It plays a vital role in every field. This paper covers two parts: first part is based to the study of various types of images and image enhancement and second part is based on analysis of various basic intensity transformation functions in image processing. All these analysis is performed in MATLAB software. We get various results in term of output images and their histograms respectively. Here we see that each transformation function is suitable for some particular applications, not for all. So, According to application requirement, we choose a particular transformation function for image enhancement.

Keywords- Image processing, Image enhancement, Matlab, Hue Transformation, Log transformation, Power Law Transformation.

I. INTRODUCTION

Image enhancement refers to accentuation, or sharpening of image features such as edges, boundaries, or contrast to make a graphic display more useful for display and analysis. The enhancement process does not increase the inherent information content in the data. But it does increase the dynamic range of the chosen features so that they can be detected easily. Image enhancement includes gray level and contrast manipulation, pseudo-coloring, and so on [6].

Image enhancement is used to improve the quality of an image for visual perception of human beings. It is also used for low level vision applications. It is a task in which the set of pixel values of one image is transformed to a new set of pixel values so that the new image formed is visually pleasing and is also more suitable for analysis [8].

Hue, saturation and intensity are the attributes of color. Hue is that attribute of a color which decides what kind of color it is, i.e., a red or an orange. In the spectrum, each color is at the maximum purity (or strength or richness) that the eye can appreciate, and the spectrum of colors is described as fully saturated. If a saturated color is diluted by being mixed with other colors or with white light, its richness or saturation is decreased. For the purpose of enhancing a color image, it is to be seen that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image [7, 8].

We all know that there are various image processing techniques which we use to process the image. But, one question arise in our mind that what is the need of Image Processing techniques and why we process these images? So, the answer is motivated by three major applications [4,7,13]:

Improvement of pictorial information for human perception. It means whatever image we get, we want to enhance the quality of the image. So, that the image will have a better look and it will be much better when we look at them.

Image processing for autonomous machine application. This has various applications in industries particularly for quality control, in assembly automation and many such applications.

Efficient storage and transmission. For example, if we want to store an image on a computer, then this image needs a certain amount of disk space. Now, we will look at whether it is possible to process the image using certain image property. So that, the disk space required for storing an image will be less. Not only that, we can also have applications heard we wants to transmit the image, or a video signal over a transmission media and in that case, if the bandwidth of the transmission medium is very low, we will see that how to process the image or the video can be transmitted over low bandwidth communication channel.

So, let us first look at first major application which is meant for human perception. Now, these methods mainly employ different image processing techniques to enhance the pictorial information for human interpretation and analysis [1, 2, 3].

Typical applications of these kinds of techniques are:

- **Noise Filtering:** In some cases, the images we will get have some very noisy. So, we have to filter those images so that the noise present in the image can be removed and the image appears much better. In some other kind of applications, we may have to enhance certain characteristics of the image. So the different kind of applications, we may have to enhance certain characteristics of the image. There is some other kind of application under this category is Contrast Enhancement.

- *Content Enhancement:* It covers two techniques such as Contrast Enhancement and Deblurring. So, sometimes the image may very poor contrast and we have to enhance the contrast of the image for better visual. In some other cases, the images may be blurred, this blurring may occur due to various reason such as may be camera sitting is not proper or the lens is not focus properly, so that leads to one kind of blurring. The other kind of blurring can be if we can take a picture from a moving train or moving car, in that case we might have observed the image that we get a blurred image or not cleared image.
- *Remote Sensing:* In remote sensing, the type of image which are used of the aerial images. In most of the cases, the aerial images are taken from the satellite.

II. CLASSIFICATION OF IMAGES

An image can be classified by following categories:

A. Intensity Images:

An intensity image is a data matrix whose values have been scaled to represent intensities. When the elements of an intensity image are of class unit 8, or class unit 16, they have integer values in the range [0, 255] and [0, 65535].respectively. If the image is of class double, the values are floating-point numbers. Values of scaled, class double intensity images are in the range [0, 1] by convention.

| | | | |
|----|----|----|----|
| 5 | 6 | 13 | 1 |
| 9 | 8 | 15 | 11 |
| 3 | 1 | 7 | 6 |
| 15 | 10 | 12 | 14 |

Figure 1. 4x4 Intesity Images

B. Indexed Images

Array of class logical, unit 8, Unit 16, single, or double whose pixel values are directed indices into a color map. The color map is an m-by-3 array of class double. For single or double arrays, integer values range from [1, p]. For logical, unit8, or unit 16 arrays, values range from [0, p-1]. An indexed image consists of an array and a color map matrix. The pixel values in the array are directed indices into a color map.

