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Adaptive Quality Enhancement for Videos Using AGCWD

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***Abstract*— Image enhancement is the one of the most important issues in image processing. Histogram equalization (HE) is the common method used for improving contrast in digital images due to its simple function and effectiveness. However, it usually results in mean shift problem, which causes the unnatural look and visual artifacts of the processed image. Thus it cannot be used in consumer electronic products such as TV. Gamma correction is another technique used for contrast enhancement and this technique will exhibit the same changes in intensity with respect to a fixed parameter on different images. Adaptive gamma correction with weighting distribution combines the cumulative distribution function (CDF) and gamma correction. Inorder to avoid the problems in both the techniques, Adaptive gamma correction with weighting distribution was introduced, which combines HE and gamma correction. In the case of videos impulse noise may appear, which affect the CDF of the frame. So Adaptive Quality Enhancement for videos Using AGCWD was proposed, in which denoising is performed to overcome the changes in CDF of the frame.**

***Keywords*— Histogram equalisation, Contrast enhancement, Gamma correction.**

I. INTRODUCTION

Image enhancement is a process involving changing the pixels' intensity of the input image, so that the output image should subjectively looks better [1]. Histogram equalization (HE) is a very popular technique for enhancing the contrast of an image [2]. Its basic idea is to map the gray levels based on the probability distribution of the input gray levels. HE has been applied in various fields such as medical image processing and radar image processing [3][4]. Generally, HE is classified into two principle categories – global and local histogram equalization [15]. Global histogram equalization (GHE) uses the histogram information of the entire input image for its transformation function. Local histogram equalization (LHE) uses a small window that slides through every pixel of the image sequentially and only the block of pixels that fall in this window are taken into account for he and then gray level mapping for enhancement is done only for the center pixel of that window [1]. So GHE does not consider the fine details of the image. Here we consider the GHE techniques for image enhancement. GHE usually introduces two types of artifacts into the equalized image: over enhancement for the image regions with more frequent gray levels; and the loss of contrast for the image regions with less frequent gray levels [13].

In the equalizing procedure, the neighboring gray levels with light probabilistic density are combined into one gray level, while the gap between neighbour two gray levels with heavy probabilistic density is enlarged. Thus the processed image can have a uniform gray distribution property [7]. So the image contrast is enhanced in the whole sense. But it is just because of the gray scale stretching effect that may be cause the average luminance of the image shift significantly, and that it is sure to result in impulse vision sense, sometimes even degrade the image quality. This is why the histogram equalization technique is seldom utilized in video system in the past [6].

A. *Histogram Equalization*

For a given image X, the probability density function (PDF) $P(X_k)$ is defined as

$$P(k) = n_k/N \qquad \text{for } k=0,1....L-1 \qquad (1)$$

where N is the total number of pixels in the image. From the PDF in (1), the cumulative distribution function (CDF) is defined as

$$C(k) = \sum_{j=0}^{k} P(j) \qquad \text{for } k=0,1,.....L-1 \qquad (2)$$

Note that C(L-1) = 1 from (1) and (2).

Based on the CDF, histogram equalization now maps an input gray level X_k into an output gray level f(k), where f(k),
commonly called a level transformation function, is defined as

$$f(k)= X_0+(X_{L-1}-X_0)C(k) \qquad (3)$$

Thus, histogram equalization remaps the input image into the entire dynamic range $[X_0, X_{L-1}]$[9].

B. GAMMA CORRECTION

The simple form of the transform-based gamma correction (TGC) is derived by

$$T(l) = l_{max}(l/l_{max})^{\surd} \qquad (4)$$

where l_{max} is the maximum intensity of the input.

The rest of the paper is organized as follows. Section II presents literature survey, and the Section III discusses proposed work. Section IV presents the results and discussion and finally, Section V presents conclusion and future work.

II. Literature Survey

Various techniques are introduced to improve the HE. Some of the innovative approaches are described.

