

# Contrast Image Enhancement By Gamma Correction

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## Abstract

One of the important techniques in digital image processing is to enhance images. Contrast enhancement is a method that is used to enhance images for viewing process or for further analysis of images. Main idea behind contrast enhancement techniques is to increase contrast and to preserve original brightness of images. In this a project contrast enhancement technique called Gamma correction is used for this purpose . The value of the Gamma affects the result of the contrast of the image, the larger the light increases, the smaller the light decrease . the best value is " 2.2 "

**Keywords:** digital image processing , Image Enhancement .

## 1. Introduction

### 1.1 Introduction

Image enhancement is a preprocessing step in many image processing applications. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques. [2] There are various reasons for poor quality of an image such as distortion being introduced by the imaging systems, lack of expertise of the operator or the adverse external conditions at the time of image acquisition. Mainly, Image enhancement includes intensity and contrast manipulation, noise reduction, edges sharpening and filtering,

etc. Contrast Enhancement is focused on the problem of improving the contrast in an image to make various features more easily perceived. Contrast of an image is determined by its dynamic range, which is defined as the difference between lowest and highest intensity level. Contrast enhancement techniques have various application areas for enhancing the visual quality of low contrast images. Many contrast enhancement algorithms have been developed over the years.

Histogram equalization is widely used for contrast enhancement in a variety of applications due to its simple function and effectiveness. Examples include medical image processing and radar signal processing. One drawback of the histogram equalization can be found on the fact that the brightness of an image can be changed after the histogram equalization, which is mainly due to the flattening property of the histogram equalization. Thus, it is rarely utilized in consumer electronic products such as TV where preserving the original input brightness may be necessary in order not to introduce unnecessary visual deterioration. This paper proposes a novel extension of histogram equalization to overcome such a drawback of histogram equalization. The essence of the proposed algorithm is to utilize independent histogram equalizations separately over two sub images obtained by decomposing the input image based on its mean with a constraint that the resulting equalized sub images are bounded by each other around the input mean. It is shown mathematically that the proposed algorithm preserves the mean brightness of a given image significantly well compared to typical histogram equalization while enhancing the contrast and, thus, provides a natural enhancement that can be utilized in consumer electronic products.

The filters are used to remove noise or to improve the image. These filters apply directly to the image elements (not directly to the image elements) and not to the frequency range. The image elements are used with one of the

transformations such as Fourier transforms into three types:

Medium filter, median filter, and optimization filter. The first and second types to remove noise in addition to some applications that give the form of smoothing the image i.e: noise removal - smoothing.[3]

The third type is used to clarify the edges and details in the picture where the filters are applied either by using the elements directly without the use of a mask or through a clutch with the elements and adjacent .The results of the catcher are as follows: If the sum of the catcher coefficients equals 1, it means high light. If the transactions are negative and positive, that means information about the edges. If the transactions are positive only, there is a kind of distortion in the picture.

Image enhancement techniques are techniques used to determine the rigidity or boundaries in the image to highlight the characteristics, characteristics and analysis of the image

These techniques are used in multiple applications using so-called feedback from input to output to give models of improvement tested in nature after development.[3]

### 1.2 Related work

Contrast enhancement algorithms can broadly be divided into two categories: spatial domain techniques and frequency domain techniques. In spatial domain techniques, the image enhancement is based on direct manipulation of the pixels in an image . frequency domain processing techniques are based on modify the Fourier transform of an image. In frequency domain methods ,the image is first transferred in to frequency domain.it means, that, the Fourier Transform of the image is computed first all the enhancement operations are then performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image[3].

### 1.3 Aim of project

The aim of this project is to apply gamma correction method in order to enhance the contrast of an image .

### 1.4 Research layout

The researches arranged as follows:

- Chapter one consists of a general introduction to all topics, which are implemented, in the project and research problem.
- Chapter Two introduces for digital image, gamma correction.
- Chapter three the design and implementation of the proposed system.
- Chapter four Results of Gamma correction .