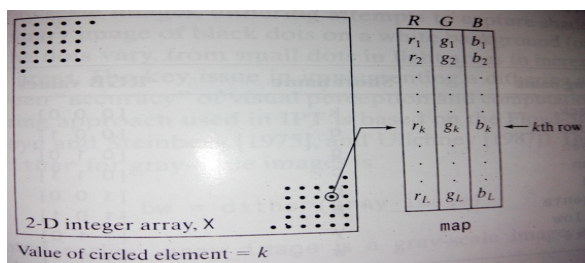


Figure 2. Elements of an indexed image. Note that the value of an element of integer array X determines the row number in the colormap. Each row contains an RGB triplet, and L is the total number of rows.

C. Binary Images

Binary images have a very specific meaning in MATLAB. In a binary image, each pixel assumes one of only two discrete values: 1 or 0, interpreted as black and white, respectively.



Figure 3. Binary image

D. Grayscale Images

A grayscale image is a data matrix whose values represent intensities within some range. MATLAB stores a grayscale image as an individual matrix, with each element of the matrix corresponding to one image pixel. By convention, this documentation uses the variable name I to refer to grayscale images. Array of class unit8, unit16, int16, single, or double whose pixel values. For single or double arrays, values range from [0, 1]. For unit8, values range from [0, 255]. For unit16, values range from [0, 65535]. For int16, values range from [-32768, 32767].



Figure 4. Grayscale image

E. True Color Images

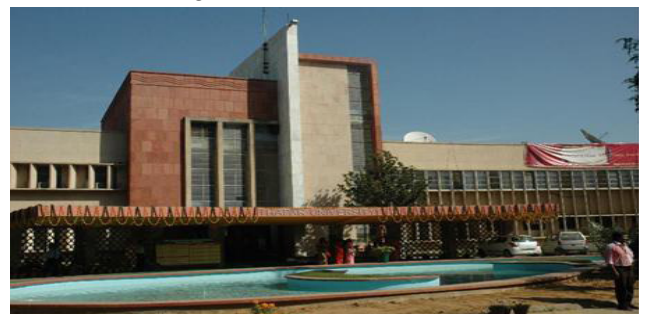


Figure 5. Color image

A true color image is an image in which each pixel is specified by three values one each for the red, blue, and green components of the pixel's color (see figure 7). MATLAB store true color images as an m-by-n-by-3 data array that defines red, green, and blue color components for each individual pixel. True color images do not use a color map. The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location. Graphics file formats store true color images as 24-bit images, where the red, green, and blue components are 8 bits each. This yields a potential of 16 million colors. The precision with which a real-life image can be replicated has led to the commonly used term true color image.

III. BASIC INTENSITY TRANSFORMATION FUNCTIONS

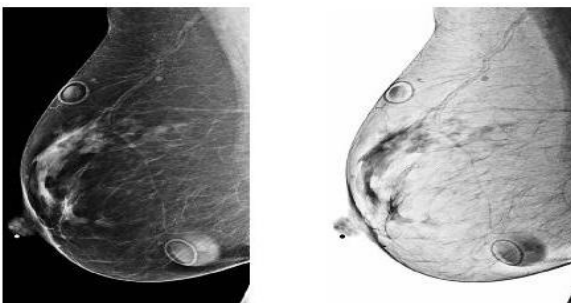
Intensity transformations are among the simplest of all image processing Techniques. The values of pixels, before and after processing, will be denoted by $f(x,y)$ and $g(x,y)$, respectively.

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

where, T is a transformation that maps a pixel value form $f(x,y)$ into pixels $g(x,y)$. Here $f(x,y)$ is input image and $g(x,y)$ is output or processed image.

A. Negative Image Transformation

The most basic and simple operation in digital image processing is to compute the negative of an image. The pixel gray values are inverted to compute the negative of an image. For example, if an image of size X -by- Y , where X represents number of rows and Y represents number of columns, is represented by $f(x,y)$. The negative $n(x,y)$ of image $f(x,y)$ can be computed as [11, 12]:



Original Digital Mamogram Image

Negative Image of Original Digital Mamogram Image

Figure 6. Input Mammogram and output negative Mammogram image.

$$n(x,y) = 255 - f(x,y) \quad (2)$$

where, $0 \leq x \leq X$ and $0 \leq y \leq Y$

Here $f(x,y)$ is input image and $g(x,y)$ is output or processed image. It can be seen that, see expression (2), every pixel value from the original image is subtracted from the

255. The resultant image becomes negative of the original image. Reversing the intensity levels of an image in this manner produces the equivalent of a photographic negative. Negative images are useful for enhancing white or grey detail embedded in dark regions of an image [5, 14].

