# A REVIEW ON IMAGE ENHANCEMENT

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***ABSTRACT:*** Image Enhancement is one of the most important and difficult techniques in image research. The aim of image enhancement is to improve the visual appearance of an image, or to provide a "better transform representation" for future automated image processing. Many images like medical images, satellite images, aerial images and even real life photographs suffer from poor contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in medical imaging and analysis is based on Image Enhancement techniques which improve the quality (clarity) of images for human viewing, removing blur and noise, increasing contrast, and revealing details are examples of image enhancement operations. The enhancement technique differs from one field to another according to the objective. The existing techniques of image enhancement can be classified into various categories namely: Contrast, Frequency domain, point processing enhancement and histogram equalization. In this paper, I present an overview of Image Enhancement processing techniques in various domains focussing on histogram equalization method. More specifically, processing methods are categorized based on representative techniques of Image Enhancement.

Keywords-**contrast; blur; frequency domain; point processing; histogram equalization**

## Introduction

Image processing involves the processing of image such as altering, enhancement, compressing etc the existing image. Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

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 is used to improve the quality of an image for visual perception of human beings. It is also used for low level vision applications. Image enhancement is the mechanism to process the input image to make it more appropriate and clearly visible for the required application. Image enhancement improves the information content of the image and alters the visual impact of the image on the observer. The objective of image enhancement is to modify attributes of an image to make it more suitable for a specific task. In the image enhancement process, one or more attributes of the image are modified and processed.

## Literature Survey

### 1. Contrast Enhancement

Contrast enhancement techniques expand the range of brightness values in an image so that the image can be efficiently displayed. The density values in a scene are literally pulled farther apart, that is, expanded over a greater range. The effect is to increase the visual contrast between two areas of different uniform densities. This enables the analyst to discriminate easily between areas initially having a small difference in density.

### 1.1 Linear Contrast Stretch

This is the simplest contrast stretch algorithm. The gray values in the original image and the modified image follow a linear relation in this algorithm. A density number in the low range of the original histogram is assigned to extremely black and a value at the high end is assigned to extremely white. The remaining pixel values are distributed linearly between these extremes. The features or details that were obscure on the original image will be clear in the contrast stretched image. Linear contrast stretch operation can be represented graphically as shown below in the paper. To provide optimal contrast and color variation in color composites the small range of gray values in each band is stretched to the full brightness range of the output or display unit.

Linear contrast enhancement also known as contrast stretching, the original image can linearly expand into a new distribution. The total range of sensitivity of the digital device can be utilized by expanding the original value of an image. This method of enhancement is mostly used in remote sensing images.

### 1.2 Non-Linear Contrast Enhancement

In this method, the input and output data values follow a non-linear transformation. The general form of the non-linear contrast enhancement is defined by y = f (x), where x is the input data value and y is the output data value. The non-linear contrast enhancement techniques have been found to be useful for enhancing the color contrast between the nearly classes and subclasses of a main class. A type of non linear contrast stretch involves scaling the input data logarithmically. This enhancement has greatest impact on the brightness values found in the darker part of histogram. It could be reversed to enhance values in brighter part of histogram by scaling the input data using an inverse log function.

Through the use of an algorithm the non linear contrast enhancement involves the histogram equalization method. The limitation of non linear contrast enhancement is that in which the each value of input image have several values in the output image, due to this the original object lose their accurate brightness.