A. Brightness preserving bi-histogram equalization (BBHE)

BBHE method tries to overcome the brightness preservation problem. It firstly separate the input image's histogram into two based on its mean. Next, it equalizes the two histograms independently [5]. So the input image is decomposed into two subimages X_L and X_U as

$$X = X_L \cup X_U \quad (6)$$

The histogram with range from 0 to L-1 is divided into two parts, with separating intensity. This separation produces two histograms. The first histogram has the range of 0 to mean, while the second histogram has the range of mean+1 to L-1. The ultimate goal behind the BBHE is to preserve the mean brightness of a given image while enhancing the contrast of a given image. Here the mean brightness of the image is middle of the input mean and the middle gray level.

B. Dualistic Sub-Image Histogram Equalization (DSIHE)

DSIHE decomposes the image into two equal area sub images based on its original probability density function. So the gray level can be remained in their original scales respectively after sub-image histogram equalizing. Then the two sub images are equalized separately. At last, the processed sub-images are combined to form one image. The average luminance of the original image is kept from significant shift since the histogram doesn't change greatly[6]. DSIHE method is the average of the equal area level of the image X and the middle gray level of the image.

C. Recursive Mean-Separate Histogram Equalization (RMSHE)

RMSHE is the recursive version of BBHE. Here the histogram is decomposed recursively up to a recursion level r, generating 2^r sub-histograms. The resultant sub histograms are then equalized individually. If r=0, then it is equivalent to conventional histogram equalization. When r=1, the histogram is decomposed into two. This case is the same as BBHE [7].

D. Minimum Mean Brightness Error Bi-Histogram Equalization(MMBEBHE)

MMBEBHE is an extension to BBHE. It separates the input image's histogram into two based on Absolute Mean Brightness Error (AMBE - the absolute difference between input and output mean) before equalizing them independently [8]. It is defined as the absolute difference between the input and the output mean as follow:

$$AMBE = | E(X) - E(Y) | \quad (7)$$

Lower value of AMBE gives better brightness preservation.

E. Recursively Separated and Weighted Histogram Equalization(RSWHE)

RSWHE first segments the histogram recursively up to a recursive level r and generates 2^r sub histograms based on mean or median. Due to histogram equalisation, the gray levels of high probabilities dominate other gray levels of low probabilities. So RSWHE introduces the histogram weighting module, where the input histogram (or PDF) is modified in such way that the infrequent gray levels are given relatively more weights than the frequent gray levels [9]. Then each sub histograms are equalized separately. And finally all equalized sub histograms are combined to form the resultant histogram.

F. Dynamic Histogram Equalization (DHE)

In order to eliminate the domination of higher histogram components on lower histogram components in the image histogram, DHE divides the histogram in to a number of sub histograms until it ensures that no dominating portion is present in any of the newly created sub-histograms [10]. Then distributes the total available dynamic range of gray levels among the sub histograms based on their dynamic range in input image and cumulative distribution (CDF) of histogram values. Finally, HE is applied to each sub histogram.

G. Contrast Enhancement Using Adaptive Gamma Correction With Weighting Distribution(AGCWD)

AGCWD combines gamma correction with histogram equalization.

$$T(l) = l_{max}(l/l_{max})^{\gamma} = l_{max}(l/l_{max})^{1-cdf(l)} \quad (8)$$

Thus increase the low intensity values and avoid the significant decrement of the high intensity values. Furthermore, in fig.1 the weighting distribution (WD) function is also applied to slightly modify the statistical histogram. Finally, the gamma parameter based on CDF is applied [11].

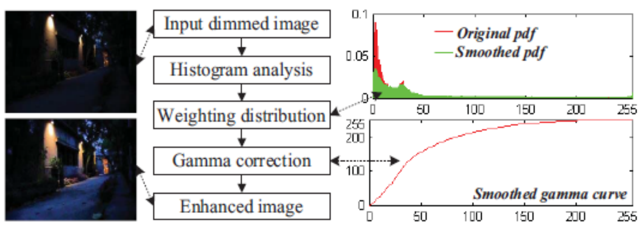

Fig. 1. Flowchart of AGCWD method

This method is also applied in video. Computational complexity and controllability become an important issue when the goal is to design a contrast enhancement algorithm for consumer products [12]. For reducing the computational complexity, measure the differences of the information content between two successive frames and if it is less than a predefined threshold, the existing mapping curve is directly applied to transform each intensity level in the incoming video frame.