## 2 . Digital Image and Gamma Correction

### 2.1 Introduction

Gamma correction is an integral part of all the digital imaging systems, but a lot of people don't know about it! It is an essential part of all the imaging devices like cameras, camcorders, monitors, video players, etc. It basically defines the relationship between a pixel's numerical value and its actual luminance. why would they be different? Isn't a pixel's numerical value supposed to be exactly the same as its luminance? Without gamma, shades captured by digital cameras wouldn't appear as they did to our eyes. If we fully understand how gamma works, we can improve our exposure technique, along with making the most of image editing. Why do we need gamma correction at all?

the main thing to understand here is that our eyes do not perceive light the way cameras do. Human visual system is an extremely refined system. It does a lot of work in the background and makes stuff look prettier. Let's consider a digital camera for a moment here. The way it works is that the photons hit the sensor, the camera then receives a signal, and an image is formed. So when thrice the number of photons hit the sensor, it receives three times the signal. It's a simple linear relationship! But that's not how our eyes work. When thrice the number of photons hit our eyes, we perceive thrice the light as being only a fraction brighter. This effect becomes increasingly more prominent for higher light intensities. This basically indicates a nonlinear relationship.

Have you ever noticed how we tend to miss out on smaller details if the image is really bright? The reason for this is that we are much more sensitive to changes in dark tones than we are to similar changes in bright tones.

There's actually a biological reason for this peculiarity. It happens because it enables our vision to operate over a broader range of luminance. Otherwise, the typical range in brightness we encounter outdoors would be too overwhelming. Our visual system is really smart that way!

we need to understand how we perceive luminance in order to understand why we need gamma correction. Gamma basically establishes a relationship between our eye's light sensitivity and that of the camera. When a digital image is saved, it's therefore "gamma encoded". This way, twice the value in a file more closely corresponds to what we would perceive as being twice as bright.

The reason we do gamma encoding is because gamma encoded images store tones more efficiently. Since gamma encoding redistributes tonal levels closer to how our eyes perceive them, fewer bits are needed to describe a given tonal range. The number of bits you allocate to a particular thing dictates the level of detail you can store about it. Since our visual system doesn't really care about the details in the brighter regions, we don't have to waste more number bits to store information about that region. The extra bits that are saved can instead be devoted to describe the darker tones, where the camera is relatively less sensitive.

In the picture here, it is can see how the linear encoding uses insufficient levels to describe the dark tones. As in, since human eye is sensitive towards the dark tones, we need sufficient level of detail to represent those regions.

If we assign uniform number of bits to all the regions, we end up with an excess of levels to describe the bright tones. This is not necessary at all! On the other hand, the gamma encoded gradient distributes the tones roughly evenly across the entire range. This is perceptually more uniform



Figure 2.1: applied Gamma correction

Up until now, we saw why we need gamma correction. But despite all of these advantages, we cannot avoid the fact that gamma encoding adds a layer of complexity to the whole process of recording and displaying images. A gamma encoded image has to have "gamma correction" applied when it is viewed, which effectively converts it back to the original scene. This means that the purpose of gamma encoding is for recording the image, not for displaying the image. Fortunately, this second step is automatically performed by your monitor and video card.

This gamma actually appears at different steps in the pipeline:

1. **Image Gamma:** This is applied either by your camera or RAW development software. Whenever an image is captured, it is converted into a standard JPEG or TIFF file. So when the camera software does that, it redistributes native camera tonal levels into ones which are more perceptually uniform. This way, we make the most efficient use of a given bit depth. As in, we only have a certain number of bits to represent an image and we need to make the best of it. In order to use it efficiently, our camera software assigns more bits to darker tones and lesser number of bits to the brighter tones.
2. **Display Gamma:** This refers to the net influence of your video card and display device. The main purpose of the display gamma is to compensate for a file's gamma. We need this step because we need to ensure that the image isn't unrealistically brightened when displayed on your screen. A higher display gamma results in a darker image with greater contrast. You can see this in the image above. The image on the right has a higher gamma, and is therefore brighter.
3. **System Gamma:** This represents the net effect of all gamma values that have been applied to an image. The net effect basically refers to the combination of image gamma and display gamma. For faithful reproduction of a scene, this should ideally be close to a straight line (gamma = 1.0). A straight line ensures that the input is same as the output, i.e. the original scene is the same as what's being displayed

on your screen. However, the system gamma is sometimes set slightly greater than 1.0 in order to improve contrast. As we all know, human eye loves contrast!.

