International Journal of Recent Engineering Research and Development (IJRERD)
Volume No. 02 – Issue No. 04, ISSN: 2455-8761
www.ijrerd.com, PP. 98-103

A Critical Review on Low Light Video Enhancement

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Abstract: Low light video enhancement is one of the most significant components in digital video research. Low light conditions such as night time videos, foggy situations, rainy and so on, is very difficult for human observation. The principle of video enhancement is to improve the visual appearance of the video. This paper discusses a brief review of existing video enhancement methods and technologies, different video noises and video quality assessment.
Keyword: Video enhancement, foggy, Low Light, noise.

I. INTRODUCTION

Digital video has become an integral part of everyday life. It is well-known that video enhancement as an active topic in computer vision and has received abundant attention in recent years. The aim is to boost the visual appearance of the video. Carrying out video enhancement understanding under low quality video is a challenging problem because of the following reasons: due to poor dynamic range and high noise level. Videos are used in various public places such as hospitals, schools, companies, airports, etc., security in many such manners. Modern digital cameras have a restricted dynamic range this cause's poor visibility due to over exposure in bright regions & under exposure in dark areas of a captured video. Noise in video frames creates the serious poverty of image quality. Colour of the objects with similar background, low intensity of light and the unknown level of darkness while capturing a video, make it more complicate. Video enhancement of low light video is really a tedious job.

The survey of low light video enhancement is based on the existing techniques of video enhancement, which can be classified into two broad categories: spatial-based domain video enhancement and transform-based domain video enhancement. Spatial based domain video enhancement operates directly on pixels. The main advantage of spatial based domain technique is that they are conceptually simple to understand, and the time complexity of these techniques is low which favors real time implementations. But these techniques generally lack in providing adequate strength and very slight requirements. A survey of spatial-based domain enhancement techniques can be found in. Transform based domain video enhancement is a term used to describe the analysis of mathematical functions or signals with respect to frequency, and operate directly on the transform coefficients of the image, such as Fourier transform, discrete wavelet transform(DWT), and discrete cosine transform(DCT). The basic idea in using this technique is to enhance the video by manipulating the transform coefficients. The advantage of transform-based video enhancement contain (i) Low complexity of computations, (ii) Ease of viewing and manipulating the frequency composition of the image, and (iii) the easy applicability of special transformed domain properties. The fundamental limitations including (i) it cannot concurrently enhance all parts of the image very well, and (ii) it is difficult to computerize the image enhancement procedure. If enhanced video implant high quality background information, the existing techniques of video enhancement can be classified into two broad categories: Self-enhancement and frame-based fusion enhancement. Video enhancement traditional methods are to improve the low quality video itself. It doesn't embed any high quality background information. For example contrast enhancement method, HDR-based video enhancement, wavelet-based transforms video enhancement and compressed-based video enhancement. These approaches are uniformly called self-enhancement of low quality video. It don't enough luminous of low quality video. The cause is that in the dark video, a few areas are so dark that all the details are already lost in those regions. It doesn't matter how much illumination you apply, it will not be able to bring back lost information. Frame-based fusion enhancement deals with low quality videos, which fuse illumination information in different time video. The frame-based fusion enhancement is by extracting high quality background details to embed low quality video.

II. LITERATURE REVIEW

A. Minjae Kim, Dubok, Park, David K. Han, Hanseok Ko [1] has proposed A Novel Approach for Denoising and Enhancement of Extremely Low-light Video. The methodologies used are:

- A motion adaptive temporal filtering on a kalman structure is used for noise deduction.
- Dynamic range is increased by alteration of RGB histograms using gamma correction with adaptive clipping thresholds.
- Residual noise is eliminated by a nonlocal means (NLM).
- Less memory consumption is achieved by Color filter array (CFA) raw data.
- Histogram adjustment using the gamma transform and the adaptive clipping threshold is also presented to increase the dynamic range of the low-light video.

Limitations:

- Not effectively work on colour video (Over saturation problem while brightness of the dark region increases).
- Based on uncompressed video.

