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SURVEY ON VARIOUS IMAGE CONTRAST ENHANCEMENT TECHNIQUES

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Abstract*— In this paper a survey on various image contrast enhancement techniques has been done. Colour image enhancement plays an important role in digital image processing. Contrast enhancement is an optimization problem and is done for the images which are experiencing poor quality. Poor quality on images is due to various factors like environmental lighting conditions, defects in photographic devices etc. Therefore image contrast enhancement is important in order to improve the human acceptance rate. Most of the papers are based on histogram equalization technique and its extensions. Histogram equalization is a contrast enhancement technique based on histogram of the image. Each technique has got its own advantages as well as disadvantages. Various contrast enhancement techniques have been proposed by different authors as an extension of the traditional histogram equalization. They are power constrained contrast enhancement, dynamic range compression, colour model conversion, gamma correction and channel division methodologies. Several recent papers are being surveyed under each technique.

***Keywords*— histogram equalization, gamma correction, contrast enhancement, local tone mapping, brightness preservation.**

I. INTRODUCTION

Image enhancement is a process of improving the visual appearance of an image to make it more acceptable for the human or machine. Image enhancement is done by changing some attributes of the image. Different techniques are available for the image enhancement. Contrast enhancement is one of the image enhancement techniques. Image enhancement methods can be categorized into two type's namely spatial domain methods and frequency domain methods. In spatial domain methods, we are directly dealing with the pixels of the image and in frequency domain methods, the image is converted to frequency domain and then the processing is done for the enhancement and finally it is converted back to original image. In order to convert it to frequency domain, Fourier transform operations are performed on the image.

Contrast enhancement is done when the image quality is suffering from poor contrast due to the environmental lighting conditions or due to the defect in the photographic devices. In the case of dimmed images or dimmed videos the contrast enhancement is an essential factor that needs to be considered. Under the contrast enhancement technique several algorithms have been proposed like histogram equalization, gamma correction, dynamic range compression etc.

In this paper several contrast enhancement techniques have been proposed like histogram equalization, gamma correction, frequency domain methods, channel division methods, dynamic range compression methods and colour model conversion techniques.

II. HISTOGRAM EQUALIZATION

Power saving is an important issue in multimedia devices. A large portion of the power is consumed by the display panels of these devices [21]. There are two types of display panels, emissive displays and non emissive displays [22].

Several contrast enhancement algorithms have been developed for non emissive displays, which needs external light sources. In [1] they have proposed a power constrained contrast enhancement algorithm for emissive displays which is based on histogram equalization. Initially they developed a histogram modification (HM) scheme for reducing large histogram values to control the contrast overstretching of the

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conventional HE technique. For that they reviewed the conventional HE and HM techniques. HE produces some drawbacks in the output image. So to overcome these drawbacks HM technique is proposed. Then a logarithmic function is applied to this HM method to reduce the dynamic ranges of high dynamic range images, while preserving details. After that, a Power constrained contrast enhancement algorithm is proposed, in which first, gather the histogram information h from the input image and apply LHM to h to obtain the modified histogram m. To get the transformation function x, solve equation $Dx=\bar{m}$. Then design an objective function, which consists of terms for power constraint and contrast enhancement. Objective function is y=Dx. After finding the optimal y, finally the transformation function x is constructed from y using $x=D^{-1}y$. They extended the proposed PCCE algorithm to enhance video sequence also.

Another variant of histogram equalization is explained in [2]. In histogram equalization the dynamic range of the input image is stretched using cumulative distribution function. The problem with the histogram equalization is mean-shift for consumer electronics products. That is, the mean brightness of the input image is different from that of output image. So many variants of histogram equalization are used to overcome this problem. They are Brightness preserving Bi-Histogram Equalization (BBHE) in [23], Dualistic Sub-Image Histogram Equalization (DSIHE) in [24], Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) in [25], and Recursive Mean Separate Histogram Equalization (RMSHE) in [26]. The two artefacts produced by histogram equalization are over-enhancement and loss of contrast [27]. It is focused on the image brightness preservation than the image contrast improvement. So a new histogram equalization method, named RSWHE (Recursively Separated and Weighted Histogram Equalization) to enhance the contrast of the image as well as the image brightness preservation. The RSWHE consists of three modules: segmentation of the histogram, weighting the histogram, and finally equalization of the histogram. Initially the input image is given to the histogram segmentation module to produce the input histogram and divides the histogram into two or more sub histograms recursively. Then a normalized power law transformation function is used to modify the sub histograms in the weighting module. Finally, the histogram equalization function individually runs over each of the modified sub histograms.

