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Low Light Video Enhancement Using Effective Framework Approach

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Abstract: Over the several decades, there have been improvements in Digital cameras including resolution and sensitivity. Other than these improvements, digital cameras are still limited in capturing images in low-light conditions. Video in low light is targeted. Many approaches are developed to improve the quality of low light video; however most of them consider video from moderately dark conditions. In this project, we propose an effective framework approach to enhance video from low light condition using noise removal filter technique and Weber's law used to detect the background in video in poor lighting. Finally, the performance of the proposed technique is illustrated through the processing of videos with different backgrounds, the majority of them with poor lighting conditions. The proposed method not only enhances the contrast but also measuring image quality by using MSE, PSNR and Correlation factor. Experimental results show that the proposed method has good performance on enhancing contrast and visibility for a majority of images. The software tool used is a MATLAB.

Keywords: Video, Enhancement, Low Light, Weber's Law, MATLAB.

I. INTRODUCTION

Video has become an integral part of everyday's life. As video surveillance equipment and mobile devices such as digital cameras, smart phones are increasingly used; cameras are expected to capture video content in all lighting and weather conditions. The majority of cameras, however, are not designed to be all-purpose and weather-proof, making the video unusable.

It is well-known that video enhancement as an active topic which received much attention in recent years. The aim is to improve the visuality of the video. Moreover, it helps to analyses background information which is essential to understand the object behaviour without human visual inspection.

There are various applications where digital video is acquired, processed and used, such as surveillance, general identity verification, criminal justice systems, civilian or military video processing. Carrying out video enhancement under low quality video is a challenging problem because of the following reasons.

(i)Due to low light, we cannot clearly extract moving objects from the dark background. Most colour-based methods will fail to identify colour of the moving objects and that of the background are similar.
(ii) The signal to noise ratio is usually very low due to high ISO (ISO is the number indicating camera sensors sensitivity to light). Using a high ISO number can produce visible noise in image.
(iii)Environmental information acts in many types on information. So, dealing with moving tree, fog, rain, behaviour of people in night time video are the difficult
because they lack background due to poor illumination.
(iv)The moving objects region as weight since successive images should change smoothly.
(v) One pixel from a low quality image is important even if it is small, such as the area between the head lights and the tail lights of a moving car.

A general methodology for noise reduction and contrast enhancement is presented. Videos from dark background is targeted. Many approaches are developed for enhancing low light video; however most of them consider video from moderately dark conditions. In this project, we propose an effective framework approach to enhance video from low light environment using appropriate noise removal filter technique and Weber's law used to detect the background in video affected by poor lighting.

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II. LITERATURE SURVEY

This section presents related literature concerning low light video enhancement technique.

Henrik Malm Magnus Oskarsson Eric Warrant [1] presented a methodology for adaptive enhancement and noise reduction for very dark image sequences with very low dynamic range. The approach is very general and adapts to the spatio temporal intensity structure in order to prevent motion blur and smoothing across important structural edges.

Qing Xu1, 2, Hailin Jiang1, Riccardo Scopigno3, and Mateu Sbert4 [2] presented a novel three-stage algorithm for very low-light video denoising and enhancement. A new framework for very dark videos denoising and enhancement has been introduced and shown to largely improve current state-of-the-art results.

Jinhui Hu, Ruimin Hu, Zhongyuan Wang, Yan Gong, MangDuan [3] presented a technique of kinect depth based method for low light surveillance image enhancement. Comparing with the previous works, this method is able to enlarge the low dynamic range and promote both globe and local depth perception for the low light surveillance image meanwhile.

Minjae Kim1, Student Member, *IEEE*, Dubok Park1, David K. Han2, and Hanseok Ko1 [4] proposed a novel framework for enhancement of very low-light video. For noise reduction, motion adaptive temporal filtering based on the Kalman structured updating is presented. The experimental results indicate that this method is highly promising for real time applications to consumer digital cameras, especially CCTV and the surveillance video system

III. PROPOSED WORK

In this we focus on the techniques of video enhancement, which can be made better in poor visibility light condition. Desired outcome of the project is to enhance video. The steps to get desired outcome is as shown in fig.1

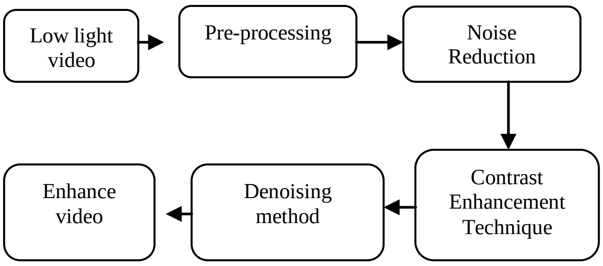

Fig. 1: Block diagram of proposed approach

A. Pre-processing

The low light video is applied to the first step which is pre-processing. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features in video relevant for further processing. Image pre-processing use the redundancy in images. Gaussian smoothing is also used as a pre-processing stage in algorithms in order to enhance image structures at different scales. A Gaussian smoothing is the result of smoothing an image by a Gaussian function.

Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. This is also known as a two dimensional Weier strass transform. Since the Fourier transform of a Gaussian is another Gaussian, applying a Gaussian blur has the effect of reducing the image's high frequency components; a Gaussian blur is thus a low pass filter.The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

In two dimensions, it is the product of two such Gaussians, one in each dimension:

$$G(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x^2+y^2)}{2\sigma^2}}$$

Where x- distance from the origin in the horizontal axis,
y- Distance from the origin in the vertical axis, and
σ - Standard deviation of the Gaussian distribution.

Values obtain from this distribution are used for convolution matrix which is applied to the original image. Each pixel's new value is set to a weighted average of that neighbourhood pixel. The original pixel has heaviest weight than neighbouring pixels as their distance to the original pixel increases. This results in a blur which preserves boundaries and edges better than other, more uniform blurring filters.

B. Noise Reduction

In noise reduction we have to reduce noise in image. For this purpose we can use linear or non-linear filter,the linear filtering technique applies the algorithm linearly to all pixels in the image without identifying the corrupted or uncorrupted pixel. Since the algorithm applies to all the pixels in the image so this causes the uncorrupted pixels to be filtered.

Nonlinear filter uses two phase of filtering. In the first phase the pixels are identified as corrupted or not and in second phase the corrupted pixels are filtered while uncorrupted pixels are retained.

1) Adaptive Median Filter

The median filters perform quite well but it cannot remove the noise with probability of occurrence is High. To overcome the limitation of median filter there is an adaptive median filter. Adaption aims to adjust the filter parameters. This filter is to be robust in removing mixed impulses with high probability of occurrence is high while preserving sharpness. The adaptive median filter also applies the noise detection and filtering algorithms to remove impulsive noise. The size of the window applied to filter the pixels is adaptive, i.e. the window size is increased if the specified condition does not meet. If the condition is met, the pixel is filtered using the median of the window. Let, I_{ij} be the pixel of the corrupted image, I_{min} be the minimum pixel value and I_{max} be the maximum pixel value in the window, W be the current window size applied, W_{max} be the maximum window size that can be reached and I_{med} be the median of the window assigned. Then, the algorithm of this filtering technique completes in two levels as :

Level A:

a) If $I_{min} < I_{med} < I_{max}$, then the median value is not an impulse, so the algorithm goes to Level B to check if the current pixel is an impulse.

b) Else the size of the window is increased and Level A is repeated until the median value is not an impulse so the algorithm goes to Level B; or the maximum window size is reached, in which case the median value is assigned as the filtered image pixel value.

Level B:

a) If $I_{min} < I_{ij} < I_{max}$, then the current pixel value is not an impulse, so the filtered image pixel is unchanged.

b) Else the image pixel is either equal to I_{max} or I_{min} (corrupted), then the filtered imaged pixel is assigned the median value from Level A.

These types of median filters are widely used in filtering image that has been denoised with noise greater than 20%.

C. Contrast Enhancement Technique

After the noise reduction we have to amplify the contrast of low light video. This stage is used to enhance the contrast of low light video. It is also called as tone mapping. In this paper we propose two techniques for contrast enhancement and observing the best method based on the result.

1) Histogram Equalization

Histogram equalization is a technique for adjusting image intensities to enhance contrast. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. A disadvantage of this method is it may increase the contrast of background noise, while decreasing the usable signal. The histogram equalization is operated on an image in three step:

i. Formation of histogram
ii. Calculation of new intensity value for each Intensity Levels. New intensity values are calculated by applying the following equation:

$$O_i = \left[\sum_{j=0}^{i} N_j \right] \times \frac{\text{Max. Intensity Level}}{\text{No. of Pixels}}$$

iii. Replace the old Intensity values with the new intensity values

2) Weber's Law

Some morphological transformations are used to detect the background in images characterized by poor lighting. Lately, contrast image enhancement has been carried out by the application of two operators based on the Weber's law notion. The first operator employs information from block analysis, while the second transformation utilizes the opening by reconstruction, which is employed to define the background notion. Weber's law given as,

In psycho-visual studies, the contrast C of an object with luminance against its surrounding luminance is defined as follows:

