Extremely Low-light Video Denoising and Enhancement with Tone mapping and Filters

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Abstract - In this paper we proposed a novel approach for noise reduction and enhancement of extremely low-light video. For noise removal, a motion adaptive temporal filter is used which is based on a Kalman structured updating. The dynamic range of denoised video is increased by the adjustment of RGB histograms using gamma correction with adaptive clipping thresholds. Finally, residual noise is removed using a nonlocal means (NLM) denoising filter. The proposed method works directly on the color filter array (CFA) raw video for achieving low memory consumption.
KEYWORKS:Noise reduction, Lowlightvideo, Temporal filter, Gamma correction , NLMfilter.

I. INTRODUCTION

The cameras for Surveillance videos were sometimes placed in dim light conditions. The objects in the videos may be not clearly visible due to poor lighting conditions. A method that enhances the low illuminant videos without modifying much in the color information's was proposed. The video frames were filtered and tone mapped based on Non-local means filter and kalman filter..In kalman filter the updating and the prediction steps were included for the estimation of the noise. The performance of the process is measured on the basis of the PSNR, SSIM, GCF, NIQE calculation. Low-light noise is a significant problem in photography. Most of the cameras have poor low-light characteristics, which typically result in images with noticeable white noise or speckle noise. . Active lighting in the form of a flash is not always viable as it causes color aberrations and is effective only for nearby objects. The color information has to be preserved and also the noises in the images have to be removed. The application of the noise removal process can be effective when developed in software environment. A software-based approach to suppress the noise effects in low-light images, making it possible to capture sharp as well as noise-free images with short exposures and also the low light images were tone mapped in order to obtain enhanced video revealing the original color information in the videos. The proposed enhancement methods enhances the images based on Tone mapping and also noise removal process were applied in stepwise procedure to remove the noises occurring in the videos while applying tone mapping process. The comparison of the performances indicates that the proposed method is more efficient.

II. PROPOSED SYSTEM:

The input video is converted into frames. The Gaussian noise is added to the video frames. The temporal noise reduction process is first employed. The difference between the current frame and the previous frame is calculated. The calculated difference is the motion difference in each frames of the video. The sum of squared distance and the mean absolute deviation were calculated..The kalman gain of the process is calculated and based on that the noise amount estimated .The prediction and the estimation step is helpful in the identification of the noises and the removal of the noises. Since noise in a low-light video can be amplified by stretching dynamic range, severe noise should be suppressed before the tone-mapping step. A spatial-temporal filtering can suppress most of noise in a low-light video. However, too strong demising may cause over-smoothing and blurring effect around moving object regions.

.An effective motion adaptive temporal filtering, which is developed by modifying the Kalman filter approach, is applied at the very first. And then, the narrow dynamic range of demised signal is widened by Gamma correction of each RGB histogram with low and high intensity levels clipped by appropriate thresholds. Lastly, the remaining amplified noise after having been through the former two steps is filtered by spatial noise reduction. Noise in low-light video is regarded as a zero-mean Gaussian after eliminating FPN, it can be suppressed easily with a simple averaging along the temporal direction. Be that as it may, a basic transient averaging may come about antiquities when movement exists in video successions. The info video is changed over into edges. For the identification of the movements in the video the current video frame is subtracted from the previous frame to obtain the difference image.

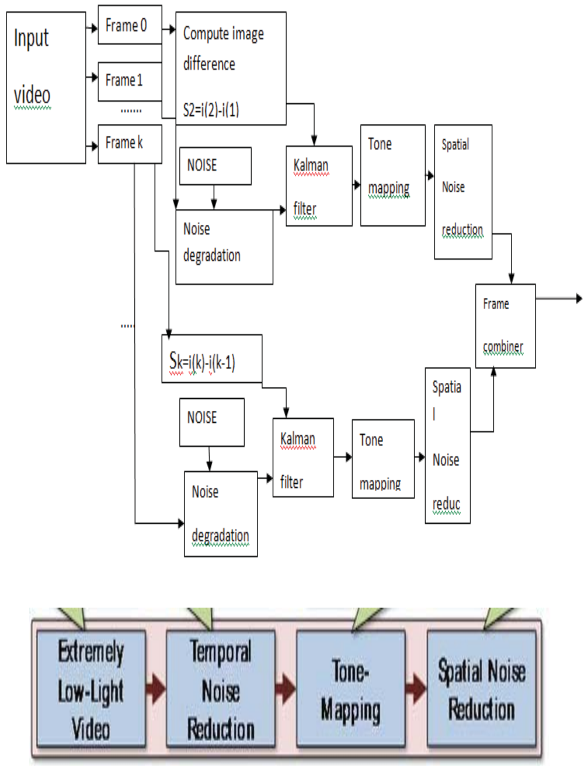
The difference image represents the movements in the video frames and they were useful for the removal of the ghost effects while employing noise reduction. The difference image is also helpful for the identification of the noise locations in the frames which can be then eliminated. The added Gaussian noises in the images were removed based on the temporal noise reduction for which the identification of the difference image is the first step. The difference image also indicates the most complex motion fields in the images. The difference frame is used for the temporal noise reduction of the images. The kalman filter has two steps predictions and the updating steps. In the prediction step the noise level in the images were estimated by the calculation of the weight matrix.