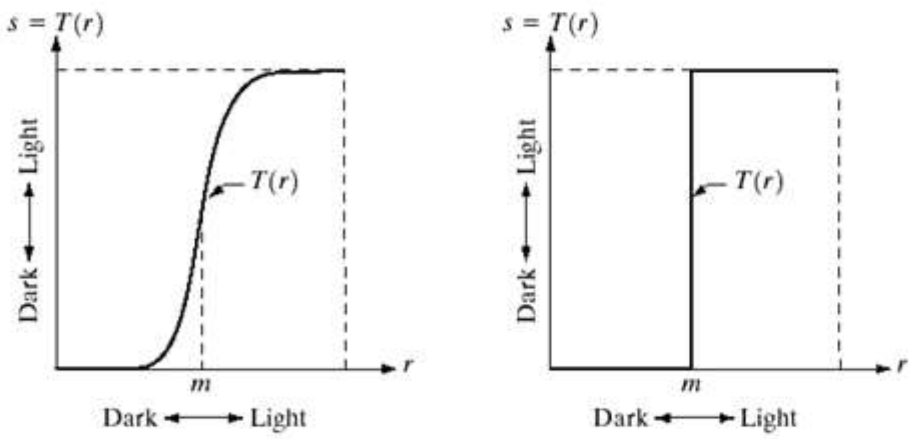


Figure: - Gray level transformation for contrast enhancement

## 2. Frequency Domain Techniques

Frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are suited for processing the image according to the frequency content. The principle behind the frequency domain methods of image enhancement consists of computing a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform. The orthogonal transform of the image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The phase is used to restore the image back to the spatial domain. The usual orthogonal transforms are discrete cosine transform, discrete Fourier transform, Hartley Transform etc. The transform domain enables operation on the frequency content of the image, and therefore high frequency content such as edges and other subtle information can easily be enhanced. Frequency domain which operate on the Fourier transform of an image.

(i) Edges and sharp transitions (e.g. noise) in an image contribute significantly to high frequency content of Fourier transform.
(ii) Low frequency contents in the Fourier transform are responsible to the general appearance of the image over smooth areas.
The concept of filtering is easier to visualize in the frequency domain. Therefore, enhancement of image function let f(x, y) can be done in the frequency domain based on DFT.

### 3. Point Processing Method

The point processing methods are most primitive, yet essential image processing operations and are used primarily for contrast enhancement. Image Negative is suited for enhancing white detail embedded in dark regions and has applications in medical imaging. Power-law transformations are useful for general purpose contrast manipulation. For a dark image, an expansion of gray levels is accomplished using a power-law transformation with a fractional exponent. Log Transformation is useful for enhancing details in the darker regions of the image at the expense of detail in the brighter regions for the higher-level values. For an image having a washed-out appearance, a compression of gray levels is obtained using a power law transformation with $\gamma$ greater than 1. The histogram of an image (i.e., a plot of the gray level frequencies) provides important information regarding the contrast of an image. Histogram equalization is a transformation that stretches the contrast by redistributing the gray-level values uniformly.

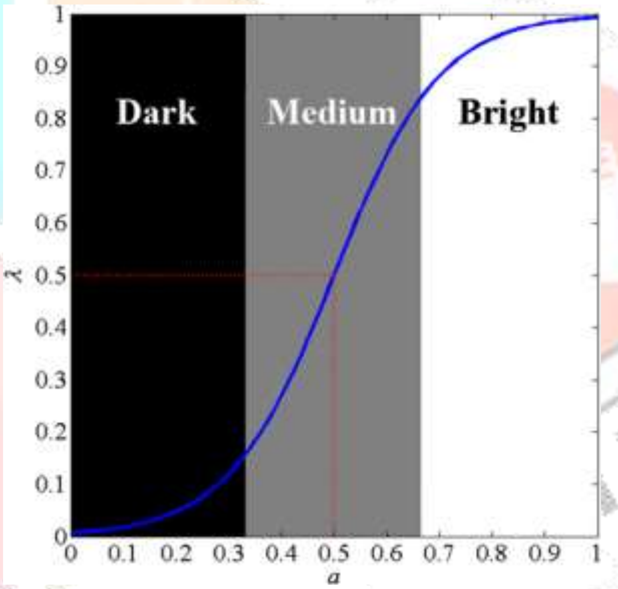


**Figure**: - The average brightness a(x) can be simply divided into dark, medium and bright three areas

### 4. Histogram Equalization

Histogram of a discrete gray-level image represents the frequency of occurrence of all the gray levels in the image. Histogram based techniques are the most popular digital image processing techniques which can be used for image enhancement owing to their simplicity and effectiveness besides being economical. Histogram based techniques for image enhancement, are mostly based on equalizing the histogram of the image which increase the dynamic range corresponding to the image. It can be categorized into two methods: - Global Histogram Equalization (GHE) and Local Histogram Equalization (LHE).

