Design/Mini Project (ECS43402)

Topic:

"Image Contrast Enhancement Using Histogram Equalization"

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CONTENT

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Thanking You.

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DECLARATION

We hereby declare that the project on "**Image Contrast Enhancement using Histogram Equalization**" submitted by us to the **Department of Computer Science and Engineering** of **School of Engineering and Technology** of **Adamas University** for the fulfilment of **Design/Mini Project (ECS43402)** module of **6th** semester of **B. Tech. (C.S.E.)** course has not formed the basis of any other degree or diploma.

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CERTIFICATE

This is to certify that the project on "**Image Contrast Enhancement using Histogram Equalization**" has been submitted by **Anirban Saha (2015ETCS002), Sanjoy Goswami (2015ETCS020),** and **Sayantan Roy (2015ETCS022)** for the fulfilment of **Design/Mini Project (ECS43402)** module of **6th** semester of **B. Tech. (C.S.E.)** course and it has not formed the basis of any other degree or diploma.

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Abstract

Image Enhancement is one of the important requirements in Digital Image Processing which is important in making an image useful for various applications which can be seen in the areas of Digital photography, Medicine, Geographic Information System, Industrial Inspection, Law Enforcement and many more Digital Image Applications. Image Enhancement is used to improve the quality of poor images. The focus of this project is an attempt to improve the quality of digital images using Histogram Equalization. In this project we are applying Histogram Equalization on both grayscale and colour images with RGB colour space.

1. Introduction

We all are familiar about how human beings perceive the world through their eyes but in this section, we will be stating how a computer system views into an image. This section contains a brief discussion about the concept of digital images, how it is viewed by a computer, two different colour models, some basic idea about image processing and its implementation, and a brief note on contrast enhancement.

1.1. Image

Basically, an image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows .An Image is a 2D function *f(x,y)*, where *x* and *y* are spatial coordinates and amplitude of *f* at any pair of coordinates *(x,y)* is called the intensity or gray level of the image.

