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Image and Video Enhancement Based On Weighting Distribution and Gamma Correction

R. Sridhar and N.P. Deepa
Department of electronics and communication, DayanandaSagar College of Engineering, Bangalore, Karnataka, India

***Abstract* -- In *this*paper, we present an efficient method to transform histogram and to improve contrast in images. Contrast enhancement is one of the most important issues in image processing, computer vision and pattern recognition. We present techniques that enhance the brightness of low contrast image via gamma correction and distribution of luminance pixels. Then, the gamma corrected frame is applied to pixel intensity transformation which can be implemented by nonlinear transfer function followed by center surround enhancement. Both pixel intensity transformation and center surround enhancement are carried out for value component and preserving spectral composition and purity of the color. On the other hand, to enhance video sequence, the proposed image enhancement uses entropy model, which calculates the temporal information with respect to differences between each frame to reduce computational complexity. Simulation results demonstrate that the proposed method produces enhanced images of comparable quality.**

Index Terms -- Contrast Enhancement, Entropy Model, Gamma Correction, Histogram Equalization, Weighting Distribution, Luminance Enhancement.

I. Introduction

Image enhancement is a process of improving visual appearance of an image to make it more acceptable to human or machine. Image enhancement is used as a pre-processing step in image/video processing application, medical image analysis [1]. Image enhancement is done by changing some feature of the image. Different techniques are available for image enhancement.

Contrast enhancement is the most popular and plays very important role in image enhancement techniques. Contrast enhancement will be used to perform adjustment on darkness and lightness of an image. It is mainly used to bring out the features hidden in an image or to increase the contrast of low contrast image.

Contrast enhancement is one of the most important issues of image processing applications such has image analysis, remote sensing digital photography, LCD display processing and scientific utilization. Contrast enhancement is applied only when the image/video is suffering from poor contrast due to lack of operator expertise, poor quality of capture device and the adverse environmental conditions at the time of acquisition. This results in underutilization of the dynamic range. As a result such images and videos do not reveal all the information in the captured scene. Contrast enhancement targets to eliminate these problems and thereby to obtain a more visually pleasing images and videos [2]. Contrast enhancement is an essential factor in case of dimmed images or dimmed videos.

Contrast enhancement is an essential factor in case of dimmed images or dimmed videos. The most commonly used techniques for contrast enhancement falls under two categories direct methods and indirect methods. Direct method defines criterion of contrast measurement and enhance the image by improving the contrast measure. Indirect methods, improve the contrast through exploiting the under-utilized regions of the dynamic range without defining a specific contrast term. Most methods in the literature fall into second group. Indirect methods can be further divided into following sub groups: i) histogram modification techniques. ii) Techniques that decompose an image into high and low frequency signals for manipulation, and iii) transformed based techniques.

Among these three subgroups histogram modifications techniques receives the most attention due to its straightforward, easy and fast implementation. Through histogram modification, the original gray level is assigned a new value. As a result. The intensity span of the pixels is expanded. Histogram modification technique onlystretches the distribution of the intensity. Many contrast enhancement techniques have been used in order to optimize the visual quality of the image for human or machine vision through grayscale or histogram modifications. All these methods try to enhance the contrast of input image. [3]

Video enhancement is one of the most important and difficult components in video research. The main aim of the video enhancement is to improve the visual appearance of the video. Video enhancement plays an important role in analysis, recognition, surveillance, traffic, criminal justice system, detection, segmentation.

The rest of the paper is organized as follows: section II provides a brief discussion of related works. Section III presents our proposed method in detail. In section IV, the simulation results. Finally, conclusion and future work is presented in Section V.

II. PREVIOUSWORKS

Histogram is defined as the probability distribution of each gray level in a digital image. Histogram equalization is one of the well-known methods for enhancing the contrast of given images. Histogram equalization is an effective technique to transform a narrow histogram by spreading the gray level clusters in the histogram and is adaptive since it is based on the histogram of given image. However histogram equalization is rarely employed because it may significantly change the brightness of an input image and cause undesirable results. In order to solve the aforementioned problem associated with histogram equalization, many variants of histogram equalization that preserves the image brightness have been proposed. Kim proposed Brightness preserving Bi histogram equalization (BBHE) to overcome the problem. BBHE first separates the input images histogram into two sub histogram by it mean. Next it equalizes the two sub histograms separately.. Thus BBHE can preserve original brightness to certain extent [4].

Wan, Chen and Zhang Proposed Dualistic Sub Image Histogram Equalization (DSIHE), which is similar to BBHE except the threshold for histogram segmentation is not the mean of the input image, but the median of the input image brightness. It produces good image enhancement, but equalization effect is reduced. [5].