III. Gamma Correction

The technical limitation with many of the imaging devices is that they may not display actual appearance of objects. This problem is called gamma distortion [19]. It is not monotonic in nature. Image distortion relies on the depth, texture of image, and relative reflection of objects in the image. In order to enhance an image an adaptive approach is needed. In [3] a simple technique for estimating the gamma values without any knowledge of the imaging device is explained. Gamma distortions may not be the same on all objects. In this method, the input image is divided into overlapping windows and each window is individually enhanced. To determine the gamma value of each window, twenty different gamma values starting from 0.2 to 2.2 intervals 0.1 are applied to each window. The gray level co-occurrence matrix is calculated for each window and the homogeneity feature is extracted from each of these matrices and selects a gamma value that minimizes this homogeneity feature value. The features of an image are measured by the homogeneity value and a lowest homogeneity value means highest amount of detail. This technique is used to enhance both gray images as well as colour images. The HSV colour model is used to enhance colour images where value (V) is only processed [20].

In [4] a gamma correction technique with cumulative distribution function has been explained. When the probability density function (PDF) and cumulative distribution function (CDF) is used to enhance the pixel intensity, the image brightness may get distorted. So a traditional gamma correction function method is used for the image enhancement, where a constant power functions with exponent γ. The γ value is determined in [4] based on PDF and CDF as follows.

$$T(l)=255\left(\frac{l}{255}\right)^{1-CDF(l)} \quad (1)$$

Unfortunately, there are some significant fluctuations in the CDF curve of the dimmed image. In order to solve this problem, we use the weighting distribution function.

Another method for image enhancement using gamma correction technique uses an SVM classifier which is explained in [5]. This method consists of two different stages. First one is the training stage where, initially a database is constructed containing training images. After that each of the

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training images is divided into overlapping windows. Then the features from each window are extracted using 3 methods. First method is the feature extraction from the histogram. Histogram is the probabilistic distribution of gray levels in an image [13]. When the γ value is less than one, then there is a peak at the right side of the histogram. And when it is greater than one, then the peak will be at the left side. If it is around one, then peak will be at the centre. From this, the information features are extracted. Next method is the gray level co occurrence matrix. It is a two dimensional matrix and its size is equal to number of gray levels in the image [14]. In GLCM, the relationship between the neighbouring pixels is described. And finally in discrete cosine transform method, it represents an image as a sum of sinusoids of different frequencies and magnitudes [15]. So the information about the image complexity is derived from this frequency component [16]. These extracted features are then applied to SVM for training. The second stage is the testing stage where, when a new image comes it is tested for the performance.

IV. Frequency Domain Method

Tone mapping is a method used for display devices with limited dynamic range in order to map high dynamic range (HDR) image to low dynamic range (LDR) image. Tone mapping algorithms are used to improve the colour, contrast and details of the image. When the number of LDR images increases then the amount of noise in the HDR images are reduced. A noise reduction method and an adaptive contrast enhancement for local tone mapping have been proposed in [6]. Here the HDR image is initially compressed and then the proposed TM algorithm decomposes this compressed image into multi-scale sub bands with the help of discrete wavelet transform. The decomposed sub bands are then filtered using bilateral filter. Then an adaptive weight is derived from the compression function to enhance the local contrast [18]. Finally, the colour of the tone mapped image is reconstructed. The TM algorithm shows its effectiveness in the HDR images in terms of visual quality as well as details preservation. From the noisy HDR image, the proposed local TM algorithm produces the tone mapped colour image with high contrast.

V. Channel Division

A content aware method has been proposed in [7] to analyse the contrast in boundaries and texture regions of the image to produce adhoc transformation functions. For that the different characteristics of the image are separated and then grouped them together. These groups are treated individually by building specific functions for each group thereby enhancing its characteristics. Finally, the results of transformations of each of the groups are mixed adaptively to increase the details of the image. Also it preserves the characteristics of the image as well.