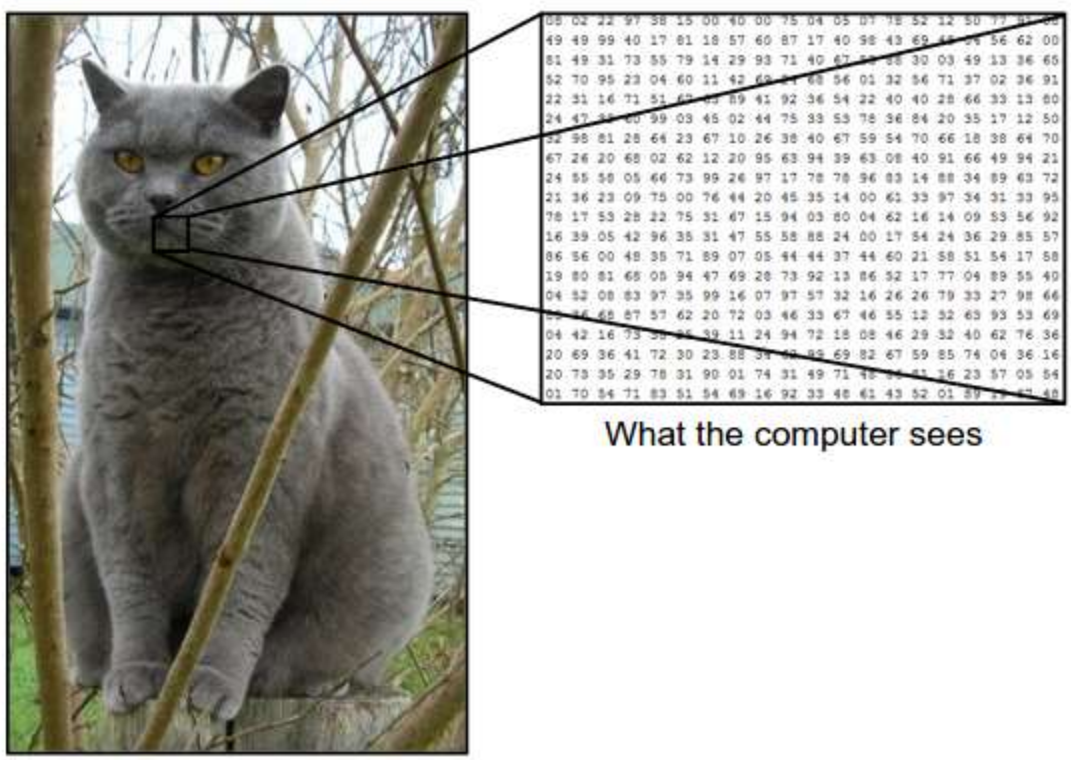

Fig. 1.1: Digital Image perceive by a computer system

1.2. Types of Images

There are broadly three types of images: Binary Image, Gray-scale Image, and Colour Image.

Binary Image is represented by only 0s and 1s as pixel values in 2-D matrix form where black pixel is denoted by 0 and white pixel is denoted by 1. This form of image is also known as Black and White Image. This image has application in computer vision and used when only the outline image is required.

Gray-scale Image is represented by a range of 0-255 as its pixel values in 2-D matrix form where pure black is denoted by 0 and pure white is denoted by 255 and there exists different shades of gray as per the pixel value. This form of image is also known as Monochrome Image as it only represent the level of brightness and not the colour.

Colour Image can be represented in different form having different label of 2-D bands where each bands hold the intensity level value of that band which altogether defines the actual colour of the image.

Fig. 1.2: Black and White Image, Gray-scale Image, and Colour Image respectively from the left

1.3. Colour Models

A colour model is an abstract mathematical model describing the way colours can be represented as tuples of numbers, typically as three or four values or colour components. When this model is associated with a precise description of how the components are to be interpreted, the resulting set of colour is called colour space.

There exists different colour models such as RGB (Red-Green-Blue) colour model, HSV (Hue-Saturation-Value) or HSL (Hue-Saturation-Lightness) or HSI (Hue-Saturation-Intensity) colour model, CMY (Cyan-Magenta-Yellow) colour model, CMYK (Cyan-Magenta-Yellow with black shades) colour model, and many more which included LAB, NCS, HKS, etc. In this section, we will have a look on two different colour model, those are RGB colour model and HSV or HSL or HSI colour model.

1.3.1. RGB Colour Model

The RGB colour model is an additive colour model in which red, green, and blue light are added together in various ways to reproduce a broad array of colours. The main purpose of RGB colour model id for the sensing, representation, and display of images in electronic systems such as televisions and computers.

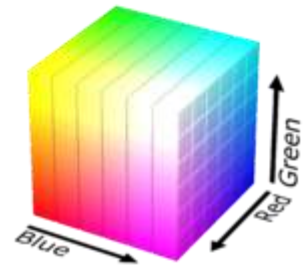

Fig. 1.3: RGB colour space

RGB is a device dependent colour model: different devices detect or reproduce a given RGB value differently since the colour element and their response to the individual R, G, and B levels vary from manufacturer to manufacturer.

1.3.2. HSI colour model

The HSI colour model is very important and attractive colour model for image processing applications because it represents colours similarly how the human eye senses colours. The HSI colour model represents every colour with three components: Hue, Saturation, and Intensity.