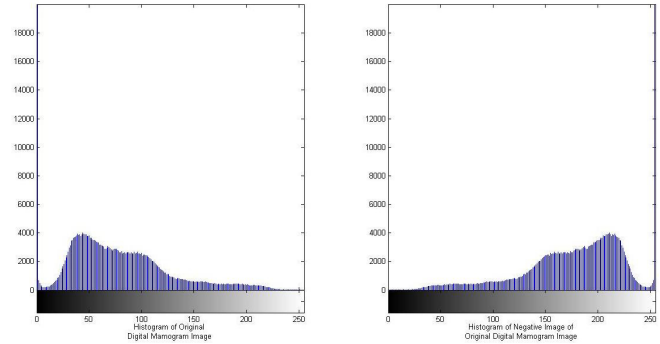


Figure 7. Input Mammogram Histogram and output negative Mammogram Histogram image.

B. Logarithmic Transformations Function

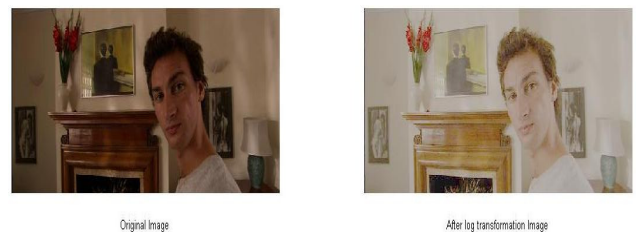
The general form of the log transformation:

$$g(x,y) = c \log_2 [1 + f(x,y)] \quad (3)$$

where c is a constant, here we choose $c=0.1$.

Here $f(x,y)$ is input image and $g(x,y)$ is output or processed image. This transformation maps a narrow range of low gray-level values in the input image into a wider range of output levels. The opposite is true of higher values of input levels. We would use a transformation of this type to expand the values of dark pixels in an image while compressing the higher-level values. The opposite is true of the inverse log transformation. However, the log function has the important characteristic that it compresses the dynamic range of images with large variations in pixel values [10, 11].

The log transformation maps a narrow range of low input grey level values into a wider range of output values. The inverse log transformation performs the opposite transformation. Log functions are particularly useful when the input grey level values may have an extremely large range of values, see figure 10 and figure 11 [12,14].



Original Image

After log transformation Image

Figure 8. Input image and output log transform image

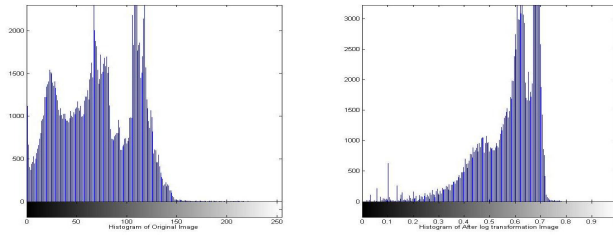


Figure 9. Histogram of Input image and histogram of output log transform image

Grey levels must be in the range [0.0, 1.0].

C. Power-Law Transformations Function

The general form of the power-law transformation:

$$g(x,y) = c[f(x,y)]^\gamma \tag{4}$$

where c and γ are positive constants. We use $c=0.1$ and $\gamma=0.465$.

Here $f(x,y)$ is input image and $g(x,y)$ is output or processed image. Sometimes expression (5) is written as $g(x,y) = c*[f(x,y) + \text{exp.}]^\gamma$ to account for an offset (i.e. a measurable output when the input is zero). However, offsets typically are an issue of display calibration and as a result they are normally ignored in expression (5) [9, 12].



