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# A Brief Review on Image Contrast Enhancement Techniques

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***Abstract*—** In the field of image processing one of the important process is image enhancement. In many image processing applications, image enhancement techniques are used. Many research works have been done for image enhancement. In this paper, different techniques and algorithms using machine learning approach such as genetic algorithm, neural networks, fuzzy logic enhancement and optimization techniques are studied and discussed. The aim of this study is to determine the application of machine learning approaches that have been used for image enhancement. The review given in this paper is quite efficient for future researchers to overcome problems related to machine learning approach as well as helps in designing efficient algorithm which enhances quality of the image.

***Keywords*—** Image enhancement, Image quality, Machine learning approaches, Digital image processing**.**

## I. INTRODUCTION

Image processing is an essential and promising research area in various real time application fields such as medical imaging, video surveillance, industrial X ray imaging, oceanography etc. [1]. Image enhancement is a pre-processing technique in many image processing applications that can produce an improved quality image than the original image so that the output image is more suitable for analysis by human or machine in specific applications. The image enhancement techniques are categorized into spatial domains and frequency domains. In spatial domain techniques, the pixels themselves are modified directly to improve an image. In frequency domain method, modification is done on the Fourier transformed image and inverse Fourier transform is applied to the modified image to get the enhanced image. Quality of the image gets affected by uneven or poor illumination, external atmospheric condition such as fog or haze, wrong lens aperture setting of the camera, noise etc.

So, these degraded quality images are improved by increasing the brightness and contrast, by de-noising the image through various enhancement techniques. Researchers have developed numerous enhancement techniques that are good in enhancing the contrast of an image, while some are good for de-noising the images. In real time applications an enhancement technique should be capable of enhancing real colour images in lesser time with lesser computational cost by reducing (i) the effect of haze or fog, (ii) poor or uneven illumination effect on an image and (iii) noise introduced in an image. This research review work focus on various colour image enhancement techniques that improves the contrast of real time images. Requirements of real time image enhancement techniques [2] are (i) It should be adaptive in nature (i.e.) should be able to enhance any type of images for a specific application, (ii) Should enhance a image in less processing time, (iii) It should utilize less computational resources.

## II. RELATED WORK

Image enhancement is a process by which we can improve the quality of the digital image which makes it easier for identifying features. This can be done by removing noise, sharpening, or brightening an image. The techniques identified in the paper to enhance an image are contrast stretching and image sharpening, nonlinear image enhancement technique, genetic algorithm, generalized fuzzy enhancement, wavelet transform technique, multi-scale and single-scale retinex improvement technique, etc [3].

In [1], Dong-liang et al. proposed the generalized fuzzy enhancement method that overcomes the limitations of the traditional fuzzy method of enhancement. The enhancement problem of the low contrast and the narrow gray range images is solved by this method. The improved label algorithm is used for image segmentation and recognition, which is helpful in understanding an image and in object recognition.

In [2], Xianghong et al. discussed the enhancement algorithm for colured medical images. It includes two features: colour space transform enhancement and wavelet analysis enhancement. By using wavelet analysis, the image is fragmented and improved. From RGB space, the colour image is converted to IHS (intensity, hue, and saturation) space. The new saturation which is enhanced replaces the

 

image saturation. The nonlinear transform adjusts the intensity of the image. The image is then reconverted from IHS space to RGB space, and finally, the image is enhanced.
In [3], Benala et al. proposed an ABC optimizing algorithm for magnifying the image. This algorithm provides excellent magnitudes for an image. It is better than GA. The chance of dropping into local optimum is less in ABC algorithm. The main goal of this algorithm is to advance the local search ability of GA by maintaining the global search ability.

In [4], Wang et al. discussed NIE (Nonlinear Image Enhancement). Simulation and identification processes are used along with the proposed NIE method. This process uses clipping and scaling parameters which are an appropriate combination of various images. This process enhances the quality of blurred image and a better quality is achieved, and PSNR (signal-to-noise ratio) performance is obtained than other nonlinear enhancement techniques.