In channel division enhancement, inspired by intensity pairs [17], contrast is encoded using contrast pairs. The relationship between the two neighbouring pixels share similar characteristics, and then their intensities will be shared by the force generated by the contrast pairs. Also due to lack of interaction, the intensities of isolated pixels will remain as itself. After that the contrast pairs are accumulated to form local contrast indicator (LCI) functions and then these functions are merged into channels. This is done to reduce the artefacts creation. This process is termed as channel division. Then these channels are grouped to form region channels. The major building blocks of region channels are intensity channels, which allow controlling interference and also the overlap of contrast pairs. So here in order to implement this, initially we need to transform our image to HSV colour model.

VI. Dynamic Range Compression

A dynamic range compression method for the enhancement process is described in [8]. Among several dynamic range compression techniques, this method addresses low dynamic range image and video enhancement for the LDR digital video cameras. Here a [11] new form of fast dynamic range compression with local contrast preservation (FDRCLCP) algorithm that has been proposed for the image enhancement problem. In order to achieve LDR image enhancement this method can combine with any continuously differentials intensity-transfer function like gamma curve. This is one of its merits. Depending on the local statistical characteristics of the image, this spatially variant intensity-transfer function selects an appropriate intensity mapping curve for each pixel in the image. This method extends to linear colour mapping algorithm which controls saturation with minimum distortion and also improves the computational efficiency of the video enhancement process. By combining these three methods the local lightness, local contrast and the colour saturation of the enhanced image can be controlled separately.

The visual quality of an image greatly depends on local image contrast [12]. So here the condition of local image contrast preservation is derived initially. After that the dynamic range compression is combined with this local contrast preservation for the enhancement of LDR images. Then an intensity-transfer function is determined and the

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FDRCLCP method is applied to it and the dynamic range compression function is realized by preserving the local contrast. Here an adaptive intensity transfer function is used. So here only the luminance component of the input image is processed. Because of that some colour distortion problems may arise. So a linear colour remapping algorithm is used to preserve the colour information of the original input image in the enhancement process.

VII. COLOUR MODEL CONVERSION

In image processing the most commonly used colour space is the YCbCr colour space where Y is the 'luma', Cb and Cr are the colour difference or chroma signals. In [9] a contrast preserved chroma enhancement algorithm has been described which uses the YCbCr colour signals that preserve the original image. Initially, the YCbCr colour space is analysed. It is analysed in a uniform colour space. In that Y values is set between 0 and 255. And Cb and Cr values between -128 and 128. This value is then converted to 128. This value is then converted to CIECAM02 colour coordinates values j, c and h. YCC chroma can be defined as the chroma and here angle in YCbCr colour space. As CIECAM02 increases YCC chroma also increases but the lightness difference between same luma differences becomes smaller. This lightness change can be balanced by changing the luma value to a point that has same lightness as the original image. For that a mathematical model is developed. In order to develop the model, calculate the amount of luma value which is denoted as Δluma is added with the original luma to preserve the original lightness. Now the chroma enhancement algorithm contains two functions chroma enhancement and lightness compensation. This chroma enhancement function is used to enhance the input YCC chroma value. It can be done by multiplying the input Cb and Cr values with the chroma weight. The lightness compensation function is used to calculate the Δluma and added with input Y value to get the same CIECAM02 values as input colour.

In [10] an efficient colour model is used for better gamma encoding in image processing is described. Initially the input image which is in the RGB format is converted to HIS and HSB models. The luma value is denoted using Y which represents the brightness of an image. The weighted luma value is calculated by using the weighted R, G and B values. That is R', G' and B'. Then a saturation adjustment is done on the colour image to make it soft and better for human acceptance. For that histogram normalization is done. Then finally they compared the HIS and HSB models to RGB and compare it with some brighter and darker images for performance evaluation. And as a result they got HSB as the better model.