## 2.2. Image processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.[1]

- Image processing basically includes the following three steps:
  - Importing the image via image acquisition tools.
  - Analyzing and manipulating the image.
  - Output in which result can be altered image or report that is based on image analysis.

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, and display, information extraction.[1]

## 2.3. Digital image

A digital image is an electronic file that forms into square picture elements (pixels) when displayed on a viewing device (e.g., a computer monitor). The displayed image is a two-dimensional matrix of thousands or millions of pixels each of which has its own address, size, and color representation. You might think of pixels as serving a role similar to the grains in a photograph.3 digitizing a photograph means converting or capturing its image electronically through a scanner or digital camera. Digital image processing software allows you to magnify an image to see the pixels, and to sometimes measure the numeric color values for each pixel – like a sophisticated, computer generated, paint-by-number matrix.

People use digital images in many ways. The same image can be viewed on a wide variety of monitors, printed in many formats, and transmitted electronically through e-mails, cell phones, and other systems. Digital images are stored electronically on media such as computer hard drives, CDs, DVDs, or magnetic tapes.[2]

The image types we will consider are: Binary Image, Gray Scale Image , Color Image , Multispectral image.( It will be described in Chapter two)

Pixel is the smallest element of an image. Each pixel correspond to any one value. In an 8-bit gray scale image, the value of the pixel between 0 and 255. The value of a pixel at any point correspond to the intensity of the light photons striking at that point. Each pixel store a value proportional to the light intensity at that particular location. [2]

## 2.4 Types of Digital image

The image types we will consider are: Binary Image, Gray Scale Image , Color Image, Multispectral image.[2]

### 2.4.1 Binary image

Binary images are the simplest type of images and can take on two values, typically black and white, or ‘0’ and ‘1’. A binary image is referred to as a 1 bit/pixel image because it takes only 1 binary digit to represent each pixel.[2]

It is often created from gray-scale images via a threshold value is turned white (‘1’), and those below it are turned black (‘0’). Every pixel in a binary image must be one of two colors, usually black or white. This inability to represent intermediate shades of gray is what limits their usefulness in dealing with photographic images.[2]

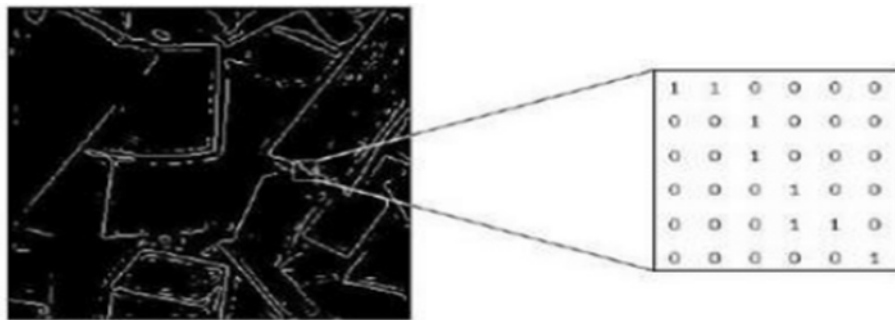


Figure 2.2:binary imag

### 2.4.2 Gray Scale Image

Gray \_scale images are referred to as monochrome or one-color image. They contain brightness information only, no color information. The number of different brightness level available .The typical image contains 8 bit/ pixel (data, which allows us to have (0-255) different brightness (gray) levels. The 8 bit representation is typically due to the fact that the byte, which corresponds to 8-bit of data, is the standard small unit in the world of digital computer.