In [5], Gorai et al. discussed a particle swarm optimization (PSO)-based image enhancement technique. PSO depends on objective function optimized the parameters. The local information and global information of an input image are used by the intensity transformation function. To measure the quality of an image, the edge information and entropy are acknowledged by the objective function. With the help of scaling, the enhanced image is achieved.

In [6], Hanumantharaju et al. discussed a technique for magnifying an image by applying the particle swarm optimization. The algorithm uses criteria based on the information of edge and entropy of the image. By using this method, the specifications of the multiscale retinex like number of scales, Gaussian surround space constants, etc., are optimized. Their proposed algorithm resulted better image enhancement as compared to existing algorithms like histogram equalization, filtering, etc.

In [7], Zhou et al. explored a fuzzy-based image enhancement algorithm whose parameters are optimized using GA. In the proposed technique, firstly image is transformed from spatial domain to fuzzy domain. Then, membership function is optimized using GA and applied on the fuzzy image. Finally, image is converted back to space domain using de-fuzzification and enhanced image is obtained. Further, enhancement can be done by applying the same process again.

In [9], Verma et al. used genetic algorithm to enhance an image. GA enhances the image naturally as it measures the fitness of a particular by estimating the intensity of spatial edges comprised in the image. Image is broken into sub images. Transformation function is applied. Fitness function is used. One with higher fitness is selected using tournament selection. Crossover is done using an arithmetic crossover, and finally, PCA-mutation is done.

In [10], Khan et al. proposed fingerprint image enhancement using multi-scale DDFB-based diffusion filters and modified Hong filters. The major goal of a fingerprint image enhancement is to magnify the image in order to remove noise and magnify reliable minutiae points. To calculate orientation field of a fingerprint image, multi-scale DDFB is required. This shows that this technique is more reliable than any derivatives-based techniques.

In [12], Negi et al. discussed contrast stretching and image sharpening techniques. It is an approach that concurrently adjusts contrast and enhances boundaries of an image. On the gray-scale image contrast stretching is applied and then it proceeds to Laplacian mask, and finally, Laplacian image is appended to the original gray-scale image to obtain the desired sharpened image.

In [13], Wu et al. proposed image enhancement using wavelet-based contourlet transform with cycle translation. In this, wavelet transform is used for decreasing the redundancy occurring in the original method of contourlet transform. WBCT and cycle translation are merged. At last, to magnify the images, adaptive enhancement function is selected. The proposed method can efficiently magnify the images and decrease the flecked at the background region, the image edges.

In [14], Premkumar et al. discussed the colour image contrast enhancement technique. Firstly, RGB image is transformed to HSV (hue, saturation, and value) colour space. Hue colour channel is selected for DST decomposition. The lower directional sub band is used for reformation. By transforming HSV to RGB colour space, the enhanced image is acquired. From proposed DST-based contrast image enhancement approach, the satisfactory result is attained.

In [15], Bhattacharya et al. proposed a fast algorithm for raising the contrast of an image locally by using singular value decomposition (SVD) approach. The contrast of a partially degraded image is magnified by using this approach. Under global and partial degradation, the method is carried out properly and a good perceptual quality after processing is achieved.

In [16], Shanmugavadivu et al. discussed a contrast enhancement technique using the basic concept of histogram equalization. In this proposed technique, the image histogram is first divided into two parts using the Otsu threshold. Thus, a series of optimized weighing conditions formulated using particle optimization (PSO) is applied to both parts.

Single image contrast enhancement (SICE) aims to enhance the visibility of the scene in a very given single low-contrast image. It provides the way to boost the low contrast pictures captured from a high dynamic range scene. several histogram

 

and Retinex based SICE ways are projected within the past decades.

Histogram-based ways [4], [5] are wide used due to their simplicity in enhancing low contrast pictures. Those ways plan to distribute the bright intensity on bar chart in a very international or native manner. However, such easy redistribution operations could turn out serious unrealistic effects within the enhanced pictures since they ignore image structural information.