Chen and Ramli introduced Minimum Mean Brightness Error Bi Histogram Equalization (MMBEHE), which is the extension of BBHE, MMBEHE performs separation based on threshold level, which would yield minimum difference between input and output mean. [6].

Chen and Ramli also proposed Recursive Mean Separate Histogram Equalization (RMSHE), it recursively separates the input image histogram into multiple sub histograms. If the sub histogram is too large then no significant enhancement is performed [7].

Sim, Tso, Tan proposed recursive sub image histogram equalization (RSIHE), which has multiple local intensities to overcome the drawback of DSIHE. Instead of separating image once, it recursively separates into multiple sub histograms. This method has good contrast enhancement effect [8].

Kim and Chung introduced recursively separated and weighted histogram equalization (RSWHE), to enhance the image contrast as well as preserve the image brightness. RSWHE consists of three modules: histogram segmentation, histogram weighting and histogram equalization. The histogram segmentation splits the input histogram into two or more sub histograms recursively. Histogram weighting changesthe sub histograms trough weighting process based on normalized power law function. Histogram equalization equalizes the weighted sub histograms independently. [9].

Contrast enhancement can be optimized by the histogram modification framework, which incorporates penalty terms for histogram deviation as well as minimizes a cost to compute a target histogram. In order to accurately preserve brightness, the automatic weighting mean separated histogram equalization (AWMHE), method uses two modules. Automatic histogram separation to separate the input image histogram recursively based on weighting mean function. The piece wise transformation function equalizes the sub histograms in small scale details able to achieve contrast enhancement. This technique uses only one dimensional histogram, even if it might possess spikes which compress other gray levels for distribution [10]. To overcome the previous discussed problem, the two dimensional histogram is used to generate contextual and variational information (CVC) in the image while the Gaussian mixture model (GMM) can also be used to compensate for gray level distribution of the image. The contextual and variational contrast enhancement method is more effective at showing the visual quality of the image, because it directly constructs a prior probability, which further represents information of the image. However the CVC method requires a high level of computation when increasing the gray level differences between neighbouring pixels [11].

III. PROPOSED METHOD

In order to compensate for the above limitations of these methods, a technique must be developed which creates a balance between visual quality and low computational costs. In this paper, two methods are proposed to accomplish this goal. a) Gamma correction with weighting distribution technique (GCWD) for image enhancement. b) Temporal Based (TB) method for video enhancement.

Fig.1 shows the block diagram of proposed GCWD method. A low contrast image is used as an input; most of the pixels are densely distributed in the low levelregions. In histogram analysis, the input image is converted into grayscale imageand histogram equalization is performed to change the value in intensity image. The weighting distribution function is applied to slightly modify the statistical histogramand lessen the generation of adverse effect. Thus, the fluctuant phenomenon can be smoothed.Gamma correction reduces the over enhancement by preserving the brightness of the color image.

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The gamma correction parameter can be formulated by basic form of power law transformation function defined as [12].

$$S = L_{max} * (L / L_{max})^{\gamma} \quad (1)$$

Where γ are positive constants
L_{max} is the maximum intensity of the input. The intensity L of each pixel in the input image is transformed as S after performing Eq. (1).

The exponent in the power law equation is referred to as gamma (γ). The process which is used to correct this power law response is called gamma correction. If the $\gamma>1$ then image appears as a darker image and if $\gamma<1$ leads to contrast stretching, so images appears as brighter thus having opposite effect. Thus $\gamma>1$ have exactly opposite effect as those generated with $\gamma<1$.
In the next step, gamma corrected image applied to the pixel intensity transformation using nonlinear transfer function followed by center surround enhancement [13].
The luminance enhancement through pixel intensity transformation implemented by using nonlinear transfer function which is defined as

$$V_{LE} = \frac{V^{(0.75z+0.25)} + 0.4(1-z)(1-V) + V^{(2-z)}}{2} \quad (2)$$

Wherez is the dependent parameter, defined as,

$$Z = \begin{cases} 0 \text{ for } L \geq 50 \\ \frac{L-50}{100} \text{ for } 50 < L \leq 150 \\ 1 \text{ for } > 150 \end{cases} \quad (3)$$

L is the intensity levels

The above transfer function can largely increase the luminance of those dark pixels while brighter regions have lower negative enhancement.

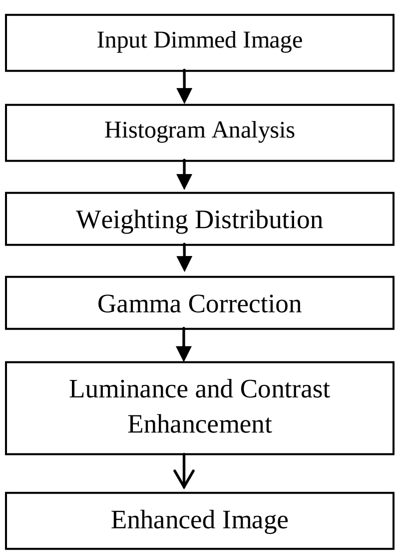

Fig.1. Block Diagram of GCWD Method.