Figure 1.3:gray image



Figure2.4:gray image

### 2.4.3 Color Image

Color image can be modeled as three band monochrome image data , where each band of the data corresponds to a different color. Typical color images are represented as red, green ,and blue or RGB images .using the 8-bit monochrome standard as a model , the corresponding color image would have 24 bit/pixel – 8 bit for each color bands (red, green and blue ). The following figure we see a representation of a typical RGB color image.[2]



Figure2.5:color image

#### 2.4.4 Multispectral images

information outside the normal human perceptual range. This may include infrared ( ),ultraviolet ( ), X-ray, acoustic or radar data. Source of these types of image include satellite systems underwater sonar systems and medical diagnostics imaging systems.[1]

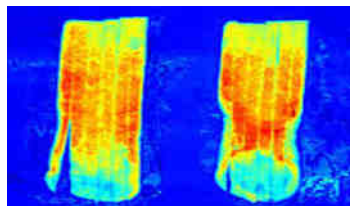


Figure2.6:multispectral image

#### 2.5 Representation of digital image

dimensional digital image can be represented as a 2-dimensional(2D) array of data  $s(x, y)$ , where  $(x, y)$  represent the pixel position. The pixel value corresponds to the brightness of the image at position  $(x, y)$ . Some of the most frequently used image types are binary, gray-scale and color images.[2]

#### 2.6 Dimension of images

An important feature of digital images, that they are multidimensional signals, meaning that they are functions of more than a single variable. The signals are usually 1D functions of time. Images, however, are functions of two and perhaps three space dimensions.[2]

Image dimensions are the length and width of a digital image. It is usually measured in pixels, but some graphics programs allow you to view and work with your image in the equivalent inches or centimeters. Depending on what you plan to use your image for you may want to change the image size.

For example, if you are using a high-resolution digital photograph, you may want to make the image dimensions smaller for publishing to a Web page. When using a graphics or image-editing program, you will usually have two options for changing the image dimensions: resize or resample.[1]

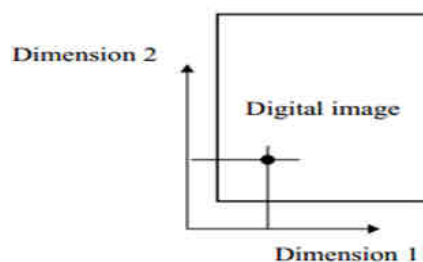


Figure2.7:dimension of image

## 2.7.Gamma Correction

Gamma correction, or often simply gamma, is the name of a nonlinear operation used to encode and decode luminance or tristimulus values in video or still image systems. Gamma correction is, in the simplest cases, defined by the following power-law expression: where the non-negative real input value is raised to the power and multiplied by the constant  $A$ , to get the output value. In the common case of  $A = 1$ , inputs and outputs are typically in the range 0–1.

A gamma value  $\gamma < 1$  is sometimes called an *encoding gamma*, and the process of encoding with this compressive power-law nonlinearity is called **gamma compression**; conversely a gamma value  $\gamma > 1$  is called a *decoding gamma* and the application of the expansive power-law nonlinearity is called **gamma expansion**.

Gamma encoding of images is used to optimize the usage of bits when encoding an image, or bandwidth used to transport an image, by taking advantage of the non-linear manner in which humans perceive light and color.

The human perception of brightness, under common illumination conditions (not pitch black nor blindingly bright), follows an approximate power function (note: no relation to the gamma function), with greater sensitivity to relative differences between darker tones than between lighter ones, consistent with the Stevens' power law for brightness perception. If images are not gamma-encoded, they allocate too many bits or too much bandwidth to highlights that humans cannot differentiate, and too few bits or too little bandwidth to shadow values that humans are sensitive to and would require more bits/bandwidth to maintain the same visual quality [5]

## 2.8. UNDERSTANDING GAMMA CORRECTION

Gamma is an important but seldom understood characteristic of virtually all digital imaging systems. It defines the relationship between a pixel's numerical value and its actual luminance. Without gamma, shades captured by digital cameras wouldn't appear as they did to our eyes (on a standard monitor). It's also referred to as gamma correction, gamma encoding or gamma compression, but these all refer to a similar concept.[5] Understanding how gamma works can improve one's exposure technique, in addition to helping one make the most of image editing.

### WHY GAMMA IS USEFUL

1. Our eyes do not perceive light the way cameras do. With a digital camera, when twice the number of photons hit the sensor, it receives twice the signal (a "linear" relationship). Pretty logical, right? That's not how our eyes work. Instead, we perceive twice the light as being only a fraction brighter — and increasingly so for higher light intensities (a "nonlinear" relationship) [5]

Compared to a camera, we are much more sensitive to changes in dark tones than we are to similar changes in bright tones. There's a biological reason for this peculiarity: it enables our vision to operate over a broader range of luminance. Otherwise the typical range in brightness we encounter outdoors would be too overwhelming.