As the result of the updating step the temporal noises from the images were removed. Tone mapping process enhances the images and produces more accurate clear image compared to the video with dim and brighter illumination. Gamma correction is employed for the tone mapping of the images. In Gamma correction the histogram of the images were normalized to particular intensity. The clipping of the histogram decreases the intensity of the brighter image pixels and increases the intensity of the dim image pixels. Tone mapping process is employed comparing the images with clipping and without clipping. The clipping process enhances the image further compared with tone mapping without clipping process. For clipping of the signals clipping thresholds were setted for the images based on the higher range of the histogram. The solution to the NLM method converges as soon the stopping condition is achieved. The convergence of the proposed method provides the solution to the identification of the local means of the neighbor that removes the unwanted pixels in the images. The most comparative pixels to a given pixel have no motivation to be close by any stretch of the imagination. The periodic patterns or the elongated edges appear in many of the images. It is along these lines licit to examine an unfathomable segment of the picture looking for every one of the pixels that truly take after the pixel one needs to denoise. The convergence of the NLM methods helps to identify the portions in the images that is needed to be searched.

The performance of the process is measured by the calculation of the performance metrics like PSNR, SSIM, GCF and NIQE. PSNR values indicates the noise ratio in the input video frame and the resulting denoised video frame. The PSNR value must be high. SSIM value indicates the similarity between the input video frame and the resulting denoised video frame. The SSIM value must be within one. GCF - Global Contrast Factor is a measure for the analysis of the comparison of the contrast in input video frame and the resulting denoised video frame. NIQE - Natural Image Quality Evaluator is a distance metric for the model statistics and a factor for the comparison of the quality of the input video frame and the resulting demised video frame.

ADVANTAGES:

. It is therefore licit to scan a vast portion of the image in search of all the pixels that really resemble the pixel one wants to demise. The prediction and the updating steps employed in the kalman filter identify the position exactly where noise is present and hence the original color information were preserved. The comparison of the performances proves that the proposed system is capable of enhancing the videos and tone mapping the images based on gamma correction. The tone mapping process is combined with the noise removal process.



FIGURE(1): Overall Block diagram

The overall framework of the proposed method consists of three steps as illustrated in Figure.

III. PROPOSED WORK

3.1. MODULES

- Difference image.
- Kalman filter.
- Tone Mapping.
- NLM filter.
- Performance Measures.

3.2. MODULE DESCRIPTION

3.2.1. DIFFERENCE IMAGE:

The input video is converted into frames. For the identification of the movements in the video the current video frame is subtracted from the previous frame to obtain the difference image. The difference image represents the movements in the video frames and they were useful for the removal of the ghost effects while employing noise reduction. The difference image is also helpful for the identification of the noise locations in the frames which can be then eliminated. The added Gaussian noises in the images were removed based on the temporal noise reduction for which the identification of the difference image is the first step. The difference images also indicate the most complex motion fields in the images. Since noise in a low-light video can be amplified by stretching dynamic range, severe noise should be suppressed before the tone-mapping step. A spatial-temporal filtering can suppress most of noise in a low-light video. However, too strong demising may cause over-smoothing and blurring effect Around moving object region

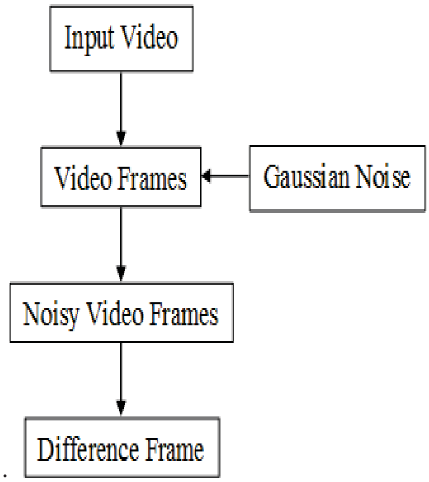


FIGURE (2):process flowchart to obtain the noisy and difference video frame.

