A Review:
Study of Various Image Enhancement Techniques

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Abstract—**Image enhancement is a basic and Very essential step in image processing. The main aim of image enhancement is to process an image and to improve the visual quality of the image, so that the resultant image is 'better' than the original image for specific application and human viewers. Enhancement operation include improving the quality of images for human viewing, removing blurring and noise, increasing contrast and revealing details (to bring out the hidden details). Many images and even real life photograph suffer from poor contrast and noise so, it is essential to enhance the contrast and to reduce the noise for better quality of image. Image enhancement is broadly classified into two techniques namely**

1) **Spatial domain method.**
2) **Frequency domain method.**

This paper emphasis on the review of different techniques of image enhancement.

Keywords— Image enhancement, Spatial domain enhancement and Frequency domain enhancement .

I.   INTRODUCTION

Image enhancement is one of the major technique used in digital image processing (DIP). It is applied in every field of science where images are understood and analysed [4]. Image enhancement is the technique to improve the interpretability or perception of information in images for human viewers [1]. The intension behind enhancement is to bring out clear detail that is obscured [2]. Restoration of image can be done using enhancement which is caused due to electronics and/or environment or optics or degradation. Various processing methods such as imaging, scanning or transmitting are used to convert the pictures from one form to another but the output image may be inferior to the original input picture [3]. It does not add any extra information to the original image it just improves the quality of the image. High dynamic resolution image consists of both dark and bright regions. By using application of enhancement technique quality of the degraded images can be improved. Enhancement algorithm that works fine in one case, may be completely different for another.

Fig.1: Basis step of image enhancement

Fig.2: Showing the effect of Image Enhancement

II.   DOMAIN TECHNIQUES

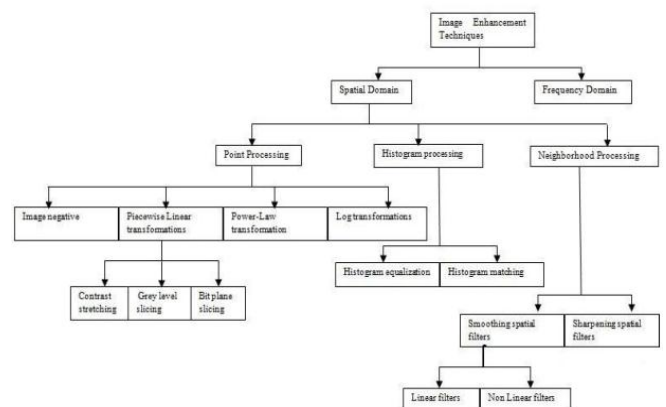Image enhancement can be broadly classified into two types:

Fig.3: Classification of Image enhancement techniques

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A. SPATIAL DOMAIN METHOD

This domain method directly deals with manipulation of pixels in an given image so that the desired enhancement is achieved [5]. Spatial domain techniques like logarithm transform, power law transform, histogram equalization are based on the direct manipulation of the pixels in the image. Grey level values of individual pixels are directly altered using this technique and hence, overall contrast of the entire image is altered. In many cases enhancing the whole image in a uniform manner usually leads to undesirable results [6]. It is not possible to selectively enhance edges or other required information effectively. The main advantage of this method is easy to understand and less complex.

It is broadly classified in to 3 types:

A.1 Point processing

A.2 Histogram processing

A.3 Neighborhood processing.

A.1 Point Processing (Intensity Transformation Function)

As operations are performed on single pixel, this is considered as simpler domain operation. Point processing consist of brightness control, contrast stretching, thresholding, Histogram equalization. Pixel values of a processed image depend on pixel value of original image. This can be classified in to four categories.

A.1.1 Image Negative (Digital Negative)

In this technique, the gray level values of the pixels in an image are inverted to get its negative image. Image negative is useful in many applications like X-Ray image [4]. Image negative is mainly useful for enhancing white or gray details in dark regions of an image.

