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Video Enhancement for Low Light Conditions

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Abstract: Digital video has become an important part of various technical and research field for efficient analysis of results. When the video taken for investigation it need to be clean for possible effective results. Every now and then when the facts containing video isn't clean and questions are not prominent as it should be then the fundamental concept of video enhancement comes into the picture. The video enhancement is the process which applied to the noisy video which contain more noise than the signal .The noise into the video can be introduce due to the different reasons such as environmental conditions ,Quality of video capturing devices, distance of object from video capturing device or any other technical reason can affect the quality of video . Thus video captured in such condition needs extra enhancement for the better results Therefore in this project we implemented the enhancement method for such low light video. Implemented method work in two stages in first stage noise reduction is done by using adaptive median filter & Gaussian smoothing. In second stage we are applied contrast enhancement of the video by using Weighted Threshold Histogram Equalization (WTHE) method. These two stags provide better enhance video from the input degraded video especially low light video.

Keywords: Video enhancement, low light video, contrast enhancement, WTHE

I. INTRODUCTION

ThisFrom last few years, there have been various capability improvements in digital cameras including resolutions and sensitivity. Even with these improvements, the modern digital cameras are still limited in capturing high dynamic range images in challenging environmental conditions [1].Mostly these video cameras work in the open air, which means the quality of captured video depends on the weather conditions.

There are different reasons for poor quality of video but one of the most affecting condition is low lightning .the video captured in low light condition having large amount of noise than the information we can consider it as signal hence such video having low signal-to-noise ratio (SNR) .When the illumination is very low, the level of noise becomes comparatively higher than the signal, so for such kind of video it is essential to apply the different enhancement process so the detailed information can be extracted from the video .

The Video enhancement is nothing but the modify the attributes of an image sequences to make it more suitable for a given task or a specific observer.

This paper is going to present a efficient method for enhancement of low light video. In proposed method enhancement is done by applying various operations to the low light video .The primary level of noise reduction is done by using Adaptive median filtering& Gaussian smoothing then the next process is weighted threshold histogram equalization WTHE is done which provide the proper brightness to the dim light video and finally the remaining noise is removed at post-processing stage at which the Gaussian smoothing is used which provide better result in less time. This method is applied to the real time low light video.

As it real time process the operation should be done in minimum time so by using this method we achieved good results less execution time.

II. LITERATURE REVIEW

In this section we are going through different proposed methods for video enhancement in past few years so that by analyzing drawbacks of all of these method we can produce a method which can overcome all the drawback of past method and produced a method which gives efficient result.

Minjae Kim Dubok Park, David K. Han, and Hanseok Ko[1] proposed methods for removal of noise motion adaptive temporal filtering based on the Kalman structured updating is introduced . By adaptive adjustment of RGB histograms causes the increment in Dynamic range of denoised video. Ultimately, remaining unwanted factor which is noise can be removed using Non-local means (NLM) denoising. In this method exploits color filter array (CFA) raw data for obtain low memory consumption. The final experimental results indicate hat this method is highly promising for various real time applications to consumer digital cameras, especially CCTV and the surveillance video system.
Henrik Malm Magnus Oskar son Eric Warrant [2] introduces a method which based on adaptive enhancement and noise reduction for very dark image

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sequences with very low dynamic range. With low dynamic range is proposed general method for noise reduction and contrast enhancement in very noisy image data. In order to conserve and enhance fine spatial detail and prevent motion blur the Smoothing substance that automatically adapt to the local spatio-temporal intensity structure in the image sequences are create .

In color image data, the chromaticity is restored and demonstrating of raw RGB input data is performed at the same time along with the noise reduction. The method is very general, contains little user-defined quantity and has been developed for efficient symmetric data processing using a GPU.

Qing Xu1, Hailin Jiang [3] presented The technique invokes three times i.e proposed algoritham is of the three stage, in the first and the third stages, the well-known Non-Local Means (NLM) method for spatial and temporal denoising use: it is well modified for the application, leading to the definition of a novel NLM tool. The middle stage execute a custom tone adjustment specifically design at extending dynamic range of very dark videos.

The overall approach transforms very dark videos into more watchable ones, Jinhui Hu, Ruimin Hu, Zhongyuan Wang, Yan Gong,MangDuan [4] gives a technique of kinect depth based method for low light surveillance image enhancement.
First step is Pre-processing for Kinect depth map, depth constrained non-local means(NLM) denoising and depth sensible contrast stretching are performed in turn with this algorithm to boost the visual quality for low light surveillance image. Observing the previous works, this method is able to magnify the low dynamic range and promote both globe and local depth perception for the low light surveillance image .

