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Contrast enhancement analysis of video sequence in the temporal-based (TB) method

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ABSTRACT

Contrast enhancement is an important video processing technique that makes various contents of video easily distinguishable through suitable increase in contrast. Contrast enhancement plays an important role in the improvement of visual quality for computer vision, pattern recognition, and the processing of digital images as well as video. Here in this paper we use temporal based method to analyze the contrast enhancement of the video sequence. Adaptive gamma correction with weighting distribution (AGCWD) function based method is used to enhance the contrast of multiple frames in the video sequence and its temporal behavior is analyzed by varying threshold value. Contrast enhancement is analyzed using various quality metrics. This paper use AMBE and ΔE94 for the measurement of the brightness preservation and color distortion respectively. Again we use PSNR and ENTROPY for measurement of peak signal to noise ratio and information contents of enhanced video sequence. Experimental result demonstrate that higher threshold value can give better preservation and lower color distortion than the lower threshold value used in the temporal based method, and the also the PSNR value increases and Entropy difference of original video and enhanced video decreases by increasing threshold value.

Keywords: Contrast Enhancement, Gamma Correction, Histogram Equalization, TB Method, Video Enhancement Quality Metrics

I.INTRODUCTION

Contrast enhancement means improving the visual appearance of the images as well as videos to make it more satisfactory for the human or machine vision. Contrast enhancement comes under the image enhancement techniques. It is used in both image as well as video processing for better visual perception. Several contrast enhancement techniques are already available. Each technique has got merits and demerits. Histogram equalization is a very traditional technique where the intensity values of the image are redistributed. Due to environmental lighting conditions or because of the defects in the photographic devices, images may suffer from poor contrast. So in order to improve the image quality contrast enhancement is done.

Generally, the enhancement techniques for dimmed images and video can be broadly divided into two categories: Direct Enhancement Methods [2]-[4] and Indirect Enhancement Methods [5]-[7]. In direct enhancement methods, the image contrast can be directly defined by a specific contrast terms [2]-[4].Conversely, indirect enhancement methods attempt to enhance image contrast by redistributing the probability density [1]. In other words, the image intensities can be redistributed within the dynamic range without defining a specific contrast term [1]. Histogram modification (HM) techniques [8]-[10] are the most popular indirect enhancement techniques due to their easy and fast implementation. Gamma Correction method scores under these HM techniques. Here a varying adaptive parameter γ is used. One of the gamma correction methods, Transform-based gamma correction (TGC) is given below:

$$T(l) = l_{\max}(l / l_{\max})^{\gamma} \qquad \text{………………..} \ (1)$$

Herel_{max} is the maximum intensity of the input. The intensity l of each pixel in the input image is transformed as $T(l)$ after using Eq. (1).
The rest of this paper is organized as follows: Section II presents Literature survey, Section III provides a brief description of analysis being performed on temporal-based AGCWDmethod; Section IV presents the Video Enhancement Quality Metrics being used in this paper, SectionV presents analysis of quality metrics for video contrast enhancement and observations, and section VI presents the conclusion and future scope.

II.LITERATURE SURVEY

Shih-Chia Huang et al [13],proposed an efficient method temporal based (TB) adaptive gamma correction using weighting distribution (AGCWD) to modify histograms and enhance contrast in digital images. They used as automatic transformation technique to improve the brightness of dimmed images via the gamma correction and probability distribution of luminance pixels. Further they used temporal information by calculating entropy difference of frames to enhance computational efficiency. C. Wang and Z. Ye et al [10] proposed a novel extension of histogram equalization, to maximize the entropy and to make the histogram as flat as possible. Their Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME) method tried to find, by the variation approach, the target histogram that maximizes the entropy, under the constraints that the mean brightness is fixed, and then transformed the original histogram to that target one using histogram specification. Comparing to the existing methods experimental results showed that BPHEME can not only enhance the image effectively, but also preserve the original brightness quite well, so that it is possible to be utilized in consumer electronic products. Y.-S. Chiu et al [7]proposed an efficient histogram modification method for contrast enhancement by using an automatic transformation technique to improve the brightness of dimmed images based on the gamma correction and probability distribution of the luminance pixels. Experimental results showed their method produces enhanced images of comparable or higher quality than previous state-of-the-art methods. M. Kim et al [5] proposed a new method Recursively Separated and Weighted Histogram Equalization (RSWHE) method which uses a weighting function to smooth each sub-histogram for image enhancement as well as brightness preservation. J.-K. Song et al [14],worked on Tone Rendering Distortion Index (TRDI) and observed that TRDI shows a strong agreement with the human-perceived image quality, despite its simplicity, while peak-signal-to-noise ratio (PNSR) and color differences do not represent the image quality very well. The proposed method has been found to be useful for developing new display technology as well as for refining the image processing within display systems. Jaya V. L et al [16], studied the various quantitative metrics for enhancement against changes in contrast and sharpness of both general and medical images. They observed that most of the commonly used metrics cannot adequately describe the visual quality of the enhanced image and there is no universal measure, which can specify both the objective and subjective validity of the enhancement for all types of images. So they proposed a new image enhancement metric (IEM) for measuring the improvement in contrast as well as sharpness which is supposed to be computationally simple applicable to all types of images.

