COMPREHENSIVE REVIEW ON VARIOUS TECHNIQUES OF IMAGE ENHANCEMENT

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Abstract- Image enhancement is one of the key issues in high quality pictures such as digital cameras. Since image clarity is very easily affected by lighting, weather, or equipment that has been used to capture the image. These conditions lead to image may suffer from loss of information. The main purpose of image enhancement is to bring out detail that is hidden in an image or to increase contrast in a low contrast image. It gives a large number of choices to enhancing the visual quality of images. That's why it is used in a huge number of applications with important challenges such as noise reduction, degradations, blurring etc. The existing techniques of image enhancement can be classified into two categories: Spatial Domain and Frequency domain enhancement. Thus, this paper reviews various methods for Image Enhancement.

Keywords- Enhancement, Spatial Domain Technique, Transform Domain Technique Histogram equalization, RGB, Degradation, Contrast Enhancement, Thresholding Transformation

I. Introduction

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The main objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task [1]. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. Enhancement of digital image without spoiling is done by various techniques. The survey of available techniques is based on the existing techniques of image enhancement, which can be classified into two broad categories: Spatial based domain image enhancement and Frequency based domain image enhancement. Spatial based domain image enhancement operates directly on pixels. The main advantage of spatial based domain technique is that they conceptually simple to understand and the complexity of these techniques is low which favours real time implementations. But these techniques generally lacks in providing adequate robustness and imperceptibility requirements. Frequency based domain image enhancement is a term used to describe the analysis of mathematical functions or signals with respect to frequency and operate directly on the transform coefficients of the image, such as Fourier transform, discrete wavelet transform (DWT), and discrete cosine transform (DCT). The basic idea in using this technique is to enhance the image by manipulating the transform coefficients. The advantages of frequency based image enhancement includes low complexity of computations, ease of viewing and manipulating the frequency composition of the image and the easy applicability of special transformed domain properties [2]. The basic limitations including are it cannot simultaneously enhance all parts of image very well and it is also difficult to automate the image enhancement procedure. Traditional methods of image enhancement are to enhance the low quality image itself. It doesn't embed any high quality background information. The reason is that in the dark image, some areas are so dark that all the information is already lost in those regions. No matter how much illumination enhancement you apply, it will not be able to bring back lost information.
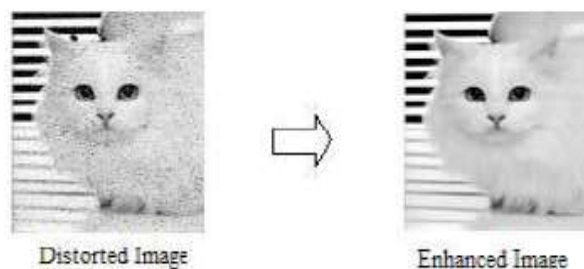

Distorted Image → Enhanced Image

Fig.1: Image enhancement

Image enhancement [3] is mainly increasing the observation of information in images for individual viewers and providing improved input for other image processing methods. The principal aim of image enhancement is to alter attributes of an image to make it more appropriate for a given job and a specific observer. Contrast enhancement has great significance in digital image processing. Histogram Equalization (HE) is one of the most popular, computationally fast and simple to implement techniques for contrast enhancement of digital images [3]. A histogram is a graphical representation of the distribution of data. An image histogram is a graphical representation of the number of pixels in an image as a function of their intensity.
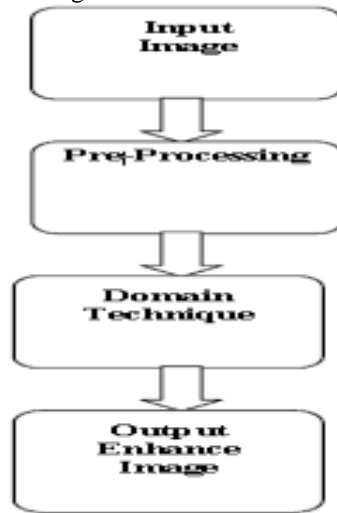

Fig. 2: Basic Steps of Image Enhancement

In figure, the basic processing of image enhancement is explained. The steps are as follows:

- Input image: In this first an image will be taken as an input. These images can be medical images, blur images, remote sensing images machine vision, the military applications etc.
- Perform pre-processing on the image: Images that will be taken as input can be blur image or noisy image so the various pre-processing methods will be performed on those images before applying enhancement technique.
- Applying Domain Techniques: After applying pre-processing method on input images then image quality will be enhanced by using Image enhancement domain techniques such as spatial or transformation.
- Output Enhanced Image: In this the output image will be get which is an enhanced image.