Xuan Dong, Jiangtao (Gene) Wen, Weixin Li, Yi (Amy) [5] presents the algorithm automatically find the dominate source of impairment, then depending on whether it is low lighting, fog or others, a corresponding pre-processing is applied to the input video wich is low light video, followed by the kernel enhancement algorithm . Temporal and spatial repetitiveness in the video input are utilized to assist real-time processing and to improve temporal and spatial property of the output video. This algorithm can be used as an autonomous module, or be integrated in either a video encoder or a video decoder for further improvement.

III.PROPOSED WORK

In this paper we are considering the obtainable methods of video enhancement, which can be made better enhancement of video taken in poor visibility light condition. Desired outcome of the process is to enhance video. The block diagram to get desired outcome is as shown as follow

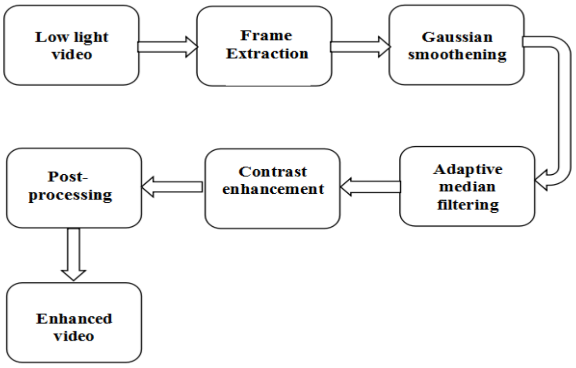

Fig. 1: Block Digram of proposed video enhancement method

1.low Light Video: This is the input to the system on which all the method are apply as the name indicate that the input video is low light video so in this project we are using two different way for capturing the low input video :
(i) By using integrated web camera (Webcam) of a system i.e default camera .
(ii) By using the external web camera (Webcam).

As we are implementing the real time video enhancement system the input video captured continuously and apply it to the next stages for further processing. the Frame Extraction : next process is the extraction of frames for enhancement it can be done by frame extraction block. block is use to detect, whether the frame is of day condition video is or it is degraded due to insufficient lighting during night condition this operation is done by frame by frame manner. The following this operation done as shown in following diagram

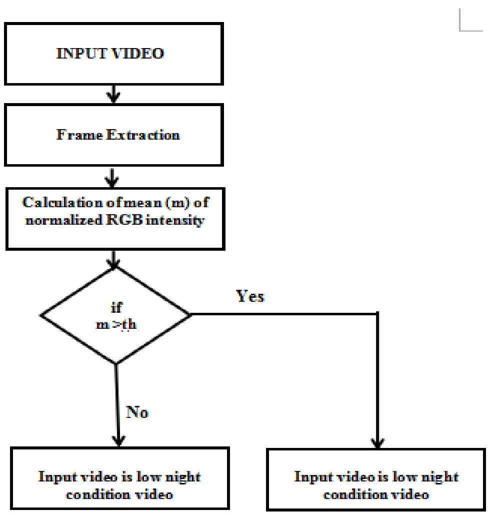

Fig. 2: Flow chart to detect the type of input frame

-Plot the histogram of the input video frame
-Determine the mean of the RGB intensity distribution (let it be 'm')
-Compare this mean with the pre-defined threshold to decide, whether the frame is of day condition or it is degraded due to low lighting during Night condition.

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-Take a threshold (say th) If m > thThen the frame is of day condition Else the frame is degraded due to low lighting of scene during night condition.
We have decided threshold (th) value on the basis of histogram of input image.