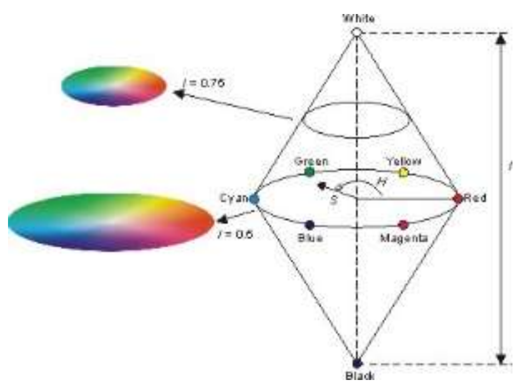

Fig. 1.4: HSI colour space

1.3.3. Mathematical Relationship between RGB and HSI

There exists some mathematical relationship between RGB and HSI colour space which helps to convert values in one colour space to the other. Those mathematical relationship are stated as follows:

$$H = \cos^{-1}\sqrt{\frac{\frac{1}{2}((R-G)+(R-B))}{(R-G)^2+(R-B)(G-B)}}$$

$$S = 1 - \frac{3}{(R+G+B)} \min(R, G, B)$$

$$I = \frac{(R+G+B)}{3}$$

1.4. Image Processing

The analysis and manipulation of digitized image is known as image processing. It includes methods to convert a real-time object/image into digital image form and perform some operation on it, in order to get an enhanced image or to extract some useful information from it.

There are various image processing techniques which are performed over a various digitized image as per their need in various applications. Some of these techniques are as follows:

- Image Representation
- Image Preprocessing
- Image Enhancement
- Image Restoration
- Image Analysis
- Image Segmentation
- Image Data Compression

1.5. Image Enhancement

The main objective of image enhancement is to process the image so that the output image will be better as compared to the input image. So this technique enhance and improve the quality of the image. It basically performs two activities: highlight interesting details in images, and make images more visually appealing.

There are various existing process to perform image enhancement. Some of them are as follows:

- Image Negative
- Log Transformation
- Grey Level Slicing
- Contrast Stretching
- Contrast Enhancement
- Bit Plane Slicing
- Power Law Transformation

2. Contrast Enhancement

The range of brightness values present in an image is termed as contrast of an image. Contrast Enhancement is an image processing technique in which the contrast of the image, or the difference in colour and light between parts of it, is touched up in order to improve its perception by human eye. It is perhaps the most common application of image processing.

The Contrast Enhancement technique plays a vital role in image processing to bring out the information that exists within low dynamic range of that image. To improve the quality of the image, it is required to perform image processing operation like contrast enhancement over the image.

Now-a-days, there are many techniques on image contrast enhancement but in this section, we will gain some brief idea about one of the most prevailing image contrast enhancement technique, i.e., histogram equalization. Firstly, we will gain some knowledge about histogram of an image, and then we will look forward and have some idea about histogram equalization followed by some mathematical concept used in histogram equalization.

2.1. Histogram of an image

A histogram is an accurate representation of the distribution of the numeric data. An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. By looking at the histogram for a specific image, a viewer will be able to judge the entire tonal distribution at a glance.