But how does all of this relate to gamma? In this case, gamma is what translates between our eye's light sensitivity and that of the camera. When a digital image is saved, it's therefore "gamma encoded" — so that twice the value in a file more closely corresponds to what we would perceive as being twice as bright. Technical Note: Gamma is defined by

$$V_{\text{out}} = V_{\text{in}}^{\text{gamma}}, \quad 2.1$$

where  $V_{\text{out}}$  is the output luminance value and  $V_{\text{in}}$  is the input/actual luminance value. This formula causes the

blue line above to curve. When  $\gamma < 1$ , the line arches upward, whereas the opposite occurs with  $\gamma > 1$ .

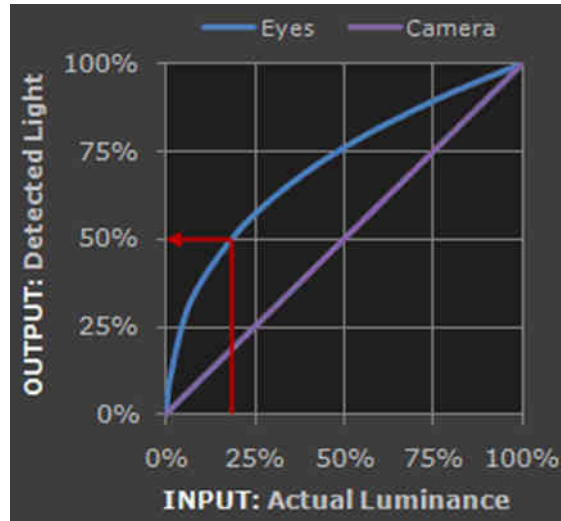


Figure2.8:gamma

### 3. Design of the proposed system

#### 3.1. Introduction

In this chapter we talk about the general steps of the system.

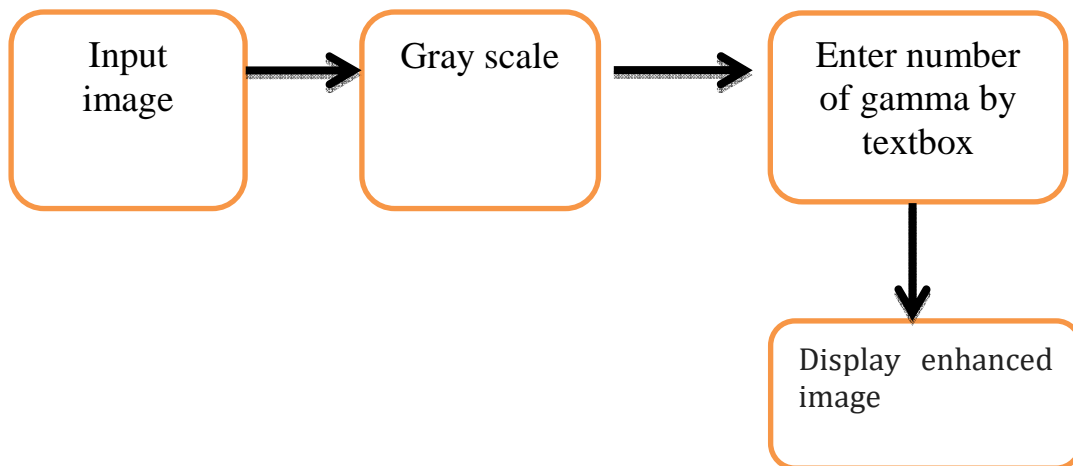


Figure 3.1 Flowchart of contrast adjustment using Gamma correction

#### 3.2 The system stages of Gamma correction

##### 3.2.1. Open image

The first step is to read an image; It depends on your file path.

The second step is open image.