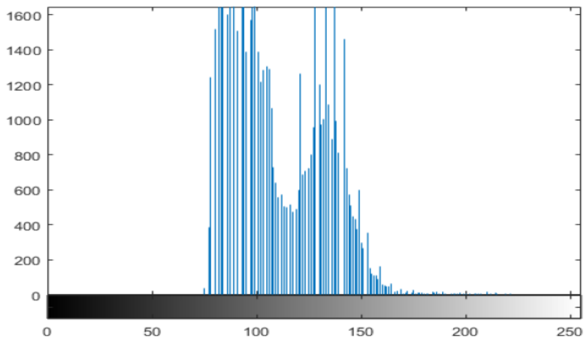

Figure.3: Histogram of input frame

Gaussian Smoothing : For primary level of noise reduction is done by Gaussian smoothing. It is widely used effect in graphics software, typically to reduce image noise. It is also used as a pre-processing stage in computer vision algorithms in order to enhance frame structures at different scales Mathematically, applying a Gaussian smoothing to an frame is the same as convolving the frame with a Gaussian function. This is also known as a two-dimensional Weierstrass transform. The Gaussian smoothing operator is a 2-D convolution operator that is used to smoothing images and remove detail and noise applying a Gaussian smoothing has the effect of reducing the image's high-frequency components; a Gaussian smoothing is thus a low pass filter
The Gaussian distribution in 1-D has the form:

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

where σ is the standard deviation of the distribution.
In 2-D, an isotropic (i.e. circularly symmetric) Gaussian has the form:

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

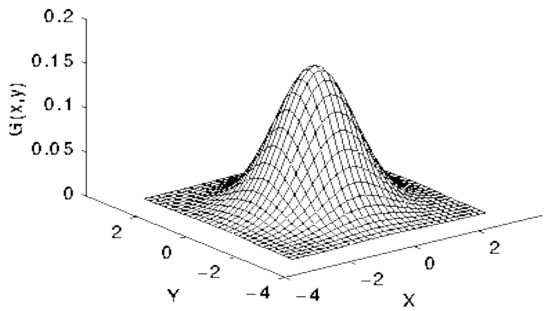

Fig.4 :2-D Gaussian distribution with mean (0,0) and σ =1

where x is the horizontal distance from the origin on the horizontal axis, y is the vertical distance from the origin on the vertical axis, and σ is the standard deviation of the Gaussian distribution.
The i Gaussian smoothing used this 2-D distribution as a `point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to create a discrete approximation to the Gaussian function before we can perform the convolution. In theory, the Gaussian distribution is non-zero everywhere, which would require an infinitely large convolution kernel, but in practice it is effectively 0(zero) more than about three standard deviations from the mean, and so we can truncate the kernel at this point. In this project we are considered the 3 by 3 kernel with standard deviation σ =0.5 Figure 3 shows a suitable integer-valued convolution kernel that approximates a Gaussian with a σ of 0.5.It is not obvious how to choice the values of the mask to approximate a Gaussian. One could take the value of the Gaussian at the center of a pixel in the mask, but this is not accurate because the value of the Gaussian change non-linearly across the pixel. We merged the value of the Gaussian over the whole pixel. The integrals are not integers: we rescaled the array so that the corners had the value 1. Finally, the 16 is the sum of all the values in the mask

1	2	1	
2	4	2	*1/16
1	2	1	

Fig.5: Discrete approximation to Gaussian function with σ =0.5

The degree of smoothing is determined by the standard deviation of the Gaussian. (Larger standard deviation Gaussian, of course, require larger convolution kernels in order to be accurately represented.) The Gaussian outputs a `weighted average' of each pixel's neighborhood, with the average weighted more towards the value of the central pixels. Once a suitable kernel has been calculated, then the Gaussian smoothing can be performed using standard convolution methods. The convolution can be performed fairly quickly since the equation for the 2-D identical Gaussian shown above is separable into x and y element. Thus the 2-D convolution can be performed by first convolving with a 1-D Gaussian in the x direction, and then convolving with other 1-D Gaussian in the y direction and produce resultant.
Adaptive median filtering: After the smoothing the noise reduction will done by using the adaptive median filtering technique . The adaptive Median Filter is meant to eliminate the issues faced with the standard median filter. the basic difference between the 2 filters is that, within the adaptive Median Filter, the scale of the window close

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every pixel is variable. This variation depends on the median of the pixels within the present window. If the median is an impulse, then the scale of the window is enlarged. Otherwise, further process is completed on the a part of the image inside this window specifications. process the image essentially entails the following: the middle pixel of the window is evaluated to verify whether or not it's an impulse or not. If it's an impulse, then the new value of that pixel within the filtered image will be the median value of the pixels in that window. If, however, the middle pixel isn't an impulse, then the value of the middle pixel is maintained within the filtered image. Thus, unless the pixel being considered is an impulse, the gray-scale value of the pixel in the filtered image is that the same as that of the input image. Thus, the adaptive Median Filter solves two different purpose of removing the noise from the image and reducing distortion within the image.