A.1.2 Piecewise-linear Transformation

Piecewise linear transformation is an arbitrary user defined transformation. The form of Piecewise function can be arbitrarily complex. Piecewise transformation requires more user input specification. It is classified in to three types:

A.1.2.a Contrast Stretching

The main key is to improve the quality of an image by increasing the dynamic range of gray level to make it look better to human viewers [8][9].Contrast stretching is the process that expands the range of intensity levels in an image. The details in dark or bright regions are brought out and revealed to the observer. Difference between intensity of two adjacent pixel is represented as Contrast. It increases the contrast of the image by making dark portions darker and bright portion brighter.

A.1.2.b Grey Level Slicing (Intensity level Slicing).

Grey level slicing is equivalent to band pass filtering in frequency domain [1].Grey level slicing highlights certain level of grey level pixels in the original image and diminish all other. The main objective of this technique is to group the grey levels of the image.

A.1.2.c Bit Plane Slicing:

Bit plane slicing is used to highlight the contribution made to the total image appearance by specific bits. The importance of each bit in the image can be analyzed by decomposing an image in to its bit planes and bit plane slicing is also useful in image compression.

A.1.3 Power Law Transformation:

It is given by the expression $S=cr^\gamma$ where S is output grey level, r is input grey level, c is a positive constant and γ is the power to which input grey level is raised [11].Since γ is used this function is also called as gamma correction and γ is called gamma correction factor. Different levels of enhancement can be achieved by various γ values. This would give a low range of dark input values into a higher range of output values. By changing the γ values, transformation curve can be obtained.

A.1.4 Logarithmic Transformation:

In this transform, the grey levels of image pixels are altered. It is used for contrast enhancement. It is given by the equation $s=c\ log(1+r)$ where s is output grey level, r is input grey level and c is constant. Mapping of low input grey values in to high range of output value is done [10]. Difference between power law transform function and logarithmic transform function is that the large number of curves can be obtained by changing γ values.

A.2 Histogram Processing:

A graphical representation of distribution of data is called Histogram. An image histogram is a graphical representation of number of pixels in an image as a function of their intensity. Histogram is very simple to calculate in software and hardware implementation. Histogram can be classified in to two types:

A.2.1 Histogram Equalization:

Histogram Equalization is one of the most common techniques for enhancing the appearance of digital images because of its simplicity and elegancy. Histogram Equalization is used to stretch the histogram of a given image. The main aim is not only to spread the dynamic range, but also to have equal pixels in all the grey levels this is called Histogram Equalization [7]. Image would become much clearer if we stretch out grey levels at the dark end to produce more flat uniformly distributed histogram.

A.2.2 Histogram Specification (Matching)

In this method, the shape of the histogram is specified manually that processed image to have is called Histogram specification [4].Automatic enhancement is desired, because the results from this technique are very simple to implement and we can predict the result in advance. In this, grey scale distribution in one image is matched with grey scale distribution in another image.

A.3 Neighborhood processing (SPATIAL Filters)

It operates on neighborhood of every pixel in an image. Filtering [14] creates a new pixel with co-ordinates equal to the co-ordinates of the center of the neighborhood and whose value is the result of filtering operation. It consists of a predefined operation that is performed on the image pixels encompassed by the neighborhood. By using spatial filters, we can obtain smoothing directly on the image itself. It is categorized into two types.

A.3.1 Smoothing spatial filters:

These are basically used blurring (i.e. smoothing) and for reduction of noise in images. It can be accomplished by blurring with linear and nonlinear filters.

A.3.1.a Smoothing linear filters

It is also known as low pass filter and sometimes these filters are also called as averaging filters. The output of this is simply the average of the pixels contained in the neighborhood of the filter mask [13]. Averaging filters works on the principle of replacing the value of every pixel in an image defined by the mask. This process results with reduced 'sharp' transitions.

A.3.1.b Smoothing nonlinear filters

The enhanced image is not related to pixel in the neighborhood of original image. It is also known as high pass filter. This filter provides less blur but rounds corners. It removes salt and pepper noise. It has max filter, median and min filter.