3.2.2. KALMAN FILTER:

The difference frame is used for the temporal noise reduction of the images. The kalman filter has two steps predictions and the updation steps. In the prediction step the noise level in the images were estimated by the calculation of the weight matrix. The predicted noise level was then updated and the gain of the process is calculated. From the predicted images the new difference matrices. The new difference matrices identify the noise location in the images more accurately compared to the previous difference frames. The kalman gain was helpful in the estimation of the temporal noises in the images. As the result of the updation step the temporal noises from the images were removed. An effective motion adaptive temporal filtering, which is developed by modifying the Kalman filter approach, is applied at the very first. And then, the narrow dynamic range of demised signal is widened by Gamma correction of each RGB histogram with low and high intensity levels clipped by appropriate thresholds. Lastly, the remaining amplified noise after having been through the former two steps is filtered by spatial noise reduction. As it is evident that visual components in the improved video are more recognized than those in the underlying info video, the patch-based nonlocal implies channel can expel the remaining commotion viably while protecting edges. Consider irregular procedures X (n) and Y(n) such that

$$X_{n+1} = A_n X_n + W_n$$
$$Y_n = H_n X_n + N_n$$

Here W_n and N_n are independent Gaussian random processes and independent of X. Clearly, X_n is a Markov process which together with the observations Y_n forms a Hidden Markov process. The problem of obtaining the best estimate of X from the observations Y requires one to estimate the conditional probabilities p (X_n| Y_n). This is accomplished in a computationally efficient manner by the forward recursion algorithm. When a large motion is present around a certain pixel, SSD of its patch becomes large, hence the weight decreases. In turn, the contribution of previous estimate is desired to be decreased to prevent motion blurs. Therefore, the prediction and update equations of Kalman filter estimation were modified as follows

$$\textbf{Prediction: } \begin{cases} \tilde{X}_t = \hat{X}_{t-1}, \\ \tilde{P}_t = \hat{P}_{t-1} + Q_t^{-1} W_t^{-1} \end{cases}$$

$$\textbf{Update: } \begin{cases} \hat{X}_t = \hat{P}_t (\tilde{P}_t^{-1} \tilde{X}_t + C_t Y_t) \\ \hat{P}_t = (\tilde{P}_t^{-1} + C_t)^{-1} \end{cases}$$

WhereX_t is the denoised frameX_{t-1} is the previous frames P_t is the predicted valueC_t is the Noise variance of the current frame and Y_t is the current frame.

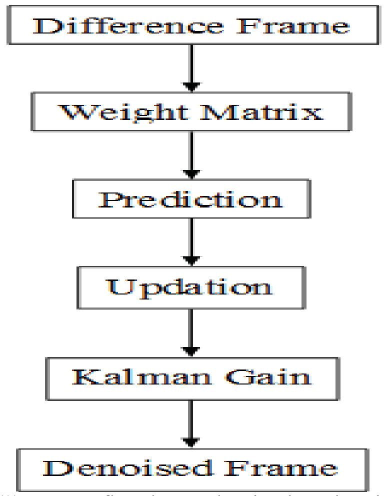
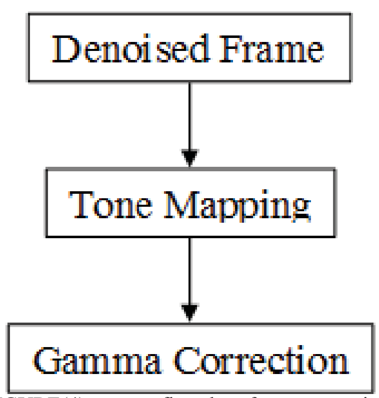


FIGURE (3): process flowchart to denoise the noisy video frame.