Adaptive Median Filtering can handle the filtering operation of a picture corrupted with impulse noise of probability larger than zero.2. This filter additionally smooths out different sorts of noise, thus, giving a much better output image than normal median filter so the adaptive median filtering has been employed in this technique as it's an advanced technique compared with standard median filtering. The adaptive Median Filter performs spatial process to work out that pixels in a picture are full of impulse noise
Adaptive median filter changes window size i.e changes size of Sxy (the size of the neighborhood) during operation. We can say that Smax can have the values in ascending order 3,5,7,9….
The operation of adaptive median filter is as follow
-Corp region of neighborhood
-Sort the value of the pixel in region
-And find out the median by considering the M×N mask in which median what ever median obtain replace it with noisy pixel.

for e.g Smax=3 the pixel window

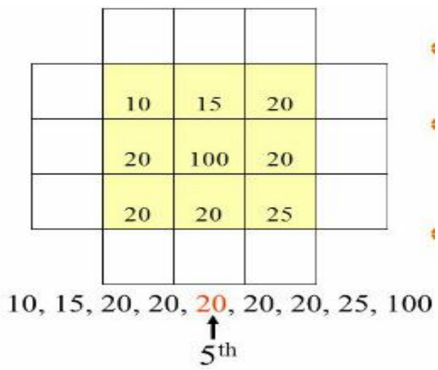

Fig.6 :Adaptive median filter with Smax=3

-window size Smax=3
-different values into the region are:
10, 15, 20, 20, 20, 20, 20, 25, 100
From this the median value is 5^{th} one i.e 20
-replace central pixel 100 which is noisy with evaluate median pixel 20.

Contrast Enhancement: The next stage is contrast enhancement. once the noise is reduced, we tend to amplify intensity of low-light video by the third block that nothing but the contrast Enchantment during which the applied input is enhance by some completely different strategies . during this method is to adjust the local contrast in several regions of the image in order that the details are brought out. These operations can generally performed as a contrast stretch followed by a tonal improvement. In contrast stretch improves the brightness variations uniformly across the dynamic range of the image. then Tonal enhancements improve the brightness variations within the shadow (dark), midtone (grays), or highlight (bright) . there are numerous strategies are available for contrast enhancement however we tend to used Weighted threshold histogram equalization .as ancient histogram equalization having some drawbacks as:

For practical pictures, wherever the intensity levels and PDF have distinct values, the normal HE mapping typically ends up in undesirable effects: over-enhancement for intensity levels with high possibilities and loss of contrast for levels with low possibilities .It is known , however, that the normal HE methodology suffers from the subsequent drawbacks:
(1) It lacks of a mechanism to regulate the degree of enhancement.
(2) It typically causes unpleasant visual artifacts, like over enhancement, level saturation and raised noise level.
(3) It might dramatically change the character of the image, e.g., the average luminance (mean) of the image.As a results of the higher than shortcomings, histogram equalization isn't utilized in its original form.These issues is overcome by Weighted Threshold histogramequalization. therefore in this project methodology used for the contrast enhancement a quick and effective methodology for image contrast enhancement based on weighted and threshold histogram equalization(WTHE).

Weighted Threshold Histogram Equalization:
The general plan adopted by the WTHE [4] methodology is to change the histogram before equalization is conducted. Such modifications cut back visual artifacts. Throughout the image enhancement the impulse noise within the image also increased [5]. To avoid this result, the enhanced image is passed through a filter. In digital signal and image processing; a picture is commonly corrupted by noise in its acquisition or transmission. Noise is undesirable data that contaminates a picture. that the standard filtering techniques are wont to eliminate the noise and to preserve the edges.

The weighted and threshold value of probability density function P(K n) is obtained by the subsequent equation given by,

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$$P_{wt}(k_n) = \Omega(P(k_n)) = \begin{cases} P_u & \text{if } P(k_n) > P_u \\ \left(\dfrac{P(k_n) - P_l}{P_u - P_l}\right)^r \times P_u & \text{if } P_l \le P(k_n) \le P_u \\ 0 & \text{if } P(k_n) < P \end{cases} \quad (5)$$