B. Xianshu Ding, Hang Lei, Yunbo Rao[2] has proposed Sparse codes fusion for context enhancement of night video surveillance. The methodologies used are

- Sparse codes fusion (SCF).
- Mutual Coherence Learning (MCL) Algorithm.

Limitations:

- For enhancement on the moving surveillance camera, it is unreliable for fusion with a fixed background. And then SCF is not applicable any more.
- If the moving objects are huge and of a great spatial part of the image, SCF will become invalid.

C. Qing Zhang, Yongwei Nie, Ling Zhang, Chunxia Xiao[3] has proposed Underexposed Video Enhancement via Perception-Driven Progressive Fusion. The methodologies used are

- Perception driven Progressive Fusion.
- Spatio-temporal filtering.

Limitations:

- The result still undergoes some noticeable noise artifacts.
- Patch based spatio temporal filtering may wash out some weak edges.
- Current progressive fusion cannot work well on videos captured by fast moving cameras since the bidirectional association may fail.

D. Anwaar Ulhaq , Xiaoxia Yin , Jing He , Yanchun Zhang[4] has proposed FACE: Fully Automated Context Enhancement for night-time video sequences. The methodologies used are

- A color night vision system, named FACE (Fully Automated Context Enhancement).
- Median filter for noise deduction.
- A glare-free video fusion unit which is responsible for efficient fusion and false-colorization using RGB color channel fusion.
- Source color image selection based on contextual.
- Color features with deep-KNN and color value imputation.

Limitations:

- It is intended to deal with a still camera environment under which background scene does not change.

E. Tunc¸ Ozan Ayd□n, Nikolce Stefanoski, Simone Croci, Markus Gross, Aljoscha Smolic[5] has proposed, Temporally Coherent Local Tone Mapping of HDR Video. The methodologies used are

- HDR video tone mapping operator (TMO).
- Edge Aware Filtering.

Limitations:

- Artifacts are concealed only to a reasonable level.
- Only a basic means of controlling Chrominance in the form of saturation slider.

F. Seungwon Lee, Nahyun Kim, Joonki Paik[6] has proposed Adaptively Partitioned block-based contrast enhancement and its application to low light-level video surveillance. The methodologies used are

- Divides the image into dark and background regions using adaptively partitioned blocks by two optimal threshold values computed by fuzzy C-means clustering in the V channel of the HSV color space.
- Contrast stretching process is operated only in the detected dark region.

Limitations:

- Long computational time
- Sensitivity to the initial guess (speed, local minima)
- Sensitivity to noise and one expects low (or even no) membership degree for outliers (noisy points).

G. R.G Hirulkar, P U Giri[7] has proposed Video nhancement for Low Light Environment. The methodologies used are

- Illumination Segmentation.
- Illumination Adjustment.
  Homomorphic filtering.
  Histogram equalization.

Limitations:

- Illumination enhancement method reduces the luminance levels around the bright regions but did not expose the information in the darker region.
- Illumination equivalent to the daytime could not be achieved.

III. SOURCES OF NOISE IN DIGITAL VIDEO

The two foremost characteristics of a low light video are the low dynamic range and high level of noise. In order to reduce the amount of noise in a low light video it is important to consider the various noise sources. There are fundamentally two types of noise sources:

- Noise from the recorded video.
- Noise introduced by the measurement device.

These consist of quantization noise, read out noise; photon shot noise, thermal or dark current noise. Important noise sources formed by the camera are listed below.