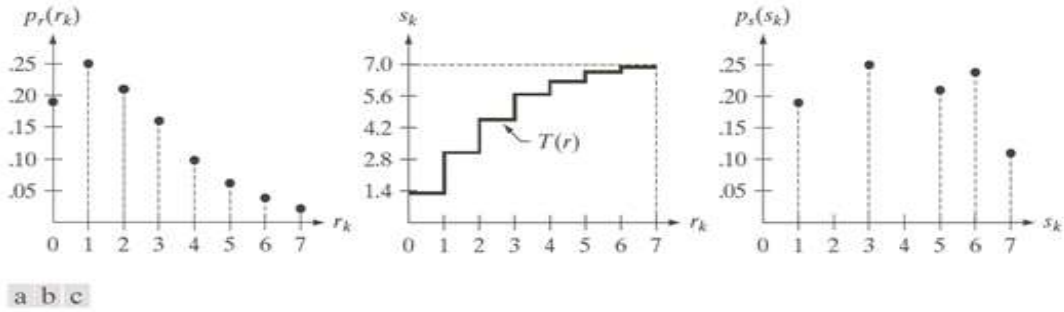


**Figure: -** Histogram Equalization of a 3-bit (8 intensity levels) image. (a) Original Histogram. (b) Transformation Function. (c) Equalized histogram

### 4.1 Global HE

Global Histogram Equalization (GHE) is one of the popular methods used to enhance the contrast of image. In GHE, the histogram of whole input image is first obtained, then the Cumulative Distribution Function (CDF) is calculated and gray transfer function is derived from the CDF. Though it is simple, it doesn't take account of local image information and often cause some contrast losses in small regions. GHE has been widely used in many areas such as medical and radar imaging. Although this global approach is suitable for overall enhancement, it fails to adapt the local brightness features of the input image and shifts the mean intensity to middle intensity level, regardless of input mean intensity. GHE is rarely used in consumer electronics such as digital cameras because it may produce undesirable distortions such as: excessive brightness change, noise-artifacts, gray-level saturation and unnatural enhancement.

### 4.2 Local HE

To overcome the shortcoming of GHE, a Local Histogram Equalization (LHE) method has been developed. In this method, a contextual region is first defined, a histogram of that region is obtained, and then its gray level transfer function is derived from its CDF. Thereafter, the center pixel of the region is histogram equalized using this function. The center of rectangular region is then moved to adjacent pixel and the histogram equalization is repeated. This method allows each pixel to adapt to its neighboring region, so that high contrast can be obtained for all locations in the image. This method is also known as Adaptive Histogram Equalization (AHE). However, since LHE (or AHE) must be performed for every pixel in the entire image, the computation complexity is very high. Hence, LHE can remove the local brightness problem; however the overlapping sliding mask mechanism makes the LHE computationally expensive.

### Implementation

The techniques mentioned above are compared based on subjective as well as objective parameters in this work. The algorithmic steps involved in these techniques are outlined below:-

**GHE Method**

*Algorithm Steps:-*

The Histogram of digital image $X=\{X\ (i,\ j)\}$, with $L$ discrete intensity levels denoted by $\{X0,1,\ldots\ldots..,XL-1\}$, is defined as:-

H($X_k$ )=$n_k$,for $k$=0,1,…,$L$−1 *(i)*

Where $X_k$ is the $k$th intensity value and $n_k$ is the number of pixels in the image with intensity $r_k$. For an M × N image, a normalized histogram known as Probability Density Function (PDF) is defined by:-

$p\ (X_k) = \frac{n_k}{MN}$ , for $k$=0,1,…,$L$−1 *(ii)*

Where $p(X_k)$ gives an estimate of the probability of occurrence of gray level $X_k$ in an image. Based on the PDF, the Cumulative Density Function (CDF) is defined as:-

$c(X_k)= \sum_{j=0}^{k} p(x_j)$ ,for k=0,1,…,L−1 (iii)

GHE enhances $X=\{X(i,j)\}$, by using CDF as its transformation function. This transformation function, $f(X_k)$, is defined as:-

$(X_k) = X_0 + (X_L - 1 - X_0)c(X_k)$ *(iv)*

Then the output image produced by GHE, $Y=\{Y(i,j)\}$ can be expressed as:-

$Y=(x)$ (*v*)

$Y=\{(X(i,j)|\forall X(i,j)\in X\}$ *(vi)*

Although GHE successfully increases the contrast in the image, this method does not put any constraint in preserving the mean brightness.

**LHE Method**

*Algorithm Steps:-*

(a) Calculate number of rows and columns in an input image i.e. size of an image. Also obtain number of bins for the histograms used in building image transform function i.e. dynamic range.