Image enhancement essentially means, changing an image f into image g utilizing T. (Where T is the change. The estimations of pixels in images f and g are meant by r and s, respectively. As said, the pixel values r and s are related by the expression,

$$s = T(r) \qquad (1)$$

Where T is a transformation that maps a pixel value r into a pixel value s. The consequences of this change are mapped into the grey scale range as we are dealing here just with grey scale digital images. So, the outcomes are mapped again into the range [0,L-1], where L=2k, k being the number of bits in the image being considered. So, for instance, for an 8-bit image the range of pixel values will be [0, 255].

II. **Objective**

- The main objectives of image Enhancement strategies is to process a picture so that the outcome is more suitable than the original picture for a particular application.
- The enhancement doesn't increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily.
- Image Fusion for the independent edge components and principle edge components and convolution with single RGB layer in spatial domain..
- To compare parameters like peak signal to noise ratio, mean square error, cross correlation based on different techniques of Image Enhancement
- It complements or hones image features for example, edges, boundaries, or contrast to make a graphic display more supportive for display and investigation.
- The most prominent trouble in image enhancement is measuring the standard for enhancement and, thus, a large number of image enhancement strategies are exact and require intelligent procedures to acquire satisfactory results.

III. Spatial Domain Methods

Spatial domain technique deals directly with the pixels of the given image. The manipulation of pixels is done to achieve image enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization are based on the direct manipulation of the pixels in the image. Spatial techniques are particularly useful for directly altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results [4]. It is not possible to selectively enhance edges or other required information effectively. Techniques like histogram equalization are effective in many images.

A) Point Processing Operation
The simplest spatial domain operations occur when the neighbourhood is simply the pixel itself. In this case *T* is referred to as a grey level transformation function or a point processing operation. Point processing operations take the form shown in equation (1).
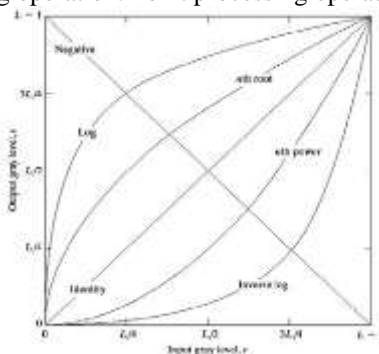

Fig 3. Basic grey level transformations

- **Create Negative of an Image**

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 R x C, where R represents number of rows and C represents number of columns, is represented by I(r, c). The negative N(r, c) of image I(r, c) can be computed as

$$N(r, c) = 255 - I(r, c) \text{ where } 0 <= r <= R \text{ and } 0 <= c <= C \qquad (2)$$

It can be seen that every pixel value from the original image is subtracted from the 255. The resultant image becomes negative of the original image. Negative images are useful for enhancing white or grey detail embedded in dark regions of an image.
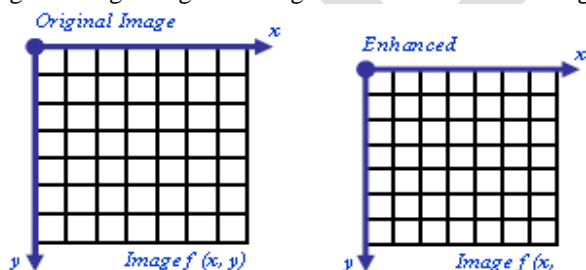
$$s = intensity_{max} - r \qquad (3)$$

- **Thresholding Transformations**

Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background as shown in figure below
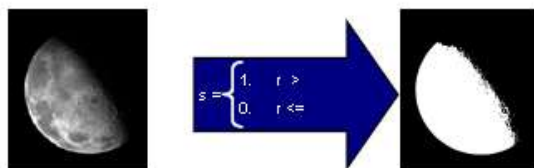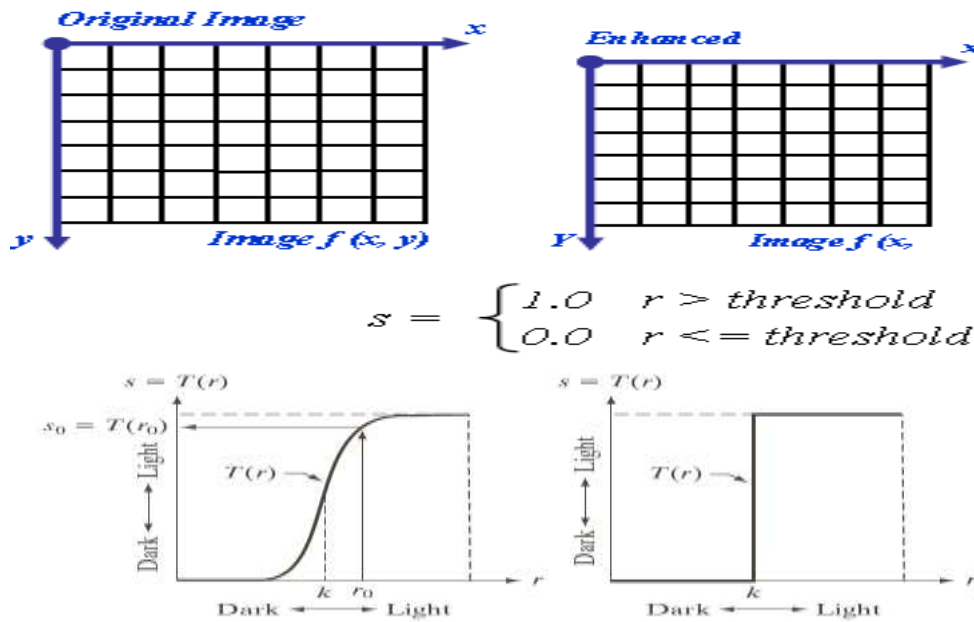