- Photon shot Noise: It points to the inherent natural variation of the photon flux. Photon collected by a CCD (Charge Coupled Device) reveal a Poisson distribution. The fluctuation in photon count is visible in the video frame as Photon shot Noise. The noise histogram has a Gaussian distribution. Fluctuations in photon counts from pixel to pixel are totally uncorrelated; in terms of its spatial variation, photon shot noise is white noise, this means that it has a identical salt-and-pepper form with no structure or pattern.
- Read out Noise: It refers to the uncertainty introduced during the process of quantifying the electronic signal on the CCD. Greater part of it arises from the amplifier when converting electrons to voltage. Each electronic circuit component in the signal processing chain - from sensor (Photosensitive part of a pixel or sensor element) readout, to ISO gain, to digitization which suffers voltage fluctuations that contribute to a deviation of the raw value from the ideal value proportional to the photon count. The fluctuations in the raw value due to the signal processing electronics constitute the read noise of the sensor. Under low light conditions read out noise is one of the leading noises. The histogram of the noise is approximately Gaussian in nature.
- Dark Current Noise: It proceeds from the statistical variation of thermally generated electrons within the silicon layer comprising the CCD. Dark current indicate the rate of generation of CCD currents at a given temperature. Fixed pattern noises are produces by pixel having high dark current. FPN can be removed using spectral subtraction.
- Quantization Noise: The analog voltage signal from the sensor is digitized into a raw value; it is rounded to a nearby integer value. Due to this rounding off, the raw value inaccurate the actual signal by a slight amount; the error introduced by the digitization is called quantization noise. The histogram of the noise is approximately Gaussian in nature.

Dark current noise is approximated as fixed pattern noise. Read out noise, quantization noise, photon shot noise and the rest of the noises can be well approximated as FPN noise.

IV. PROPOSED WORK

The video enhancement is an active area of research. The problems of video enhancement, such as false background problem, colour shift problem etc. Video enhancement is one of the most significant and difficult component of video security surveillance system. The increasing use of night operations requires more details and integrated information from the enhanced image. However, low quality video of most surveillance cameras is not satisfied and difficult to understand because they not have surrounding scene context due to poor lighting. Image processing techniques is implemented to enhance the video. The steps to get desired conclusion is as shown in fig.1.

A. Pre-processing

In the first step low light video is given as input for pre- processing. Pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease it if

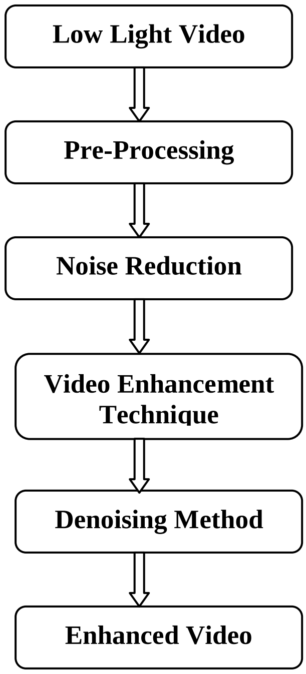

Fig 1. Flow to get enhanced video

entropy is an information measure. 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 and analysis task. Image pre-processing uses the redundancy in images. The low light video is applied to the first step which is pre-processing.

B. Noise reduction

Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. Since image sequences are temporally correlated, noise can be reduced effectively by temporal filtering. Videos are prone to a variety of types of noise. The output from first stage is given to the noise reduction. Noise reduction is the process of removing noise from a signal.

C. Enhancement technique

Videos are actually sequences of images, each of which called a frame, displayed in fast enough frequency so that human eyes can percept the continuity of its content. It is obvious that all image processing techniques can be applied to individual frames. The enhancement techniques adjust the relative brightness and darkness of objects in the scene to improve their visibility.

D. Denoising method

To get enhanced video in the final step we have to apply filtering for smoothing the remaining noise. Even still most of the noise is detached by the noise reduction; the noise is introduced by tone mapping. In addition, since the level of the noise is much superior to the low light environment, edges and textures are often over smoothed during the denoising process.

V. VIDEO QUALITY ASSESMENT

The goal of objective image and video quality assessment research is to design quality metrics that can predict perceived image and video quality automatically.

