A Review of Image Enhancement Techniques to Increase Contrast

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Abstract— Captured images generally have low contrast and high noise; sometimes they are badly illuminated, dark or hazy. Improving Quality of those images is always a difficult, challenging, as well as an important task in image processing. For resolving image related problems in many fields like biometric, X-rays etc a number of techniques are available. This paper presents comparison of various attempts to observe their effectiveness for searching optimal solutions to enhance the contrast and detail in an image. Experimental results of each technique are compared with other enhancement techniques, viz. histogram equalization, contrast stretching and particle swarm optimization (PSO) etc. Objective evaluation of results obtained Approve the superiority of DE method over the other methods as it significantly enhance detailed regions and produces little noise over-enhancement. It produces a better contrast as compared to other algorithms.

Key words: Image Enhancement, Brightness, Image Contrast Enhancement, Differential Evolution, Image Enhancement, Histogram Equalization, Contrast Stretching, Particle Swarm Optimization

I. INTRODUCTION

A. Image Processing

Image Processing is a technique to improve the quality of raw images received from cameras placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications. In past some years various techniques have been developed in Image Processing. Image Processing systems are becoming popular due to easy availability of powerful personnel computers, large size memory devices, graphics software etc. Image Processing is used in various applications such as: Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Graphic arts and Printing Industry.

1) There are two methods available in Image Processing

Analog Image Processing: Refers to the alteration of image through electrical means. The most common example is the television image.

Digital Image Processing: Digital computers are used to process the image. The image will be converted to digital form using a scanner-digitizer and then process it. It is defined as the subjecting numerical representations of objects to a series of operations in order to obtain a desired result. It starts with one image and produces a modified version of the same. It is therefore a process that takes an image into another.

2) Techniques in the digital image processing:

- Image representation: In computing, all data is logically represented in binary. This is true of images as well as numbers and text. However, an important distinction needs to be made between how image data is displayed and how it is stored. Displaying involves bitmap representation, whereas storing as a file involves many image formats, such as jpeg and png.
- Image preprocessing: In Pre-processing methods we make use of pixel's neighbourhood of input image to get a new brightness value in the output image. Such pre-processing operations are also called filtration.
- Image restoration: To "compensate for" or "undo" defects which degrade an image. Degradation comes in many forms such as motion blur, noise, and camera misfocus.
- Image analysis: To make quantitative measurements from an image to produce a description of it. In the simplest form this task could be reading a label on a grocery item, sorting different parts on an assembly line or measuring the size and orientation of blood cells in a medical image.
- Image reconstruction: reconstruction is activity of constructing image again. Reconstructions improve quality of images and produces more enhanced images
- Image data compression: Compression is a very essential tool for archiving image data, image data transfer on the network, etc. There are various techniques available for lossy and lossless compressions. One of most popular compression techniques, JPEG (Joint Photographic Experts Group) uses Discrete Cosine Transformation (DCT) based compression technique and recently wavelet based compression techniques are used for higher compression ratios with minimal loss of data.
- Image enhancement: To highlight certain image features for furthur analysis or display for eg. contrast and edge enhancement, pseudo-coloring, noise filtering, sharpening, and magnifying etc.
- Image restoration: To "compensate for" or "undo" defects which degrade an image. Degradation comes in many forms such as motion blur, noise, and camera misfocus.

3) Image enhancement

Image Enhancement is highlighting certain image features for analysis or for display. It is the task of applying certain transformations to an input image so as to obtain a visually more pleasant, more detailed, or less noisy output image. In the transformation interpretation and feedback from a human evaluator of the output result image is often required. Therefore, image enhancement is considered a difficult task when attempting to automate the analysis process and eliminate the human intervention.

4) Contrast enhancement: making shadows darker & highlights brighter to make image quality good.

5) Objective

The objective of image enhancement is to improve the quality of image for analysis or display. Image enhancement

refers to sharpening of image features such as counters, boundaries, edges or contrast in order to facilitate further analysis and display. It is characterized as low level process includes noise reduction, contrast enhancement, and image sharpening operations to produce good quality image.

6) Image enhancement techniques

Techniques of image enhancements can be classified into two broad categories as spatial domain methods and frequency domain methods.

Spatial domain image enhancement methods can be divided into four main categories: point operations, spatial operations, transformation operations, and pseudocoloring .The evaluation process of the quality of an image is subjective, needs human judgment. To define this process objective it is essential to define an objective function which will provide a quantitative measure for enhancement quality.

II. LITERATURE SURVEY

N. Sengee et al [1] focused on global histogram equalization (GHE) method for contrast enhancement, which achieves comparatively better results on almost all types of images but sometimes it causes high visual deterioration. They proposed a new extension of bi-histogram equalization called Bi-Histogram Equalization with Neighborhood Metric (BHENM) in which image contrast and histogram flatness are simultaneously improved while preserving the image brightness. This uses the distinction neighbourhood metric to sort pixels of equal intensity into different sub-bins to enhance the image local contrast, and separates the histogram into two sub histograms and then equalizes them independently to preserve the brightness of image. BHENM consists of two stages. At first big histogram bins which lead to wash off artifacts are divided up into sub-bins by making use of neighborhood metrics; the same intensities of the original image are arranged by neighboring information. In the next stage, the histogram of the original image is separated into two sub-histograms based on the mean of the histogram of the original image; the sub-histograms are equalized apart from others by making use of refined histogram equalization, which produces more flatter histograms. In an experimental observation, BHENM enhanced the local contrast of the original image while preserving its brightness also. Our experimental results demonstrate the superiority of this method over other existing methods.