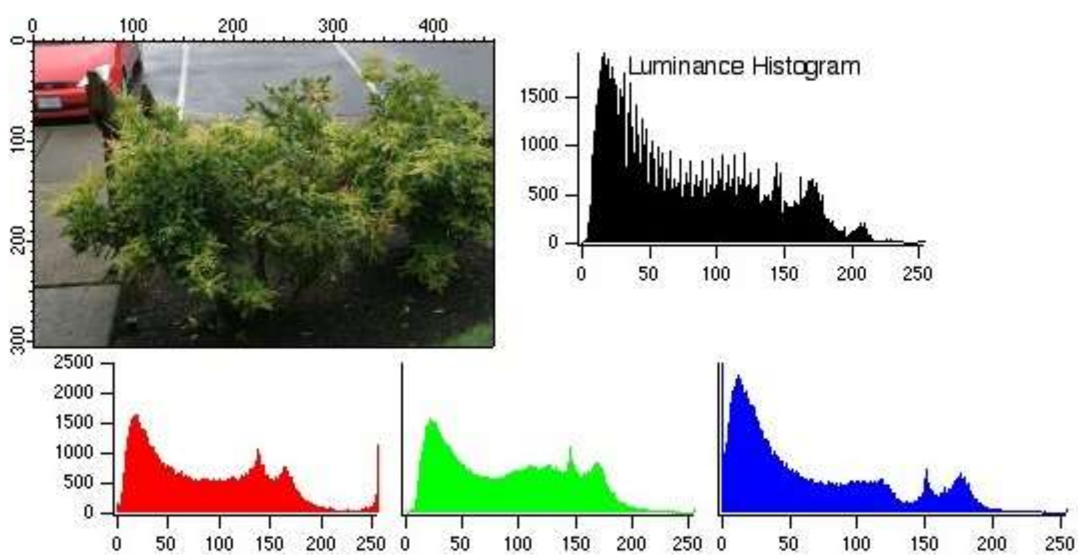

Fig. 2.1: Histogram of an image

2.2. Histogram Equalization

Histogram Equalization method usually increases the global contrast of any image, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensities values.

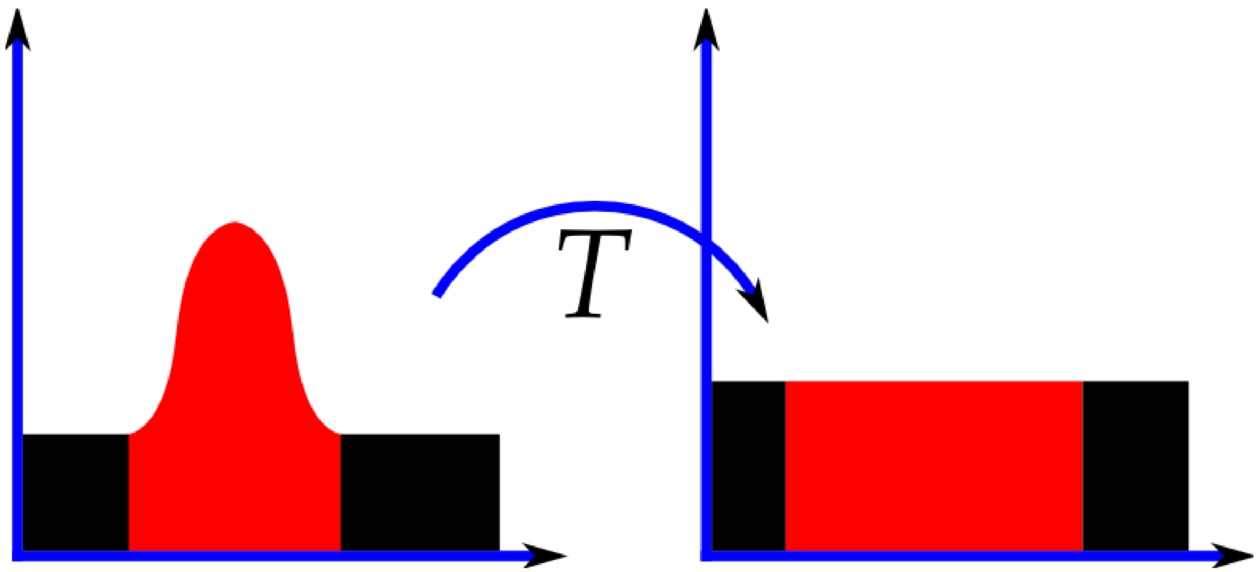

Fig. 2.2: Histogram Equalization

2.3. Mathematical Model

Let f be a given image represented as a m_r by m_c matrix of integer pixel intensities ranging from 0 to $L-1$. L is the number of possible intensity values, often 256. Let p denote the normalized histogram of f with a bin for each possible intensity. So

$$p_n = \frac{number\ of\ pixels\ with\ intensity\ 'n'}{total\ number\ of\ pixels} \quad \forall\ n = 1, 2, 3, \ldots, L$$