2D discrete convolution is carried out on the original V channel image by using Gaussian function.
The following equation defines the process of contrast enhancement for V channel.

$$V_{CE}(i, j) = V_T(i, j)^{E(i, j)} \quad (4)$$

Where E (i, j) is defined by

$$E(i, j) = R(i, j)^G = [V_T(i, j) / V_F(i, j)]^G \quad (5)$$

$V_{CE}(i, j)$ is the contrast enhanced V channel image.R (i, j) is the ratio between Gaussian filtered and original value component image. G is the image dependent parameter determined by using standard deviation of input value channel image V_F.
According to the analysis, by applying HSV color model which approximately equal to RGB model we can enhance the color image to be acceptable to human vision. In HSV color model, hue (H) is identical to dominant wavelength which represents the spectral composition of colors. Saturation (S) it is equivalent to purity which represents the purity of the color. Value (V) it is also called luminance which represents the brightness or intensity of an image. The color image can be enhanced by preserving H and S while enhancing only V.
Hence ProposedGamma Correction with Weighting Distribution (GCWD) method was applied to V component for color contrast enhancement.
The GCWD method can progressively increases the low intensity and avoid the significant decrement of the high intensity. Thus the proposed GCWD method can enhance a color image without generating artifacts or distorting the color.
In addition to the image contrast enhancement, we also propose a temporal based method (TB) technique to further reduce the computational complexity required by GCWD method to enhance video sequence.
The flow chart of temporal based method applied for video contrast enhancement is as show in Fig. 2. At the beginning of the process, the first incoming frame is directly stored in frame storage, which is used to generate mapping curve for the proposed GCWD method. For subsequent incoming frame, the entropy model can be used to measure the information content between two successive frames. The information content of each frame is approximated by the following entropy formula:

$$H = - \text{sum}(P.* \log2(P)) \quad (6)$$

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Where P is the number of histogram count.

When the absolute difference between the current H and previous H exceeds threshold T_h, the frame storage can be updated by incoming frame, while the transformation curve is also modified. In this situation, T_h is empirically set to 0.05. Otherwise, the existing mapping curve is directly applied to transform each intensity level in the incoming frame.

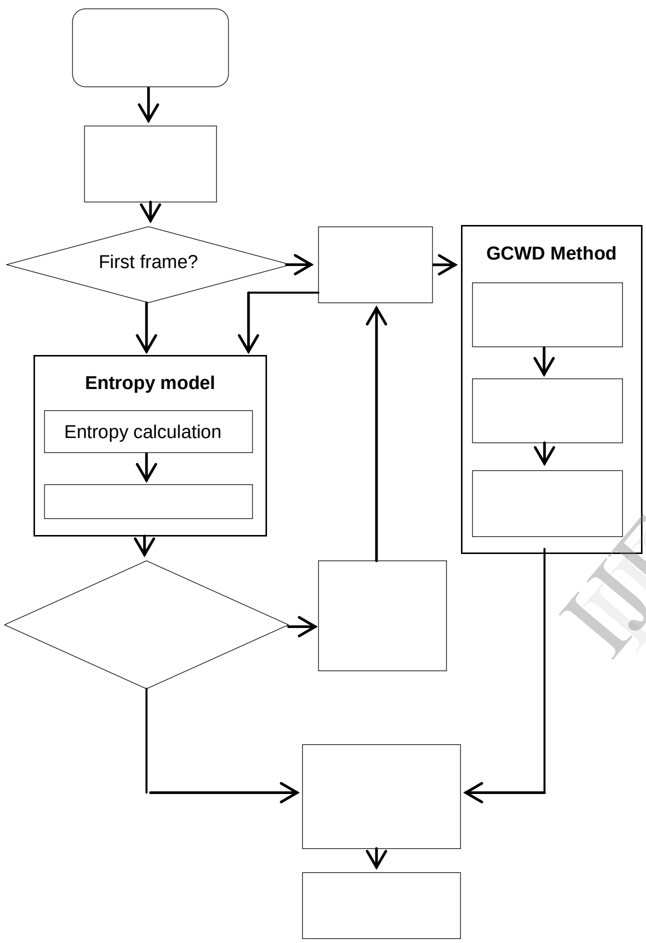

Fig. 3.Flow chart of the temporal based method

IV. SIMULATION RESULTS

This section summarizes the simulated results produced by both GCWD method and TB method. For image enhancement GCWD method was applied and TB method was applied to video enhancement.
In general, change in the contrast can be caused by many factors which are common to outdoor scenes, such as intensityof the sunshine, the location of light source, cloud cover. Similarly the image of indoor scenes, the quality is often affected by interior lighting.