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If L=Lmin and Δ = Lmax-Lmin so it can be

$$C = \frac{\Delta L}{L} \qquad (1)$$

In the above Equation Δ indicates that (log L) is proportional to C. Therefore, Weber's law can be expressed as

$$C = k\ log\ L + b \qquad L > 0 \qquad (2)$$

Where k and b are constants, b being the background. In this case, an approximation to Weber's law is considered by taking the luminance L as the grey level intensity of a function (image); in this way, above expression is written as follows

$$C = k\ log\ f + b \qquad f > 0 \qquad (3)$$

This methodology is calculate background parameter. This methodology consists of in calculating the average between the smallest and largest minima as a result contrast is not correctly enhanced in image with poor light. Hence we compute the image background by blocks is introduced. In this, first of all we will read an image as input image and divide it into several blocks and from each block we will determine the background and apply the Weber's law and thereby we obtain an enhanced image as shown in fig.(2).

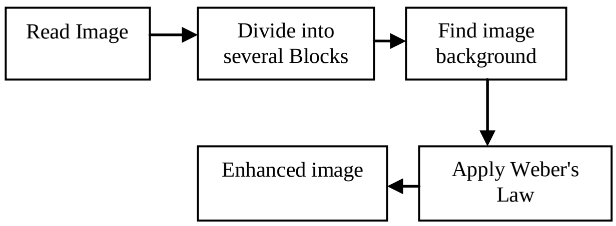

Fig. 2: Block Analysis method

Let us consider an image which is to be enhanced. The image is divided into n blocks of size. Each block is a sub image of the original image. As the image is made up of number of pixels each block consists of number of pixels. Find the maximum and minimum intensity values of pixels of each block. For each analysed block, maximum (M_i) and minimum (m_i) values are used to determine the background criteria T_i in the following way:

$$\tau_i = \frac{m_i + M_i}{2} \qquad \forall_i = 1,2, \dots n.$$

Once τ_i is calculated, this value is used to select the background parameter associated with the analyzed block. As follows, an expression to enhance the contrast is proposed:

$$\tau_{\tau i}(f) = \begin{cases} k_i \log(f+1) + M_{i,} & f \le \tau_i \\ k_i \log(f+1) + m_{i,} & otherwise \end{cases}$$

Note that the background parameter depends on the T_i value. If f<= T_i (dark region), the background parameter takes the value of the maximum intensity (M_i) within the analyzed block, and the minimum intensity (m_i) value otherwise. Also, the unit was added to the logarithm function in above equation to avoid indetermination. On the other hand, since grey level images are used in this work, the constant K_i in above equation is obtained as follows:

$$k_i = \frac{255 - m_i^*}{\log(256)} \qquad \forall_i = 1,2, \dots\dots, n$$

$$m_i^* = \begin{cases} m_i, & f < \tau_i \\ M_i, & f \le \tau_i \end{cases}$$

On the other hand, M_i and m_i values are used as background parameters to improve the contrast depending on the T_i value, due to the background is different for clear and dark regions. Now an image is formed by applying the above equation. Now consider a pixel in this image and the corresponding pixel in original image.

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D. Denoising method

For the final step of low light video enhancement we have to apply filtering for smoothing the remaining noise. Even though most of the noise is removed by the noise reduction, the noise is introduced by tone mapping step. Moreover, since the level of the noise is much higher than the low light environment, edges and textures are often over smoothed during the denoising process.

IV. RESULT AND DISCUSSION

The proposed method produces convincing results on a lot of videos, including videos with fast moving objects and the standard test videos. The enhancement results of the proposed algorithm with and without noise are shown in Fig.3.

(a)

(a_1)

(a_2)

Fig. 3: Enhancement result- (a): low light video, (a_1): By Histogram Equalization, (a_2): By Weber’s Law

From above experimental result Weber’s law gives better background quality than histogram equalization with improve SNR, PSNR, Correlation as represented in table 1.

TABLE I Values of MSE, PSNR, and Correlation

Image	Histogram equalization			Weber's law		
	MSE	PSNR	Correlation	MSE	PSNR	Correlation
A	251.75	24.12	0.90	88.63	28.66	0.82

IV. CONCLUSION

A new framework for very dark videos denoising and enhancement has been introduced and shown to largely improve results. We proposed a noise removal filter technique and Weber’s law followed by Median and adaptive median filter used for further smoothing. Histogram adjustment and Weber's law presented to increase the contrast range of the low-light video. The experimental results indicate that Weber's law is highly promising than histogram equalization.

The same framework can effectively handle normal light-level videos too. Experimental results show that the proposed method is capable of enhancing local details while avoiding excessive enhancement. Compared with histogram equalization method, the proposed method can achieve more superior performance.

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