The histogram equalized image g will be defined by

$$g_{i,j} = floor((L-1)\sum_{n=0}^{f_{i,j}} p_n)$$

where $floor()$ rounds down to the nearest integer. This is equivalent to transforming the pixel intensities, k, of f by the function

$$T(k) = floor((L-1)\sum_{n=0}^{k} p_n)$$

The motivation for this transformation comes from thinking of the intensities of f and g as continuous random variables X, Y on $[0, L-1]$ with Y defined by

$$Y = T(X) = (L-1)\int_0^X p_X(x)\, dx$$

where p_X is the probability density function of f. T is the cumulative distributive function of X multiplied by $(L-1)$. Assume for simplicity that T is differentiable and invertible. It can then be shown that Y defined by $T(X)$ is uniformly distributed on $[0, L-1]$, namely that $p_Y(y) = \frac{1}{L-1}$.

$$\begin{aligned}\int_0^y p_Y(z)\, dz &= probability\ that\ 0 \le Y \le y \\ &= probability\ that\ 0 \le X \le T^{-1}(X) \\ &= \int_0^{T^{-1}(y)} p_X(w)\, dw\end{aligned}$$

$$\frac{d}{dy}\left(\int_0^y p_Y(z)\ dz\right) = p_Y(y) = p_X(T^{-1}(y))\frac{d}{dy}(T^{-1}(y))$$

Note that $\frac{d}{dy}T(T^{-1}(y)) = \frac{d}{dy}y = 1$, so

$$\frac{dT}{dx}|_{x=T^{-1}(y)}\frac{d}{dy}(T^{-1}(y)) = (L-1)p_X\left(T^{-1}(y)\right)\frac{d}{dy}\left(T^{-1}(y)\right) = 1$$

which means $p_Y(y) = \frac{1}{L-1}$.

The discrete histogram is an approximation. While the discrete version won't result in exactly flat histograms, it will flatten them and in doing so enhance the contrast in the image.

3. Implementation

Till now, we have become familiar with the theoretical aspects about the basics of images, image processing, and contrast enhancement using histogram equalization. But in this section, we will look into the implementation part of image contrast enhancement using histogram equalization while creating a new application for the same.

3.1. Algorithm Adopted

While designing the application, we have used the following basic algorithm in the background:

Step 1: *Begin.*
Step 2: *Read the image.*
Step 3: *If the image is colour image, then go to step 5.*
Step 4: *Perform Histogram Equalization over the single channel of gray-scale image and go to step 8.*
Step 5: *Convert the image from RGB channel to HSI channel.*
Step 6: *Perform Histogram Equalization over the Intensity channel of HSI channeled colour image.*
Step 7: *Convert the image from HSI channel to RGB channel.*
Step 8: *Save the updated image.*
Step 9: *End.*

3.2. Minimum Pre-requisites

In order to run the given software application, some prerequisite software are required. Those are stated below:

1. JDK 1.7 or above.
2. Netbeans 8.2 or above.
3. MATLAB R2016b or above.

Similarly, we need to set two path variables in order to run the application. Those are:

1. C:\Program Files\Java\jdk1.8.0_131\bin
2. C:\Program Files\MATLAB\R2016b\bin\win64

Now, we are ready to run the given software application.

3.3. Understanding the GUI

Fig. 3.1: Application GUI

In this GUI, we need to browse the source image path which is to be enhanced and the path along with the file name with extension by which the enhanced image need to be saved. Then we have to click the "Enhance Image" button to perform the specific task. Then after few minutes, the output screen will appear. The operation would take few minutes due to the delay in starting of matlab in the background.