Where Pwt (Kn) is the weighted and threshold parameter value of P(Kn) . Pu is upper threshold value, that is the PDF is clamped to maximum gray level value of P (Kn) .In the WTHE method the value of Pu is given by

$$P_u = v.P_{\max} \qquad 0 < v \le 1$$

Where Pmax is the peak value of the P(Kn)
The original PDF of P(Kn) is clamped to an upper and lower thresholds value by employing a normalized power law perform with index r > 0 .The value of r is a vital parameter that management the degree of enhancement and depends upon the value of r, it provides higher and lower weights to the probability density function. once the weighting and th reshold is done the remaining procedure is analogous to histogram equalization. The cumulative distribution function (CDF) of original image G(i,j)is given by The equation

$$C_{wt}(k_n) = \sum_{m=0}^{k} P_{wt}(m)$$

For Kn = 0,1,…….,L-1
The histogram Equalization maps an input level Kn into an

output level $\bar{k}_n$ is given by

output level $\bar{k}_n$ is given by

$$\bar{k}_n = (L-1) \times C_{wt}(k_n)$$

The output level can be increment by

$$\Delta \bar{k}_n = (L-1) \cdot P_{wt}(k_n)$$

The resultant image G (i,j) let G(i,j) = F(i,j) is given by
The parameter W out and Madj are constant and it offers dynamic range of the output image and reimburse the mean change once the enhancement is done.

In the WTHE, it reduces the visual artifacts resulting from the his to gram equalization and it's capable to regulate the level of the enhancement. Capable to control the level of the enhancement.

$$\tilde{F}(i,j) = W_{out} \times C_{wt}(F(i,j)) + M_{adj}$$

Post-Processing : post-processing .this is the final stage of enhancement method at this point the all abstracted frames of the video is arrange properly consistent with sequence, and final smoothing done by gaussian filtering technique that improve the video clarity and at the output we tend to get the enhanced video. At this stage the gaussian smoothing is completed with the different values of parameters. Quantity of smoothening required less than the previous stages as a result of at this point the noise is extremely less than the previous stages in order that the right finishing of the video can be obtain by small amount of smoothing and eventually the improved video is get. detailed technique of video enhancement is shown in following flow chart:

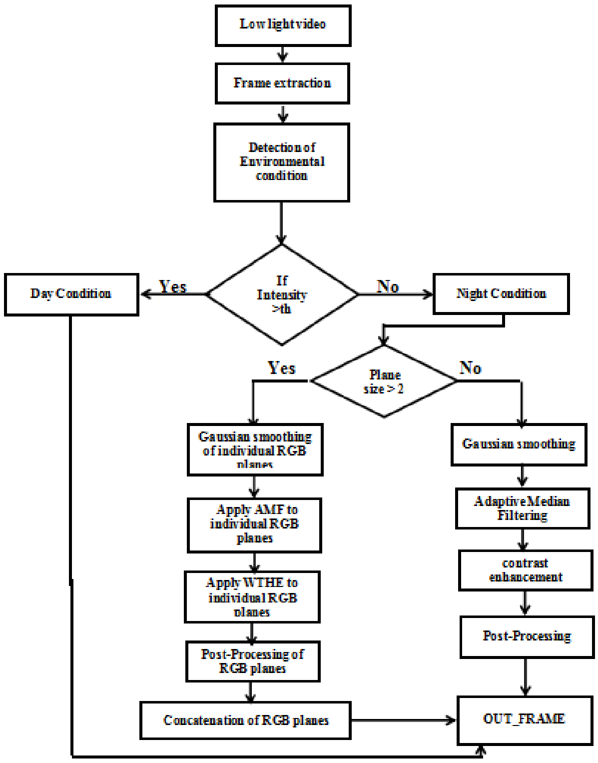

Fig.7: Flow chart for proposed video enhancement method

IV EXPERIMENTAL RESULTS

We tested the proposed method with a real low-light video captured in an extremely low-light condition for this used the different hardware systems for capturing experimental results
- Dell Inspiron N5050 Laptop - 2nd Generation Intel Core i3-2350M Processor 2.3GHz, 4GB DDR3 RAM, 500GB HDD, Windows 7,Webcam Camera 0.3MP Integrated Webcam with built-in analogue microphone,15.6" Display, .
- External webcamp used Intex IT-306WC Webcam Focus Range 4 to Infinity, Video and Image Video Sensor Resolution 30 megapixel Frame Rate 30 fps Still Image Sensor Resolution 30 mega pixel HD Sensor Type CMOS Image Capture Resolution 640 x 480 System

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Requirements Hard Drive 50 MB Memory 32 MB Processor Intel Pentium II 350 MHz Operating System Windows: In this project we used the MATLAB as the software tool it is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation.