A. Image Enhancement.

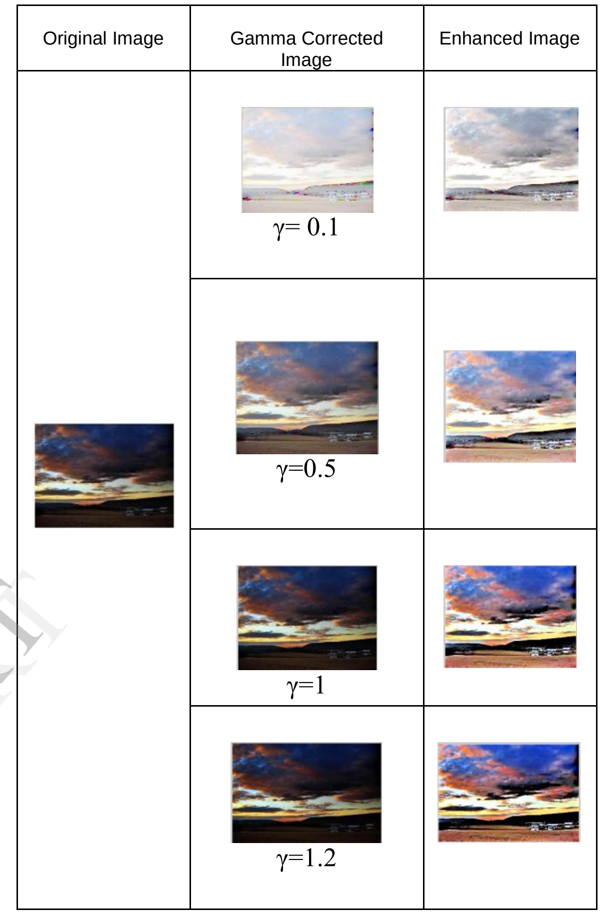

Fig. 4.Image enhancement for different values of gamma and corresponding enhanced image.

Contrast enhancement for dimmed images performed by proposed method for the above image in Fig. 4 shows original image, with its gamma corrected image and there equivalent enhanced image

B. Enhancement of Video Sequence.

In addition to the image enhancement, video contrast enhancement is also achieved. Fig.6 shows seven sampled frames of the man walking video sequence and its enhancement results generated by TB method. In the video, the man walking in dimmed area. The method increases the contrast between the man and background without distorting color or generating artifacts.

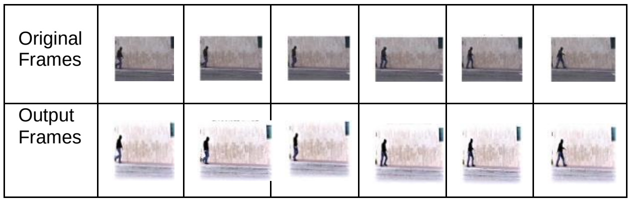

Fig.6. Seven sampled frames of the man walking and the enhancement results generated by TB method.

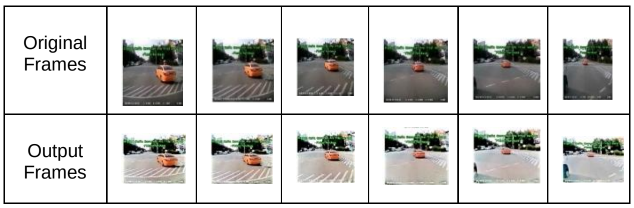

Fig. 7.Seven sampled frames of car crossing traffic signal and the corresponding enhanced frames by TB method.

Fig.7. shows the car crossing traffic signal video sequence and its enhanced results generated by TB method. This method increases contrast without distorting the color and generating artifacts.
Thus, as a result the TB method for man walking and car crossing traffic signal sequences can reduce the processing time, with dependent on temporal similarity of the sequence.

V. Conclusion And Future Work

In this paper, an enhancement method for both images and video sequences are presented. The proposed method composed of following steps. First, the histogram analysis provides spatial information of single image. In the second step, the weighting distribution is used to smooth the fluctuant phenomenon and thus to avoid generation of unfavourable artifacts. In the third step, gamma correction enhances the image contrast through smoothing curve. Finally luminance and contrast enhancement is applied for the gamma corrected frame to the value component. Furthermore, we employed temporal information to reduce the computational time for several image frames of video sequence. Based on the difference in the information content, the entropy model is used to determine whether or not frame storage should be updated. According to the simulation results indicates that, the proposed method can not only enhance image/video but also keep original image luminance without distorting the color and generating unfavourable artifacts. The proposed approach can be implemented in real time video system with limited resources.

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