Łoza et al [2] proposed a new method for contrast enhancement of low-light or unevenly illuminated images based on of statistical modelling of wavelet coefficients. They established a non-linear enhancement function depending upon the local dispersion of the wavelet coefficients modelled as a bivariate Cauchy distribution. In this they have reduced the noise by a shrinkage function while preventing the noise amplification. In this paper they have emphasized only on V-channel of HSV, treating it as a gray scale image. This method works in the wavelet domain and re-scales the wavelet coefficients non-linearly on the basis of their local dispersion and their estimated noise level. This enhancement algorithm does not require the user to specify or adjust parameters and is proved to work well with a range of general and surveillance images, showing its superiority over other conventional methods, such as nonlinear image stretch, histogram equalisation and wavelet domain gamma enhancement, in terms of both feature extraction, image quality, and noise reduction. It is also appears that the images obtained with the proposed method are of better perceptional quality as compared to the other tested methods. This method results in brighter image in low energy image regions and does not degrade the image information in high energy image regions. The experimental results have revealed that this method performs very well with insufficiently illuminated and noisy images, showing its superiority over other conventional methods, in terms of both contrast enhancement and noise reduction.

Cheng Lei et al [3] focused on the previous contrast enhancement algorithms which were Based on histogram equalization (HE) like GHE, LHE which failed to consider the speed and quality and DHE which ascertained better overall contrast enhancement with controlled dynamic range of gray levels. They have introduced a novel, fast dynamic histogram equalization algorithm (FDHE) which is similar to DHE in terms of dynamic range spanning. It is an extended form of DHE. The main advantage of FDHE is the real-time image processing. Taking into account real-time needs, the proposed algorithm uses the fast distinct partition of semi-value which may lead to partition errors which loses some image enhancement and some details. We can use FDHE for the improvement in degraded images of fog and many real-time requirements of visual navigation system for vehicles.It prevents the over-equalization of background regions, perform it more evenly and the details of images are saved. The algorithm can be used in a great extent for the visual navigation systems of intelligent vehicles, pilotless plane and so on to improve the reliability of system in foggy weather. The experiments revealed that the visibility is too low and this algorithm failed in heavy fog with certain limitations.

S. P. Ehsani et al [4] Have introduced a new repetitive algorithm (AIHM) for contrast enhancement of medical images of the chromosomes, based on adaptive histogram matching as its image quality may degrade due to many causes like staining, sample defectness and imaging conditions so, we need an image enhancement algorithm before classification of chromosomes. Firstly they have proposed a model for histogram of chromosome images and then created a reference histogram with help of this model and then used it for histogram matching of initial image in each repetition. Use of raw information in the histogram of image will lead to more dependency to the input image and ascertaining more improvement in contrast. Moreover, the iteration procedure lead to a continuous & timely contrast enhancement and getting the best results. The steps of iteration may be different on the basis of image characteristics and histogram. To ascertain the performance it is compared with techniques like, Constant Gain Transform (CGT) and Local Standard Deviation Adaptive Contrast Enhancement (LSD-ACE), and for quantitative measurement, the contrast improvement ratio (CIR) is used. The results of conducted experiments reveal that the proposed method shows the best results in terms of the CIR and, in visual perception also. They carried out detailed simulations by using different sets of single chromosomes, demonstrating that the it increases the details satisfactorily.

A. Khunteta et al [5] focused on gamma correction for contrast enhancement which is power-law

transformation method as we know that image enhancement of dark images is always a very difficult and important in image processing but the value of gamma according to the appropriate image enhancement remains a question ie. It is not known generally. Here, they have introduced fuzzy reasoning for this purpose that is based on a set of fuzzy rules. Using this, the gamma value as a function of the exposure level is founded and in turn gamma value is calculated. They also introduced approach to apply the gamma correction on the negative of the input image as a better contrast in comparison to traditional gamma correction is produced. This approach was used on several badly illuminated images, and the results obtained were compared to the results ascertained by applying histogram equalization. They have introduced a modified gamma correction approach for image enhancement which adapts the nature ie. exposure and contrast of image. This approach is simple, less complex and very easy to implement.

M. H. A. Wahab et al [6] have discussed various image enhancement techniques used for contrast adjustment of an outdoor image which is degraded because of fog, hazy, rainy or bad weather conditions. The purpose of this study is to produce images which are strong enough to withstand the weather conditions by producing much better results and preventing inaccurate decision in any situation like autonomous vehicle or robot navigation.Image enhancement approaches are of two types either model based or non-model based. In non-model only the information of the image for processing is used and in model based additional information like the equipment is used and environment in which it is captured is used. Before the image is to be fitted in image processing algorithms various image de-noising methods are used which can be classified into three categories ie. spatial domain, transform and methods based on learning. Everything like type of weather, enhancement techniques and de-noising techniques are should be analyzed before use in various applications.