3.2.3. TONE MAPPING:

Tone mapping process enhances the images and produces more accurate clear image compared to the video with dim and brighter illumination .Tone mapping methods can either be global (also called spatially invariant) or combined with a local processing (also called spatially variant), modeling either only the global adaptation, or the global and local adaptation of the HVS. Worldwide tone mapping calculations apply the same capacity to all pixels of the picture, i.e. one info esteem results in one and stand out yield esteem. They can be a force capacity, a logarithm, a sigmoid, or a capacity that is picture dependent. Local tone mapping calculations apply diverse capacities for various spatial pixel positions. For this situation, one info quality can bring about more than one yield esteem contingent upon the pixel position and on encompassing pixel values. A third class of tone mapping algorithms, not treated here, are time-dependent. Global tone mapping methods are suitable for scenes whose dynamic range correspond approximately to that of the display device, or are lower. At the point when the dynamic scope of a scene surpasses by a wide margin that of the presentation (HDR scene), worldwide tone mapping techniques pack the tonal range excessively, which results in an apparent loss of difference and subtle element deceivability. Gamma correction is employed for the tone mapping of the images. In Gamma correction the histogram of the images were normalized to particular intensity. The clipping of the histogram decreases the intensity of the brighter image pixels and increases the intensity of the dim image pixels. Tone mapping process is employed comparing the images with clipping and without clipping. The clipping process enhances the image further compared with tone mapping without clipping process. For clipping of the signals clipping thresholds were settled for the images based on the higher range of the histogram. After the temporal noise is reduced, dynamic range of low-light video is required to be stretched for enhancing visibility. Various techniques for obtaining high dynamic range (HDR) image have been presented in previous research efforts. Histogram adjustment with Gamma correction is proposed in this work. Since a large portion of pixels have little force values extending around 5% of greatest power in amazingly low brightening as alluded, extending all pixels may bring about an inaccurate change with a high offset intensity as shown.



FIGURE(4):process flowchart for tonemapping.

3.2.4. NLM FILTER:

The spatial noise in the tone mapped images was then removed using Non Local Means filter. The overall mean of the difference between the tone mapped frames were calculated. The solution to the NLM method converges as soon the stopping condition is achieved. The convergence of the proposed method provides the solution to the identification of the local means of the neighbor that removes the unwanted pixels in the images. The color in a displayed image can be represented by three numbers, usually controlling colors red (R), green (G), and blue (B). A color image is thus referred to as an RGB image, where each R, G, and B component is called a color channel. Tone mapping can be applied to the three color channels independently by performing the same operation three times. This is commonly used for global tone mapping and provides good color rendition. The most similar pixels to a given pixel have no reason to be close at all. The periodic patterns or the elongated edges appears in many of the images. It is therefore licit to scan a vast portion of the image in search of all the pixels that really resemble the pixel one wants to demise.

The convergence of the NLM methods helps to identify the portions in the images that is needed to be searched. The classical NLM demising filter is modified for the Bayer pattern CFA image. Firstly, pixels of each color channel are smoothed separately with a modified Gaussian mask to alleviate the adverse effect of the amplified noise when measuring the similarity between neighboring and reference patch. Also, only neighboring patches with the same pattern as a reference patch are considered to avoid any faulty inter-color similarity computations.

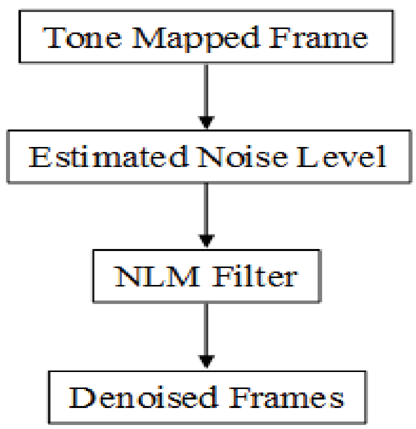
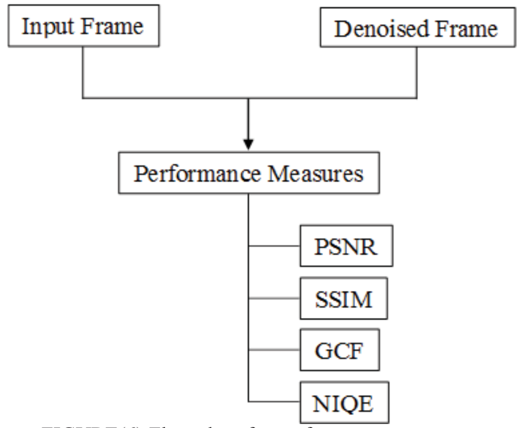


FIGURE (5):process flow chart for denoised and tone mapped video frame.