Video quality assessment has done through four stages, as shown in Fig. 2. Table 1 gives a comparison of these video quality assessment methods. QoS (Quality of Service) monitoring for the video traffic includes two parts: QoS provisioning from the network and QoS provisioning from the video application. QoS support from the network, especially wireless or mobile network, is essential for video delivery over the Internet. Three major approaches are congestion control, error control and power control. The challenges facing network QoS support include unreliable channels, bandwidth constraints, and heterogeneous access technologies. QoS support from the video application includes advanced video encoding scheme, error concealment and adaptive video streaming protocol.

Subjective test directly measures user QoE (Quality of Experience) by seeking users' evaluation scores under the laboratory environment. Users are given a series of tested video sequences, original ones and processed ones included, and then required to give scores on the video quality. Detailed plans for conducting subjective tests have been made by the Video Quality Expert Group (VQEG). Though being viewed as a relative accurate way of measuring user QoE, subjective test suffers from three major drawbacks. First, subjective test is expensive in terms of time, money, and manual effort. Second, subjective test is conducted in the laboratory environment, with limited test video types, test conditions, and viewer demography. Therefore, the results may not be relevant to video quality assessment in the wild. Third, the subjective test cannot be used for real-time QoE evaluation.

In order to keep away from high cost of subjective test, objective quality models are developed. The major purpose is to identify the objective QoS parameters that contribute to user perceptual quality, and map these parameters to user QoE. Most of the objective quality models are based on how the Human Visual System (HVS) receives and processes the information of the video signals. One of the commonly used methods is to quantify the difference between the original video and the distorted video, then weigh the errors according to spatial and temporal features of the video.

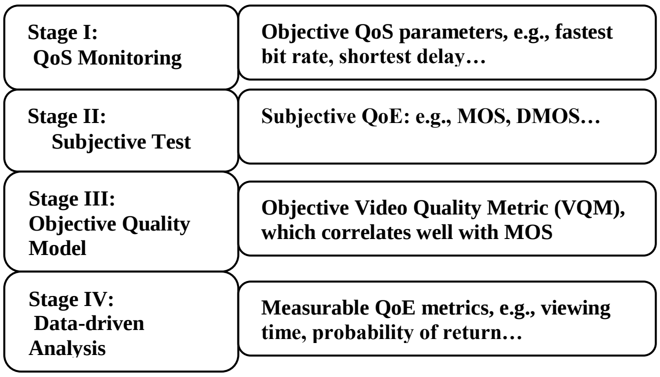

Fig 2. Video quality assessment evolution.

Data-driven video quality analysis comes forth as a hopeful way of solving the problems faced by the previous methods. There are two current trends for data-driven video quality assessment. The first trend is from user quality of "experience" to user quality of "engagement". Instead of user outlook score, which can only be obtained from subjective test, QoE metrics that can be easily quantified and measured without much human interference. The second trend is from small-scale lab experiments to large-scale data.

TABLE I. Comparison of Video Quality Assessment Methods

	Direct Measure of QoE	**Objective/ Subjective**	**Real-time**	**Wide Apllication**	**Cost**
QoS Monitoring	**No**	**Objective**	**Yes**	**Wide**	**Not Sure**
Subjective Test	**Yes**	**Subjective**	**No**	**Limited**	**High**
Objective Quality Model	**No**	**Objective**	**Yes/No**	**Limited**	**Low**
Data-Driven Analysis	**Objective**	**Yes**	**Yes**	**Wide**	**Not Sure**

VI. CONCLUSION

Video enhancement becomes a very challenging problem under low lighting conditions. Different algorithms are reviewed for enhancing low quality of videos captured under different environmental conditions especially in dark or night time, foggy situations, rainy and so on. The formerly used methodologies are able to reduce the noise as well as increase the contrast level of the video but used methods are not still effectively work on colour video. Therefore our aim is to get clear video from the low light video.

ACKNOWLEDGMENT

I would like to take this opportunity to convey my profound gratitude and deep regard to Dr. R Mathusoothana S Kumar, for his exemplary guidance, valuable feedback and constant support. His perceptive criticism kept me working to make this project in a much better way. Working under him was an extremely knowledgeable experience for me. My sincere gratitude goes to my family members and friends.

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