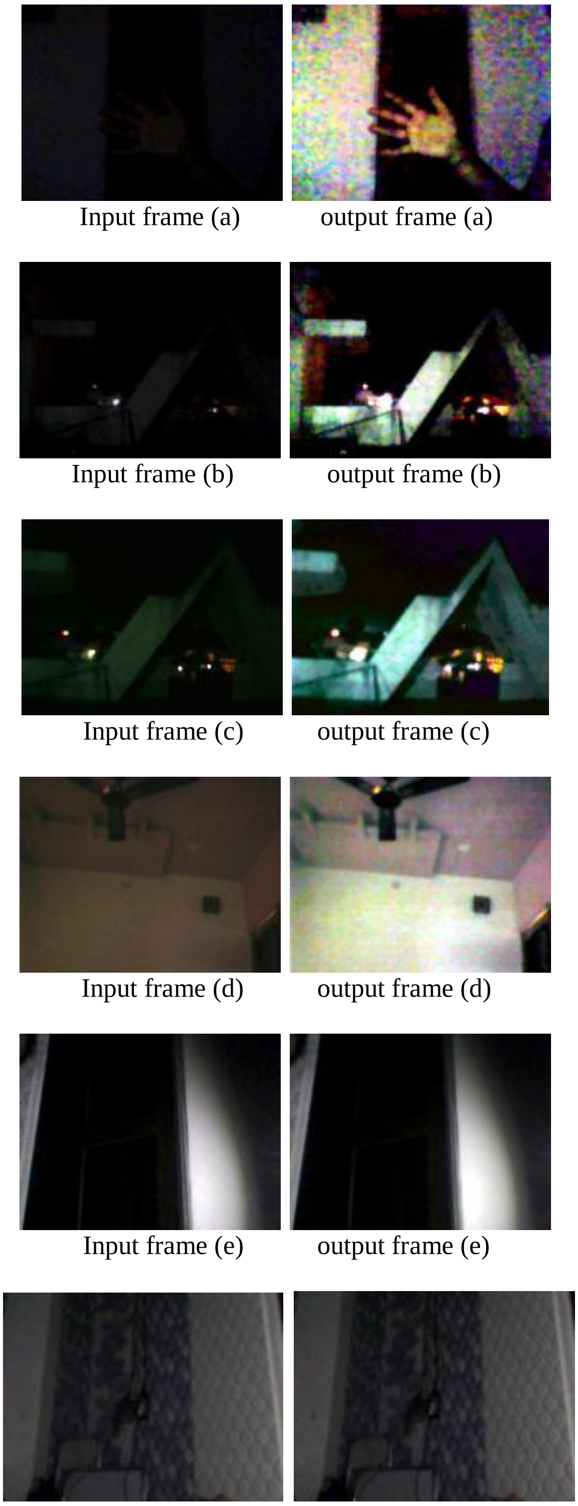

Fig.8: frames captured by using system's camera

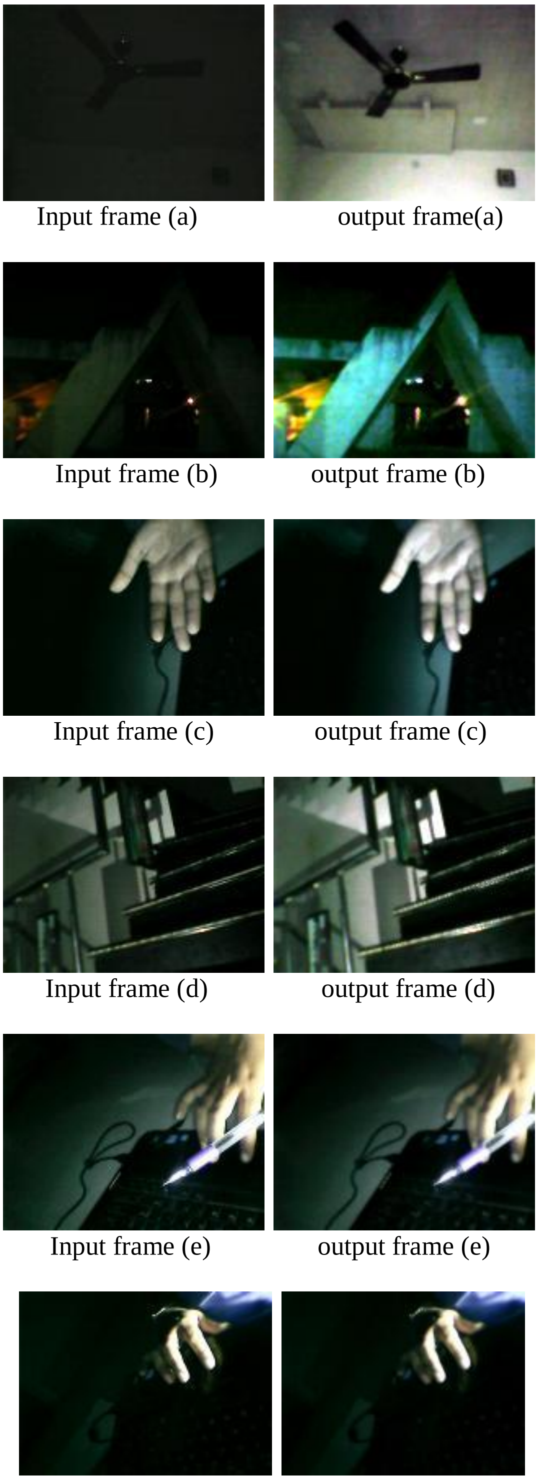

Fig.9:frames captured by using external camera

Performance parameter
The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image quality

A.Mean Square Error (MSE):
The MSE is the cumulative square error between the encoded and the original Frame Let, X(i,j) is a source

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image that contains M by N pixels and a reconstructed image Y(i,j), where Y is reconstructed by decoding the encoded version of X(i,j).

In this method, errors are computed only on the luminance signal; so, the pixel values X(i,j) range between black (0) and white (255) First, the mean squared error (MSE) of the reconstructed image is calculated as;

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j) - y(i.j)]^2}{M \times N}$$

RMSE (Root Mean Square Error): RMSE is defined as square root of MSE.

$$RMSE = \sqrt{\frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}(Yij - \hat{yij})^2}$$

B. Peak Signal to Noise Ratio (PSNR):
PSNR represents a measure of the peak error. The higher value of PSNR, lower the error.

To compute the PSNR, the block first calculates the mean squared error using the following equation

$$PSNR = 10\log_{10}\left[\frac{255^2}{MSE}\right]$$

Signal to noise ratio (SNR): SNR is given by following formula

SNR in dB:

$$SNR_{dB} = 10\log_{10}\left(\frac{P_{signal}}{P_{noise}}\right)$$

computes correlation coefficient using following formula