Recently, ways [20] are projected to train a CNN network to map the low dynamic range (LDR) pictures to HDR pictures. In [20], a CNN is trained to line the parameters of SICE, that are then used to enhance an input image to a desired image. Table 1 presents the summary of the flow of the work accomplished in the field of image contrast enhancement techniques.

Table I: Summary of the Work on Image Enhancement Techniques

| Author | Discussion | Technique Used | Parameters | Remarks |
|---|---|---|---|---|
| Dong et al. [1] (2005) | In this work, iterative fuzzy enhancement technique is used to enhance the image. The input image is converted into grayscale and further processing is done. | Fuzzy Enhancement | Vision effect | More suitable than gray-level transformation |
| Huang et al. [4] (2010) | Analyzed the suitable parameters for clipping and scaling of the image. The proposed algorithm uses B-spline filter to optimize the overall cost for improving quality of image. | B-spline filter | PSNR | Results show that the proposed method improves the quality of blurred image |
| Singh et al. [8] (2013) | Designed image sharpening algorithm which is based on edge detection. The algorithm enhances the contrast by adjusting the edges according to the algorithm. | Laplacian Transform (LT) | Histogram | Flat histogram is plotted for the final output image. |
| Verma et al [9] (2013) | In this work, edges are considered to enhance the quality. The processing is done on grayscale which identified edges as dark or light. | Genetic Algorithm | Detail Variance (DV) and Background Variance (BV) | GA naturally improves an image by measuring a fitness value by evaluating the intensity of the spatial edges contained in the image to improve the image contrast. |
| Jiang et al. [13] (2014) | In this approach algorithm is designed to enhance Contourlet Transform (CT) by adding features for multi-scale and multi-direction in oeder to reduce redundancy. | Wavelet-based Contourlet Transform (WBCT) | Catenary image enhancement effect | Proposed method has the advantages of preserving image edge details and texture. |
| Premkumar et al. [14] (2014) | The proposed algorithm used Discrete Shearlet Transform (DST) for image quality improvement. The processing complexity is reduced by converting RGB to HSV colour space. For transformation only hue scale is used. | Discrete Shearlet Transform (DST) | Histogram | Proposed approach especially uses hue as input for DST decomposition as it enhances the overall process. |
| Bhattacharya et al. [15] (2014) | In this work, particular area of interest is identified in whole image for which contrast is needed to be enhanced. This area is selected according to the overall contrast of the image. | Singular Value Decomposition (SVD) | PSNR and Processing Time | PSNR = 20.50<br>Performs well under global and partial degradation and achieves good perceptual quality after processing. |
| Jianrui [20] | In this work, CNN is used to train Single Image Contrast Enhancement (SICE) methods for correcting the contrast level in image. | Convolutional Neural Network (CNN) | PSNR and Feature Similarity Index | To improve the contrast of an under-/over-exposure image. |

 

## III. DISCUSSIONS

Image enhancement is an essential pre-processing step in many real time image processing applications. Enhancement of Images is done by many approaches and choice of every approach depends on the type of images. Among all histogram equalization techniques multi histogram equalization techniques improves the contrast and brightness of the images.

Weaknesses of existing image enhancement techniques:

1. Existing image enhancement algorithms are very computation intensive and require a large amount of memory to store the intermediate data.
2. Algorithms are quite complex to understand and implement.
3. Very few techniques are practically used for image enhancement which leaves a large scope for new enhancement techniques.

As analysed, there are various factors which can affect image quality. Some of them are noise, sharpness, distortion, contrast, colour accuracy, dynamic range, exposure accuracy, lens flare, etc. These factors must be kept in mind while choosing or designing any image enhancement algorithm. The most common algorithm traditionally used for image enhancement is histogram equalization. Other algorithms were also used but they were somehow an extension or modification of histogram equalization only. As the technology advanced, various new methods were developed for the enhancement of images. As expected, new techniques were better than the traditional image enhancement techniques. As studied from various papers, it has been found that wavelet transform- and soft computing-based methods (GA and fuzzy) were better than the traditional histogram equalization methods.

In future, this review can be used to compare various image enhancement algorithms and their feasibility can also be determined.

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