Fig 4. Showing effect of thresholding transformation for isolating object of interest

$$s = \begin{cases} 1.0 & r > threshold \\ 0.0 & r <= threshold \end{cases}$$

- **Logarithmic Transformations**

The general form of the log transformation is

$$s = c * log\,(1 + r) \quad (4)$$

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 [5]. Log functions are particularly useful when the input grey level values may have an extremely large range of values. In the following example the Fourier transform of an image is put through a log transform to reveal more detail.
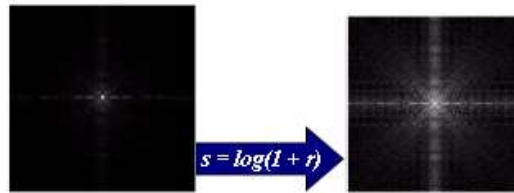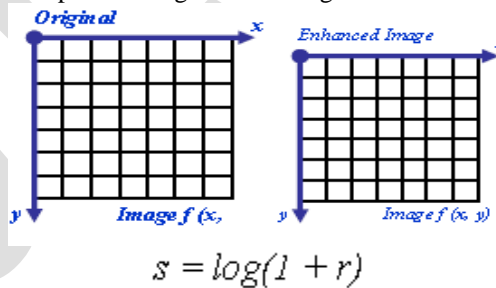

Fig 5. Example showing effect of Logarithmic transformation

$$s = log(1 + r)$$

We usually set *c* to 1. Grey levels must be in the range [0.0, 1.0]

- **Powers-Law Transformations**

The *n*th power and *n*th root curves indicated in fig. A can be given by the statement,

$$s = cr^{\gamma} \quad (6)$$

This transformation function is also called as *gamma* correction. For different estimations of γ distinctive levels of enhancements can be obtained. This procedure is usually called as *Gamma Correction*. In the event that you recognize, distinctive display monitors display images at diverse intensities and clarity. That implies, each monitor has built-in gamma correction in it with certain gamma ranges thus a good monitor consequently amends all the images showed 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 utilizing the power-law function a family of

possible transformation curves can be obtained just by varying the λ. These are the three essential image enhancement functions for grey scale images that can be connected effortlessly for any sort of image for better contrast and highlighting. Utilizing the image negation formula given above, it is not necessary for the outcomes to be mapped into the grey scale range [0, L-1]. Yield of L-1-r naturally falls in the scope of [0, L-1]. Be that as it may for the Log and Power-Law transformations resulting values are frequently quite distinctive, depending upon control parameters like λ and logarithmic scales. So the consequences of these values ought to be mapped back to the grey scale range to get a meaningful output image. For instance, Log function $s = c\ log\ (1 + r)$ brings about 0 and 2.41 for r varying between 0 and 255,
keeping c=1. Along these lines, the extent [0, 2.41] ought to be mapped to [0, L-1] for getting a meaningful image.

- **Grey Level Slicing**

Grey level slicing is the spatial domain proportional to band-pass filtering [6]. A grey level slicing function can either accentuate a gathering of intensities and lessen all others or it can stress a group of grey levels and allow the rest to sit unbothered. Example is shown in the following figure
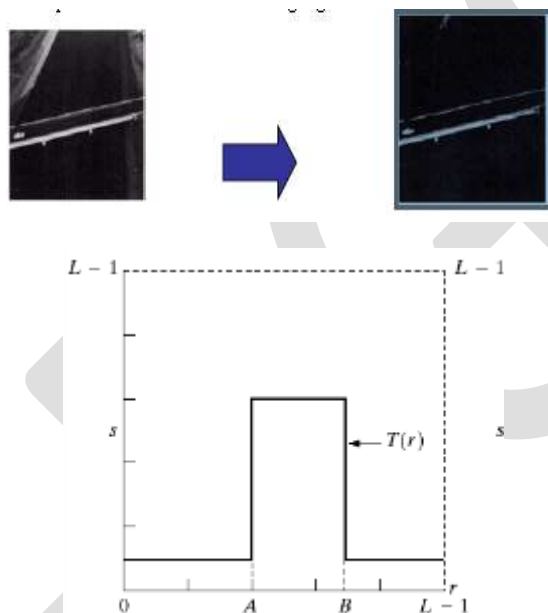

Fig 6. Showing example of Grey level slicing

B) Histogram Processing

The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function

$$h(r_k) = n_k$$

k^{th} intensity value — Number of pixels in the image with intensity r_k

Histograms are frequently normalized by the total number of pixels in the image. Assuming an M x N image, a normalized histogram.

$$p(r_k) = \frac{n_k}{MN}, \quad k = 0, 1, ... L-1$$

is related to probability of occurrence of rk in the image.