Original Image



After power law transformation Image

Figure 10. Input Image and output power law transformation image

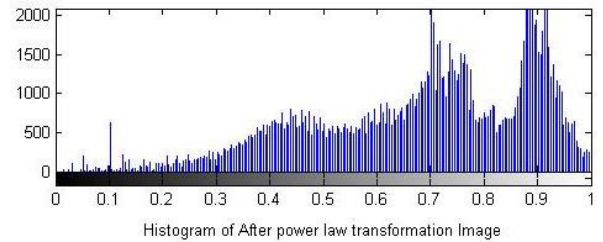
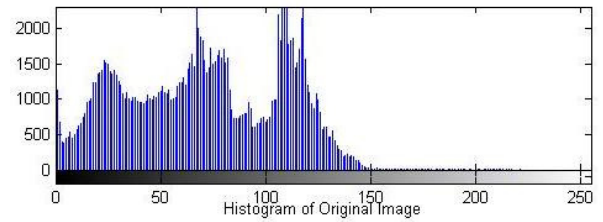


Figure 11. Histogram of Input Image and histogram of output power law transformation image

[13] This transformation function is also called as *gamma* correction. For various values of γ different levels of enhancements can be obtained. This technique is quite commonly called as Gamma Correction. If you notice, 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 and so a good monitor automatically corrects all the images displayed on it for the best contrast to give user the best experience. The difference between the log transformation function and the power-law functions is that using the power-law function a family of possible transformation curves can be obtained just by varying the γ .

D. Hue Transformation Function

Hue preservation is necessary for color image enhancement. Hue is what most people think of when we say "color." Hue is the name of a distinct color of the spectrum—red, green, yellow, orange, blue, and so on.



Figure 12. This strip shows a range of hues. It is easy to point to "red", "blue" or "yellow".

Distortion may occur if hue is not preserved. The hue of a pixel in the scene before the transformation and hue of the same pixel after the transformation are to be same for a hue preserving transformation [13].

The range, or gamut, of human colour perception is quite large. The two colour spaces discussed here span only a fraction of the colours we can see in figure 15. Furthermore the two spaces do not have the same gamut, meaning that converting from one colour space to the other may cause problems for colours in the outer regions of the GAMUTs. This illustration clearly shows the different GAMUTs of the RGB and CMYK colour spaces [15, 16].

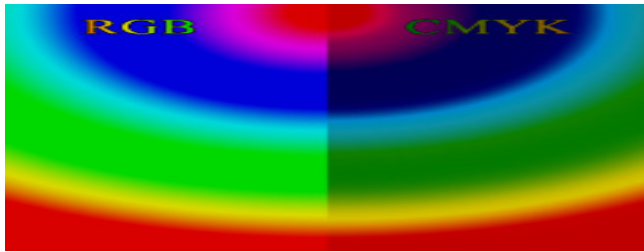


Figure 13. Different GAMUTs of the RGB and CMYK color spaces.

This is the Hue preserving transformation function:

$$f_{m,n}(x) = \begin{cases} \delta_1 + (m - \delta_1) \left(\frac{x - \delta_1}{m - \delta_1} \right)^n, & \delta_1 \leq x \leq m \\ \delta_2 + (\delta_2 - m) \left(\frac{\delta_2 - x}{\delta_2 - m} \right)^n, & m \leq x \leq \delta_2 \end{cases}$$

Here $f(x)$ denote the hue transformation function, x represents the normalized pixel value.

Thus $x, f(x) \in [\delta_1, \delta_2]$ where $\delta_1=0, \delta_2=3$, these values are get after the pixels value normalization.

And m and n are constants, δ_1 is minimum normalized pixel value, δ_2 is maximum normalized pixel value.

Here we choose $m=0.25$ and $n=2$ for hue preservation and avoiding gamut problem.



Input Image



Output Hue Transformation Function Image

Figure 14. Input and hue transformation output image

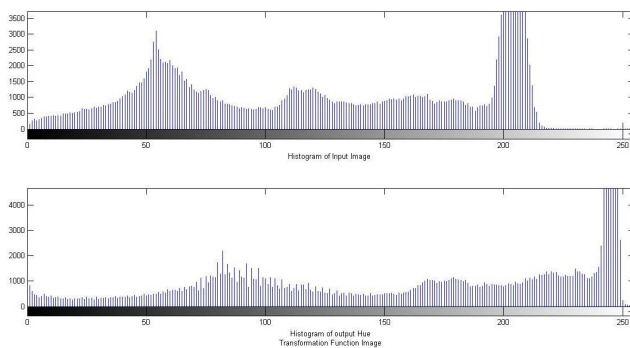


Figure 15. Histogram of Input and hue transformation output image

IV. CONCLUSIONS

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. In this paper, the study of various types of images, image enhancement, and their analysis is successfully done. This paper analysis is based on some basic intensity transformation function. All these methods for greyscale images and color images show good result.

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