(b) Pre-process the inputs obtained in step 1 to determine real clip limit from the normalized value. If necessary, pad the image before splitting it into regions.

(c) Process each contextual region (tile) thus producing gray level mappings: Extract a single image region, make a histogram for this region using the specified number of bins, clip the histogram using clip limit, and create a mapping (transformation function) for this region.

(d) Interpolate gray level mappings in order to assemble final LHE image: Extract cluster of four neighboring mapping functions, process image region partly overlapping each of the mapping tiles, extract a single pixel, apply four mappings to that pixel, and interpolate between the results to obtain the output pixel; repeat over the entire image.

## 5. Techniques

- **DWT**

The decomposition of images into various frequency ranges permits the isolation of the frequency into certain sub-bands. This process results in isolating small changes in an image mainly in low frequency sub-band images. The 2D wavelet decomposition of an image is performed by applying 1D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This Decomposition results in four decomposed sub-band images referred to as low-low (LL), low-high (LH), high-low (HL), and high-high (HH). The Haar wavelet was introduced in 1910. It is a bipolar step function. The other wavelets are Daubechies Wavelet, Morlet Wavelet, Mexican Hat Wavelet and Shannon Wavelet.

- **DCT**

The DCT transforms or converts a signal from spatial domain into a frequency domain. DCT is real-valued and provides a better approximation of a signal with few coefficients. This approach reduces the size of the normal equations by discarding higher frequency DCT coefficients. Important structural information is present in the low frequency DCT coefficients. Hence, separating the high-frequency DCT coefficient and applying the illumination enhancement in the low–frequency DCT coefficient, it will collect and cover the edge information from satellite images. The enhanced image is reconstructed by using inverse DCT and it will be sharper with good contrast.

- **SVD**

SVD is based on a theorem from linear algebra which says that a rectangular matrix A, which is a product of three matrices that is (i) an orthogonal matrix UA, (ii) a diagonal matrix ΣA and (iii) the transpose of an orthogonal matrix VA. The singular-value-based image equalization (SVE) technique is based on equalizing the singular value matrix obtained by singular value decomposition (SVD). SVD of an image, can be interpreted as a matrix.

Basic enhancement occurs due to scaling of singular values of the DCT coefficients. The singular value matrix represents the intensity information of input image and any change on the singular values change the intensity of the input image. The main advantage of using SVD for image equalization, ΣA contains the intensity information of the image.

Mean ($\mu$) is the average of all intensity value. It denotes average brightness of the image, where as standard deviation is the deviation of the intensity values about mean. It denotes average contrast of the image. Here $I(x, y)$ is the intensity value of the pixel $(x, y)$, and $(M, N)$ are the dimension of the Image.

**Proposed Work**

Satellite images are low contrast and dark images, which has complete information but is not visible. Similarly CT scans are also dark images. So the enhancement of such images will help to get more information. The problem is how the contrast of an image can be improved from the input satellite images and CT images. Here a new contrast enhancement technique is proposed. There are three parts involved. First one is dividing the image into four blocks so that the operation can be done on each block. Then DWT followed by DCT and SVD. The result shows that images are visibly enhanced using DWT-DCT-SVD method by incorporating AHE.

**Conclusion and Applications**

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions.

We focus on the existing techniques of image enhancement, which can be classified into various categories. We show the existing technique of image enhancement and discuss the advantages and disadvantages of these algorithms.

Although here, the computational cost of enhancement algorithms may play a critical role in choosing an algorithm for real-time applications.

I. Image enhancement is used for enhancing the quality of images. The applications of image enhancement are Aerial imaging, Satellite imaging, Medical imaging, Digital camera application, Remote sensing, Image Enhancement techniques used in many areas such as forensics, Astrophotography, Fingerprint matching, etc.

II. The better result for Image enhancement has also been used in real time enhancement of neuro evolution of augmenting. IE techniques when applied to pictures and videos help the visually impaired in reading small print, using computers and television, and face recognition.

III. Color contrast enhancement, sharpening and brightening are just some of the techniques used to make the images vivid. In the field of e-learning, IE is used to clarify the contents of chalkboard as viewed on streamed video; it improves the content readability.

IV. Medical imaging uses this for reducing noise and sharpening details to improve the visual representation of the image. This makes IE a necessary aiding tool for reviewing anatomic areas in MRI, ultrasound and x-rays.

V. In forensics IE is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims.

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