Algorithm (3.2.1): Open image



```
private void button1_Click(object sender, EventArgs e)
{
    ff = new Open File Dialog();
    ff . Show Dialog();
    pictureBox1.Image = Image . From File(ff . File Name);
}
```

### 3.3.2. Gray scale

#### Algorithm (3.2.2): Gray scale image

```
internal void to_ int ()
{
    Bitmap b = new Bitmap(pictureBox2.Image);
    h = b .Height;
    w = b .Width;

    int [,] res = new int[w, h];
    for (int i = 0; i < w; i++)
    { for (int j = 0; j < h; j++)
        { res[i, j] = (b .Get Pixel(i, j).R + b .Get Pixel(i, j).G + b .Get Pixel(i, j).B) / 3;
        }
    }
    for (int i = 0; i < w; i++)
    {
        for (int j = 0; j < h; j++)
        {
            richTextBox1.Text += res[i, j].To String() + " ";
        }
    }
}
```

### 3.2.3. enter number of gamma

#### Algorithm (3.2.3): Enter number of gamma

```
Bitmap temp = new Bitmap(pictureBox2.Image);
float gama = float .Parse(textBox1.Text);
float gama correction = 1 / gama;
```

### 3.2.4. Display Gamma correction

#### Algorithm (3.2.4): display gamma correction

```
for (int i = 0; i < bmap .Width; i++)
{ for (int j = 0; j < bmap.Height; j++)
    {
        c = bmap .Get Pixel(i, j);
        red = (byte)(255.0 * Math .Pow ((c.R / 255.0), gama correction));
        green = (byte)(255.0 * Math.Pow((c.G / 255.0), gama correction));
    }
}
```

```
blue = (byte)(255.0 * Math.Pow((c.B / 255.0), gama correction));  
bmap .Set Pixel(i, j, Color. From Argb(red, green, blue));  
} }
```