- **Histogram Equalization**

Histogram equalization [7] is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram[8]. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer.
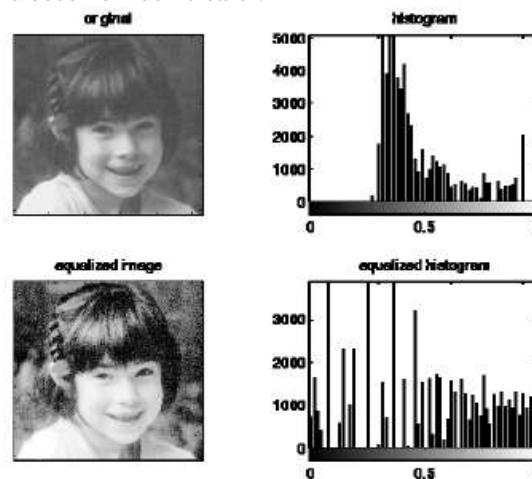

Fig 7. The original image and its histogram, and the equalized versions. Both images are quantized to 64 grey levels.

- **Histogram Matching**

Histogram equalization [9] automatically determines a transformation function seeking to produce an output image with a uniform histogram. Another method is to generate an image having a specified histogram is histogram matching. Histogram matching enables us to "match" the grayscale distribution in one image to the grayscale distribution in another image.

- **Local Enhancement**

Previous methods of histogram equalizations and histogram matching are global. So, local enhancement [10] is used. Define square or rectangular neighborhood (mask) and move the center from pixel to pixel. For each neighborhood, calculate histogram of the points in the neighborhood. Obtain histogram equalization/specification function. Map gray level of pixel centered in neighborhood. It can use new pixel values and previous histogram to calculate next histogram.

IV. 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[11]. 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.

- Edges and sharp transitions (e.g. noise) in an image contribute significantly to high frequency content of Fourier transform.
- 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 f(x, y) can be done in the frequency domain based on DFT. This is particularly useful in convolution if the spatial extent of the point spread sequence h(x, y) is large then convolution theory.

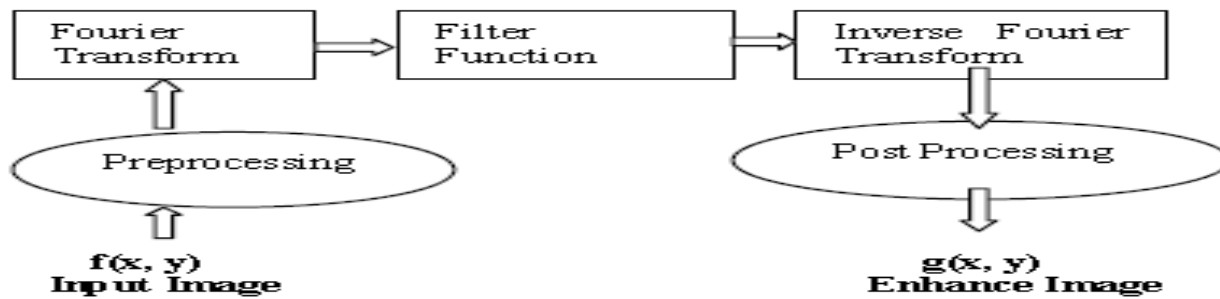$$g(x, y) = h(x, y) \square\ f(x, y)$$

where g(x, y) is enhanced image.

Fig 8. Concept of Filter function.

Conclusion- There are different possible ways to study various techniques of Image Enhancement. Some of them are-Contrast Entropy Based, Hybrid Based, Histogram Based, Hypothesis Selection Based and Median and High Pass Filter Based. The parameter like Signal to noise ratio, Mean Square Error, Cross Correlation etc. show variation on being applied to these techniques. But in the most of techniques it has been found that the available technique does not provide best possible result. It will provide better results than the existing techniques. But in the most of techniques it has been found that the available technique does not provide best possible result. It will provide best possible result. It will provide better results than the existing techniques. Most contrast of the entire image . But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results.

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. As discussed earlier the image enhancement technique can be improved by modifying the hue and saturation. It will provide better results than the existing techniques. Most of the techniques are useful for altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results.

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