III.ANALYSIS OF TEMPORAL BASED AGCWDMETHOD

Temporal based AGCWD method [13] has been used in this paper and analysis of video contrast enhancement has been done using quality metrics AMBE, ΔE94, PSNR and Entropy. Originally, the factor T_hi.e. threshold value to compare entropy of the consecutive frames has been fixed empirically to 0.05 however in this work we have intended to vary the value of threshold and study its impact on the various video contrast enhancement quality metrics.

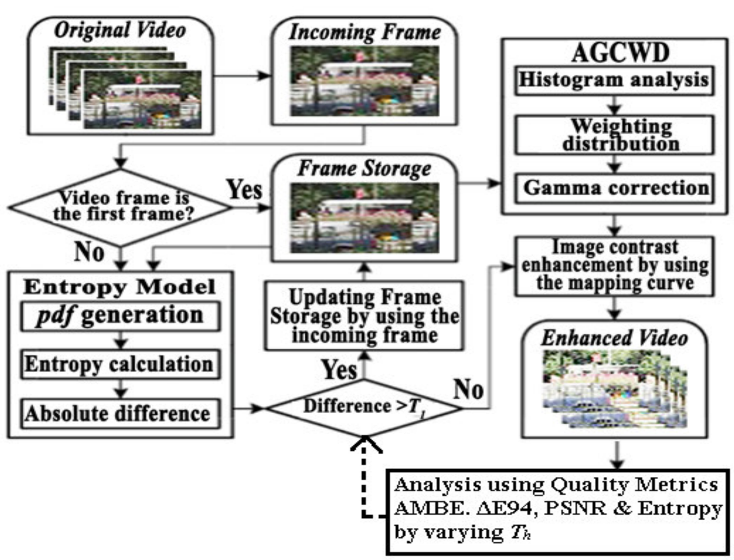

Fig. 1 Flowchart of the Temporal Based (TB) method as applied for video-contrast enhancement by varying T_h

IV. VIDEO ENHANCEMENT QUALITY METRICS

Here four parameters are used to measure the quality of the video which are Absolute Mean Brightness Error (AMBE) for measuring the mean brightness value [8], ΔE94which is based on CIE94 to measure color distortion [14],PSNR (Peak Signal to Noise Ratio), and ENTROPY for measuring information content of enhanced video.

IV.1. Absolute Mean Brightness Error

The contrast enhancement methods justify the brightness preservation of the video by considering the value of AMBE [8]. It is calculated as:

AMBE = E[Y] – E[X]

Where E[Y] is the mean of contrast enhanced video and E[X] is the mean of original video
This objective measurement is defined to rate the performance of proposed method in preserving the original brightness. A smaller value of AMBE indicates a better preservation of the brightness property. The AMBE has been calculated of enhanced video with respect to the original video.

IV.2. ΔE94

ΔE94isatraditional parameter used to measure the color distortion in the image as well as the video. This function used the lightness based color-space LAB representation of the color frames. This parameter measure the color difference of the original video and the enhanced video during its contrast enhancement, Lower the value of ΔE 94, less will be the color distortion in the video sequences [14].

IV.3. PSNR

PSNR is based upon Mean Square Error. (MSE), assuming total number of pixels in the input or output image isN, then MSE (Mean Squared Error) is calculated as –

$$MSE = \frac{\sum_i \sum_j |x(i,j) - y(i,j)|^2}{N}$$

The PSNR is calculated as-

$$PSNR = 10\log_{10}\frac{(L-1)^2}{MSE}$$

Where the number of discrete gray levels is L .The value of PSNR should be more for the better output image or video quality. PSNR has been calculated between enhanced and original color video frames separately of each of the color component i.e. R, G and B and subsequently aggregated to compute final figure.