A.3.2 Sharpening spatial filters

The term sharpening is referred to the technique used for highlighting the fine detail of an image and enhancing the intensity transition. Image sharpening emphasizes edges but details might be lost. Using spatial differentiation sharpening of image can be accomplished. The derivatives of the images are related to intensity transition between adjacent pixels.

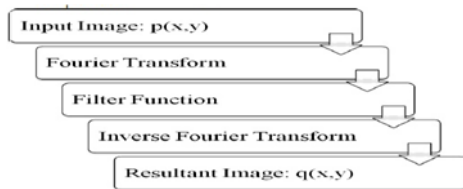### B. Frequency domain method (transform domain method)

Fig.4: Steps of frequency domain method

In this technique the original image is transferred in to frequency domain i.e. Fourier transform of image is computed first. The images are processed according to frequency content. According to the transformation function applied on input values, the pixel value of the output image changes. In order to modify the image brightness, contrast or distribution of grey levels the enhancement operation are performed. All the enhancement operations are performed on the Fourier transform of the image and then the inverse Fourier transform is performed to the resultant image [12]. It operates directly on the transform coefficient of the image such as FT, DWT, DCT. It comprise of low complexity of computation and easy applicability of special transformed domain properties. It cannot enhance all parts of image at once and finds difficult to replace the image enhancement procedure. It is classified in to four types namely

1) Low pass filtering
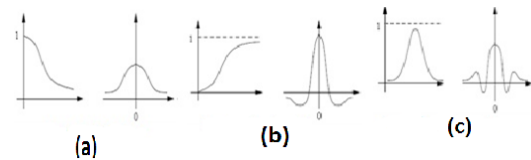2) High pass filtering
3) Homomorphic filtering

Fig.5: (a) low pass filter. (b) high pass filter. (c) homomorphic filter

B.1 Low pass filtering

A low pass filter smooth's edges and sharp transitions as the grey level contribute to the high frequency content of its Fourier transform. It eliminates low frequency components. In an image, region of relatively uniform grey values contribute to low frequency content of its Fourier transform. There are three types of low pass filters namely

1) Butterworth low pass filter
2) Gaussian low pass filter
3) Ideal low pass filter

B.2 High pass filtering

Without disturbing the high frequency information, high pass filter can sharpen the edges of an image by downgrading the low frequency components. It is used as a surround function. It is reverse operation of low pass filtering. It is classified in to three types namely

1) Butterworth high pass filter
2) Gaussian high pass filter
3) Ideal high pass filter

B.3 Homomorphic filtering

This technique is applied on low contrast images. By increasing the contrast of an image it decreases the brightness across the image. The main principle of this technique is to remove radiance in the image. Some part of the image is destroyed during this process which does not require enhancement and it is recovered using a threshold after applying this technique [13].

III. APPLICATIONS

Now a day's image enhancement technique is applied in every field, for 'better' quality of images. Image enhancement techniques provide variety of approaches for changing images to get the required acceptable images. The various applications of image enhancement are Aerial imaging, Satellite imaging, Medical imaging, CCTV Footage, Digital camera application, Remote sensing, Forensics, Astrophotography, Fingerprint matching, for reviewing anatomic areas in MRI and many more. In real time it is used for enhancement of neuro evolution of augmenting. When this technique is applied to pictures and videos help the visually impaired in reading small print, using computers and television and face recognition. In e-learning field IE improves the content readability.

IV. CONCLUSION

This paper presents a short review of various image enhancement techniques. Two methodologies of image enhancement techniques are discussed with their types, advantages and disadvantages. Spatial domain technique is one

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of the most important and difficult component of digital image processing and the results for each method are discussed. In this survey, we focus on the existing technique of image enhancement which can be broadly classified into two categories as Spatial domain enhancement and Frequency domain enhancement. Spatial domain enhancement improves the overall image by manuplating the pixels and frequency domain enhancement are used to enhance the selected objects mainly the edges of image.

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