3.2.5. PERFORMANCE MEASURES:

The performance of the process is measured by the calculation of the performance metrics like PSNR, SSIM, GCF and NIQE. PSNR values indicate the noise ratio in the input video frame and the resulting demised video frame. The PSNR value must be high. SSIM value indicates the similarity between the input video frame and the resulting demised video frame. The SSIM value must be within one. GCF - Global Contrast Factor is a measure for the analysis of the comparison of the contrast in input video frame and the resulting demised video frame. NIQE - Natural Image Quality Evaluator is a distance metric for the model statistics and a factor for the comparison of the quality of the input video frame and the resulting demised video frame. Overall processing time of the proposed algorithm implemented with an un-optimized code is about 6.8 seconds for enhancing a 1920×1080 video frame on a 2.93 GHz CPU. The proposed method only requires approximately two frame buffers for storing the estimated previous demised frame and its covariance matrix in the Kalman filter-based temporal noise reduction step.



FIGURE(6):Flow chart for performance measures

IV. CONCLUSION

The enhancement of the videos taken in low light conditions will be more helpful in the surveillance applications. The enhancement of the low resolution video frames based on tone mapping process and also noise removal process is applied. The performance measures proves that the proposed method is efficient compared to the existing works .The noise removal process were employed based on different types of filters. This system provides details on the average PSNR and runtime comparisons for a few of standard sequences artificially noise-corrupted. All the PSNR data achieved by the two- step algorithm are better than those by NLM, containing high motions which can be compensated by methods suggested. The videos taken in low intensity were taken and the videos were enhanced without any deviations in the original color information. The noise reduction process was also included along with the tone mapping process. Non local Means (NLM) filter and Kalman filter were employed for the filtering of the video frames. For tone mapping of the videos Gamma correction is employed which does not affect the original color information in the video. In the existing works the noise reduction is not employed while tone mapping is employed. The performance of the process is measured based on the performance metrics like PSNR, SSIM, GCF, NIQE calculation. The performance measures proves that the proposed method is efficient compared to the existing works. The previously 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 color video. In this way our expect to get clear video from the low light video. The methodology is extremely broad and adjusts to the spatiotemporal power structure keeping in mind the end goal to avoid movement obscure and smoothing crosswise over essential basic edges. The method also in clues sharpening feature which prevents the most important object contours from being over-smoothed. Most parameter scan be set generally for a very large group of input sequences. These parameters include: the clip-limit in the contrast-limited histogram equalization, the maximum and minimum widths of the filtering kernels and the width of the isotropic smoothing of the structure tensor and in the gradient calculations.

REFERENCES

[1] S. W. Lee, V. Mail, J. Jang, J. Shin, and J. Paik, "Clamor versatile spatio-fleeting channel for continuous commotion evacuation in low light level images,"IEEE Trans. Buyer Electron., vol. 51, no. 2, pp. 648-653, May. 2005.

[2] E. Bennett and L. McMillan, "Video upgrade utilizing per-pixel virtualexposures," ACM Trans. Illustrations, vol. 24, no. 3, pp. 845-852, Jul. 2005.

[3] H. Malm, M. Oskarsson, E. Warrant, P. Clarberg, J. Hasselgren, and C.Lejdfors, "Versatile upgrade and commotion diminishment in low light-level video," In Proc. IEEE International Conference on ComputerVision, Rio de Janeiro, Brazil, pp. 1-8, Oct. 2007.

[4] Q. Xu, H. Jiang, R. Scopigno, and M. Sbert, "another methodology for verydark video denoising and upgrade," In Proc. IEEE International Conference on Image Processing, Hong Kong, China, pp. 1185-1188, Sept. 2010.

[5] X. Dong, G. Wang, Y. Throb, W. Li, J. Wen, W. Meng, and Y. Lu, "Quick productive calculation for improvement of low lighting video," In Proc. IEEE International Conference on Multimedia and Expo , Barcelona, Spain, pp.1-6, Jul. 2011.

[6] X. Zhang, P. Shen, L. Luo, L. Zhang, and J. Melody, "Upgrade andnoise decrease of low light level pictures," In Proc. Global Conference on Pattern Recognition, Tsukuba, Japan, pp. 2034-2037, Nov. 2012.

[7] M. Kim, D. Park, D. K. Han, and H. Ko, "A novel structure forextremely low-light video upgrade," in Proc. IEEE InternationalConference on Consumer Electronics, Las Vegas, USA, pp. 95-96, Jan. 2014.

[8] A. Loza, D. Bull, and A. Achim, "Programmed contrast improvement of low-light pictures in view of neighborhood insights of wavelet coefficients," In Proc. IEEE International Conference on Image Processing , Hong Kong, China, pp. 3553-3556, Sept. 2010.

[9] F. Drago, K. Myszkowski, T. A nnen, and N. Chiba, "Versatile logarithmic mapping for showing high complexity scenes," ComputerGraphics Forum, vol. 22, no. 3, pp. 419-426, Sept. 2003