VIII. CONCLUSION

Image contrast enhancement is one among the major image enhancement techniques. It is used to improve the visual appearance of an image. And it is an important need for better human visualization. In this paper, the different contrast enhancement techniques were analysed. Other than contrast enhancement power constraints are also considered. Power saving is an important factor in the multimedia devices. The major issue faced by most of the images is noise. Various techniques have been examined for the image noise reduction. Colour model conversions are important when the processing of RGB images is tedious. Most of the techniques are the extensions of the traditional histogram equalization. Since traditional HE has got various limitations, some of the techniques that are discussed above in this paper can overcome its problems. The problems with each of the techniques are also described.

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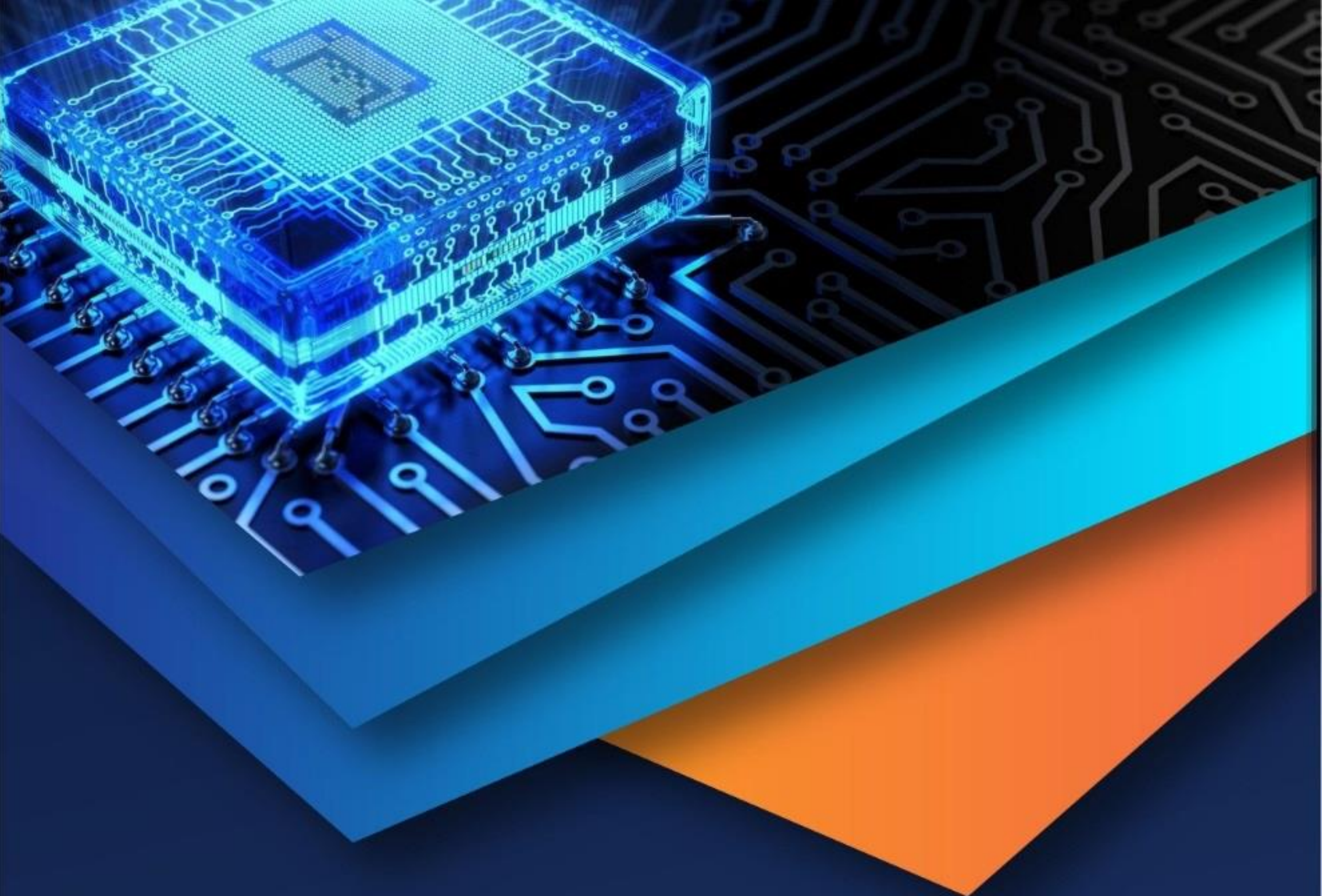

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