IV.4. Entropy

For a given PDF P, Entropy Ent [P] is computed as-

$$Ent[P] = -\sum_{k=0}^{L-1} P(k)\log_2 P(k)$$

The Entropy is used to measure the richness of the details in the output image. This has been used as the objective metric for assessing the enhancement of the video contrast. The difference of entropy of output enhanced video and that of original video has been calculated to assess this parameter.

V. ANALYSIS OF QUALITY METRICS FOR VIDEO CONTRAST ENHANCEMENT

Table I: AMBE ANALYSIS OF ENHANCED VIDEO SEQUENCE

Threshold value	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
AMBE	0.11531	0.08596	0.04577	0.04541	0.03195	0.01565	0.00478	0.00462	0.00462	0.00462

Table II: ΔE94 ANALYSIS OF ENHANCED VIDEO SEQUENCE

Threshold value	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
ΔE94	13.77529	10.05595	4.99988	4.92204	3.57665	1.95990	0.62877	0.57082	0.57082	0.57082

Table III: ENTROPY ANALYSIS OF ENHANCED VIDEO SEQUENCE

Threshold value	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
Entropy	0.28536	0.21579	0.12105	0.11926	0.08101	0.03693	0.01047	0.01038	0.01038	0.01038

Table IV: PSNR ANALYSIS OF ENHANCED VIDEO SEQUENCE

Threshold value	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
PSNR	76.741	102.125	136.014	136.023	144.671	157.384	165.906	165.924	165.924	165.924

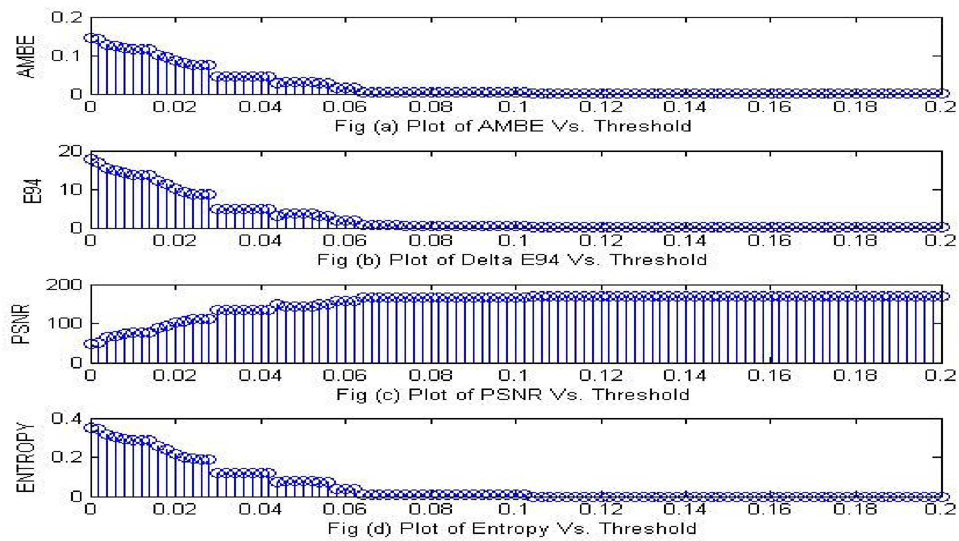

Fig. 1 Plots of video contrast enhancement quality metrics (a) AMBE versus Threshold (b) ΔE94 versus threshold (c) PSNR versus threshold (d) Entropy versus threshold, study of the Temporal Based (TB) method as applied for video-contrast enhancement by varying T_h

V.1 OBSERVATIONS

(1)Visual quality of enhanced video increases as threshold value is reduced.
(2) AMBE should be as small as possible for better preservation of the images as well as video. Here the AMBE value decreases with increasing the threshold value. That means at higher threshold value the brightness preservation of the enhanced video is more.
(3) ΔE94value decreases with increase in the threshold value i.e. color distortion decreases at higher threshold value.
(4) PSNR value increases with increasing the threshold value, whereas visual quality decreases.
(5)ENTROPY decreases with increasing the threshold value, which means quality of the video decreases. At low threshold value we get output video with high contrast.

VI.CONCLUSIONAND FUTURE SCOPE

In this paper, we analyze the temporal based contrast enhancement method for video sequences. Experimental video contrast enhancement results demonstrate that by using lower threshold value in the temporal based method we found the better contrast enhancement compared with higher threshold value. Various quality metrics have been evaluated of the video contrast enhancement. As a future scope, the detailed study of all the quality metrics for the enhancement of video and image can be done taking directions from this work and accordingly the algorithms can be fine tuned for implementing in a real-time with limited resources.

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