V. A. Kotkar et al [7] have proposed two image enhancement methods, Weighted Local Bidirectional Smooth Histogram Stretching (WLBSHS) and Local Bidirectional Smooth Histogram Stretching (LBSHS) for local enhancements and Bidirectional Smooth Histogram Stretching (BSHS) for global enhancement. We can get local enhancement using local standard deviation formula and global enhancement by stretching the histogram in both directions using modified gamma transformation. Then both local and Global enhancement methods are interpolated and a powerful hybrid mixed approach is produced which enhances the image contrast while preserving its brightness also. At last, merging of weighted and one by one approach is done in WLBDSH and LBDSH respectively. The results of experiments demonstrate superiority of the introduced method over AWIE, AGCID and VHA. It is efficient and adaptable and can be used for producing the better quality enhanced images with dynamic range.

A. Bouaziz et al [8] have proposed cuckoo-search (CS) algorithm to cope with the gray scale fingerprint images of lower quality and to overcome the limitations like consumption of much time of classical enhancement methods as, the degree of excellence of fingerprint images highly influences any fingerprinting biometric system. This approach uses the cuckoo search for the mapping of gray level and a novel objective function as a quality measure for global fingerprint enhancement of image is attained. The experimental results approve that the cuckoo algorithm can enhance the quality of fingerprint images with noise eradication also by visual and numerical clarification of ridge structure so, it is very effective and efficient for image enhancement which leads to easy and efficient processing in biometric attendance system.

P. Irrera et al [9] introduced a multi-scale (MS) decomposition method for enhancement of contrast of Micro Dose (MD) X-ray images. In this denoised input by use of a non-local means filter with adaptable parameters is attained after that, the input MS representation and de-noised input are merged to get an optimal image. The obtained image has preserved details and reduced noise. Experiments have approved that this method is efficient for getting X-ray images of high contrast and enhanced quality.

P. S. Rajpoot et al [10] focused on HE (Histogram Equalization) for image enhancement but it has problem of "mean-shift", i.e. mean brightness will reliably be the gray level of the input image So, it is not believed to be the best technique for stand out upgrades from brightness protection. Some other histogram adjustment based systems are there which outperforms mean-shift issue. The investigation of different approaches demonstrates that shine is not protected in an expert way by histogram balance method. Different approaches like BBHE and DSIHE try to overcome this problem to certain extent. RMSHE performs better then BBHE and DSIHE. MMBEBHE can save more brightness but it has a problem of more bends considering variety of dark level diffusion in the histogram. MCBHE has the ability to improve the difference without making deformations in the image and makes better neighborhood differentiation of images also.

D. Raj et al [11] have performed a comparative investigation of various contrast enhancement approaches such as contrast starching, histogram equalization and Contrast-limited adaptive histogram equalization which can be applied on a variety of gray images. Evaluation parameters like PSNR, MSE are used to find out the best enhancement method on images. Results from the experiments demonstrate that for some type of images Contrast-limited adaptive histogram equalization outputs better results, and for some contrast stretching provides the better result. But by our image experiment Contrast-limited adaptive histogram equalization ascertains better image then other approaches.

R. Kaur et al [12] have investigated various techniques like neighborhood operation, average filter, bilateral ratinex, imadjust and sigmoid function to judge which one produces the better contrast. Four parameters i.e. peak signal to noise ratio (PSNR), mean square error (MSE), normalization coefficient (NC) and root mean square error (RMSE) are calculated. Experimental results have shown that Neighborhood operation and sigmoid function has more PSNR which signifies minimum noise in image, The less value of MSE demonstrates a lower error in image, Less RMSE which proves that the image has best contrast. The NC value, proves that better image is produced after enhancement.

A. Jabeen et al [13] have introduced a contrast enhancement technique employing weighted transformation

function. In this technique the transformation functions ascertained at different levels by use of modified histograms are weighted according to their resemblance/differences from the mean value. To increase the dynamic range of produced image, bins having very negligible contribution in the histogram are removed. Visual and quantitative simulation results on variety of images show the superiority of proposed technique over other progressive techniques.

III. CONCLUSION

Some of the methods considered for image contrast enhancement in the literature survey are point operations i.e. Contrast stretching (normalization) & histogram equalization, GA, PSO and DE. Out of them Point operations always produce only one enhanced image for a particular input image with same parameters. GA & PSO methods doesn't require user interaction, and they are robust, i.e. applicable to a large category of images and there is no need of prior knowledge of image statistics. These algorithms determine the optimum parameter set rather than the individual parameters in selecting an appropriate enhancement function. They consider a large search space, Therefore, to obtain a more accurate solution one needs to increase the length of the strings though this will increase the computation time.However, DE has few parameters need to be set and it is simple to use with. It has greater robustness. It has High Computational speed and Enhanced quality.

From the conclusions of literature survey, the main objectives of our work are Survey, Proposal of an algorithm which replaces DE for more improved results, Its Implementation and Performance Evaluation.

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