1) Algorithm of AGCWD for videos:

1. Read the input video
2. If it is the first frame, perform AGCWD
3. Otherwise, measure the differences between the current frame and the previous frame

i.If the difference is less than a predefined threshold, enhance the frame by using the previous mapping curve

ii.Otherwise, perform AGCWD

In real time applications, impulse noise may appear in videos. In such cases this algorithm results undesired output due to the changes in CDF of the frames. Thus a new method is proposed to overcome this situation. Here first denoise the frame before applying AGCWD.

III. Proposed System

In the proposed method, our key observation is to denoise the noised frames in videos before performing AGCWD. In the case of noised frames in video, for improving visual quality, first check whether noise is present or not in a frame. If noise is present, then remove the noise and enhance the frame using AGCWD. Otherwise directly apply AGCWD.

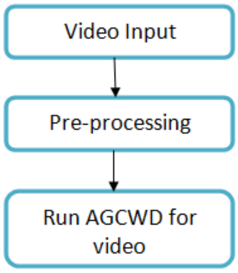

Fig.2. Flowchart of the proposed system

1) Pre-processing steps:

1. Read incoming frames
2. Check the frame
3. If it is the first frame, then check the noise

i. If noise present, then denoise the frame and go to step 7

ii. Otherwise go to step 7

4. If not the first frame, then find the moving object.
5. For moving object check for the noise

i. If noise present, then denoise and go to step 7

ii. Otherwise go to step 7

6. For non-moving object, replace that part with corresponding part in the previous frame
7. Run AGCWD for video

IV. Results And Discussions

In order to investigate the proposed method produces better visual quality, we use two objective measures. They are

PSNR (Peak Signal-To-Noise Ratio) and SSIM (Structural Similarity Index). They are described in detail below.

1) *PSNR:* Assuming that *N* is the total number of pixels in the input or output image, MSE (Mean Squared Error) is calculated in (9). Based on MSE, PSNR is then defined as (10). The greater the PSNR, the better the output image quality.

$$MSE=\sum_i\sum_j|X(i,j)-Y(i,j)|^2/N \quad (9)$$

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

2) *SSIM* :It is calculated by using average (μ), variance(σ^2) and covariance(σ_{xy}).

$$SSIM(x,y)=(2\mu_x\mu_y+C1)(2\sigma_{xy}+C2)/(\mu_x^2 + \mu_y^2+C1)(\sigma_x^2+\sigma_y^2+C2)$$

Where $C1=(.01*L)^2$ and $C2=(.03*L)^2$

Fig.3. The noised, denoised and enhanced frames of Traffic, Rhino and Plane videos respectively.

TABLE I
Computed PSNR and SSIM Values of the Video Frames of Traffic, Rhino and Plane

Video	Frame Number	PSNR	SSIM
Traffic	1	28.98	0.86
	3	28.89	0.87
	7	28.92	0.87
Rhino	1	33.01	0.85
	3	33.92	0.8
	7	33.19	0.8
Plane	1	32.92	0.89
	3	33.38	0.94
	7	31.38	0.92

From the table, we can identify the frames of the three videos have better PSNR and SSIM.

V. Conclusion And Future Work

Contrast Enhancement Using Adaptive Gamma Correction with Weighting Distribution is a novel contrast enhancement technique for both images and videos. When there is impulse noise present in a video frame, the algorithm produces the output with less visual quality due to the change in CDF of the frame. So the proposed work initially performs the denoising method on the noised frame and produces the output with high visual quality and better PSNR and SSIM.

In future the same algorithm can be extended to other types of noises.

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