3.4. Understanding the output screen

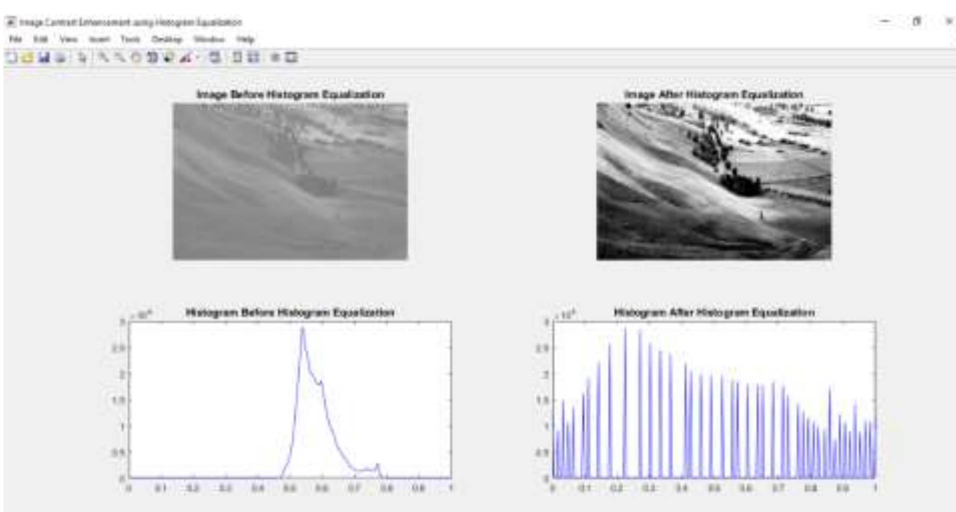

Fig. 3.2: Output Screen of the application for black and white image

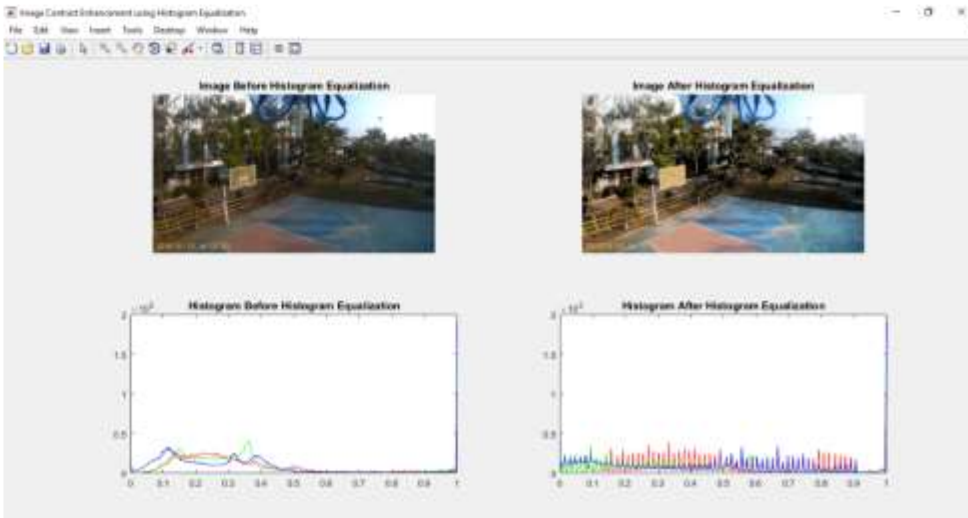

Fig. 3.3: Output Screen of the application for colour image

The left part of the output screen clearly views the input image along with corresponding histogram for the input image before applying any operation over the image. Whereas the right part of the output screen clearly views the enhanced image along with the histogram of the enhanced image after applying histogram equalization operation over the output image.

Conclusion

In this project, we have shown that we can get better enhanced image after applying histogram equalization over it. The method we applied balances the requirement of both appearance enhancement and being faithful to the original appearance of an image. Results outcome has shown the effectiveness of the algorithm. Now this enhanced image can be utilize to perform various operations such as segmentation, identification, localization, recognition, etc. which can be applied in various areas like Digital photography, Medicine, Geographic Information System, Industrial Inspection, Law Enforcement and many more Digital Image Applications.

References

1. "Digital Image Processing" by Rafael C. Gonzalez, and Richard Eugene Woods.
2. https://www.google.co.in - Google
3. https://en.wikipedia.org/wiki - Wikipedia
4. https://www.quora.com - Quora

THANK YOU.