## Chapter Four : Results

### 4.1 Results

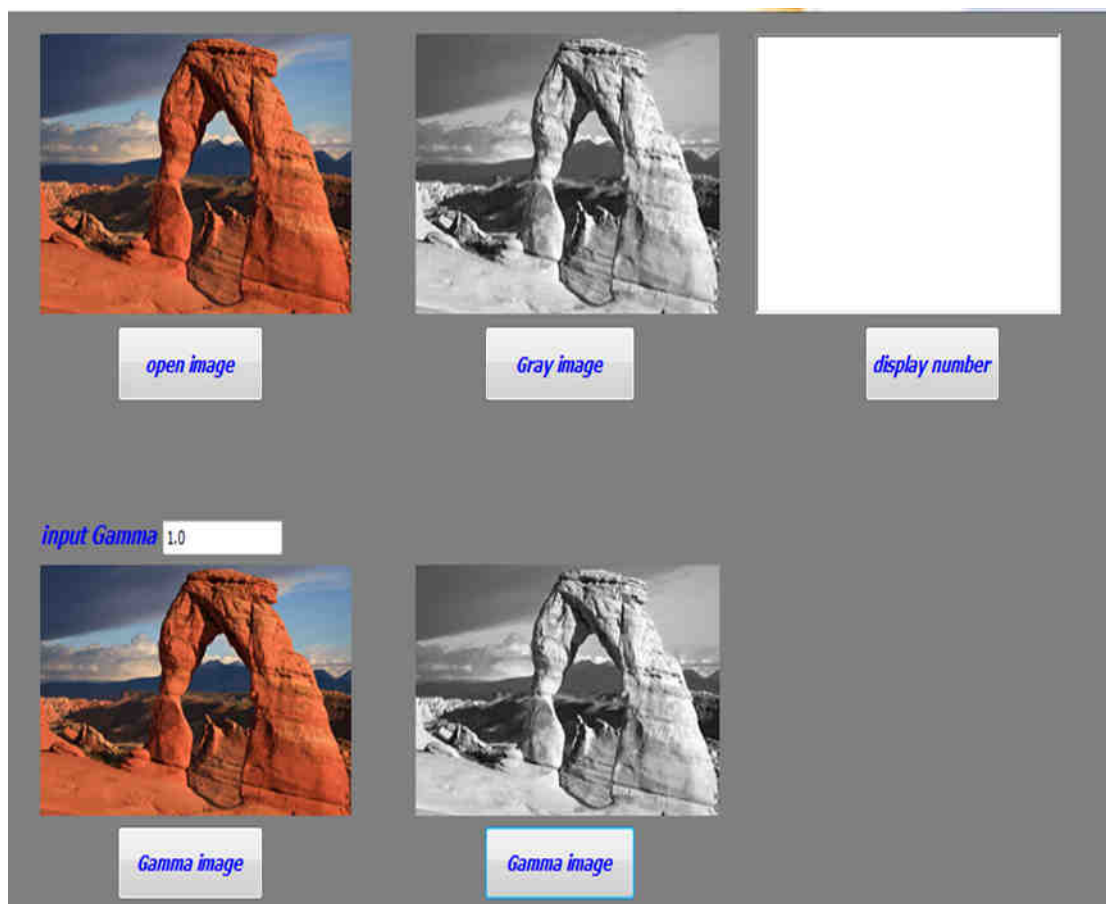




Figure 4.1:main form of proposed system

## Conclusion

In this project an efficient method to modify histograms and enhance contrast in digital images. Enhancement plays a significant role in digital image processing, computer vision, and pattern recognition. Finally the enhanced image is obtained after gamma correction. Contrast of Image is modified using many values of Gamma .

## References

- [1]R. He, S. Luo, Z. Jing and Y. Fan, "Adjustable Weighting Image Contrast Enhancement Algorithm and its Implementation," IEEE Conference on Industrial Electronics and Applications, pp. 1750-1754, 21-23 June 2011.
- [2]R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, Upper Saddle River, New Jersey, 2nd Edition, 2002.
- [3]S. C. Huang, F. C. Cheng and Y. S. Chiu, "Efficient Contrast Enhancement using Adaptive Gamma Correction with Weighting Distribution," IEEE Transactions on Image Processing, Vol. 22, No. 3, pp. 1032-1041, March 2013.
- [4]Y. T. Kim, "Contrast enhancement using brightness preserving bi-histogram equalization," IEEE Transactions On Consumer Electronics, Vol. 43, No. 1, pp.1-8, February 1997.
- [5]Y. Wang, Q. Chen, B. Zhang, "Image enhancement based on equal area dualistic sub-image histogram equalization method," IEEE Transactions on Consumer Electronics, Vol. 45, No. 1, pp. 68-75, February 1999.
- [6]S. D. Chen, A. R. Ramli, "Minimum mean brightness error bi histogram equalization in contrast enhancement," IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, pp. 1310-1319, November 2003.
- [7] S. D. Chen, A. R. Ramli, "Contrast enhancement using recursive mean-separate histogram equalization for scalable brightness preservation," IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, pp. 1301-1309,

November 2003,

- [8] C. Wang, Z. Ye, “Brightness preserving histogram equalization with maximum entropy: a variational perspective,” IEEE Transactions on Consumer Electronics, Vol. 51, No. 4, pp. 1326-1334, November 2005.
- [9] K. S. Sim , C. P. Tso, Y. Y. Tan, “Recursive sub image histogram equalization applied to gray scale images,” Pattern Recognition Letters, Vol. 28, No. 10, pp. 1209-1221, July 2007.
- [10] M. Kim, M. G. Chung, “Recursively separated and weighted histogram equalization for brightness preservation and contrast enhancement,” IEEE Transactions on Consumer Electronics, Vol. 54, No. 3, pp. 1389-1397, August 2008.
- [11] Z. G. Wang, Z. H. Liang, C. L. Liu, “A real time image processor with combining dynamic contrast ratio enhancement and inverse gamma correction for PDP,” Displays, Vol. 30, Issue 3, pp 133-139, July 2009.
- [12] T. Celik, T. Tjahjadi, “Contextual and variational contrast enhancement,” IEEE Transactions on Image Processing, Vol. 20, No. 12, pp. 3431-3441, December 2011.
- [13] S. Ashish, S. Rajeev, P. Yogadhar, “An exhaustive analysis on various foggy image enhancement techniques,” International Journal of Advanced Research in Computer Science and Electronics Engineering, Vol. 3, No. 1, pp. 11-17, January 2014.
- [14] S. Mohanram, B. Aarthi, C. Silambarasan, T. Joyce Selva Hephzibah, “An optimized image enhancement of foggy images using gamma adjustment,”