$$r = \frac{\sum_M\sum_N (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\sum_M\sum_N (x_i - \bar{x})^2)(\sum_M\sum_N (y_i - \bar{y})^2)}}$$

TABLE I PERFORMANCE PARAMETER OF FRAMES CAPTURED BY USING SYSTEM'S WEBCAM

Frame	PSNR	Correlation	SNR	Processing Time (sec)
a	9.9473	0.9581	33.908	1.52
b	9.98	0.978	32.736	1.13
c	12.3287	0.8939	20.799	1.12
d	16.34	0.9882	16.55	1.22
e	35.29	0.9995	22.59	1.17
f	41.96	0.9968	21.17	1.10

TABLE III PERFORMANCE PARAMETER OF FRAMES CAPTURED BY USING EXTERNAL WEBCAM

Frame	PSNR	correlation	SNR	Processing Time(sec)
a	5.7926	0.9342	22.03	1.17
b	11.7794	0.9087	27.016	1.08
c	17.3153	0.9846	23.694	1.45
d	26.67	0.9549	18.266	1.23
e	34.1748	0.9962	12.825	1.13
f	35.4113	0.9955	24.650	1.06

We have compared our results with the result of existing method by calculating system performance parameter. We can see that our results are better than the existing method's result. The PSNR value of our proposed work is higher than the existing method's. In our proposed work we have used Adaptive Median Filter and Weighted Threshold histogram equalization. We have calculated performance parameters such a MSE (mean square error), PSNR (peak signal to noise ratio), and correlation coefficient by using MATLAB software.

TABLE III
COMPARATIVE ANALYSIS PROPOSED WORK AND EARLIER METHODES IN TERMS OF PSNR

Performance parameter	Past work value / REF.NO.	Proposed Work
PSNR	3533dB[11].	41.96B

TABLEIV COMPARATIVE ANALYSIS PROPOSED WORK AND EARLIER METHODES IN TERMS OF PROCESSING TIME

Speed of operation	Past work value / Ref.no.	Proposed Work
Processing time	1.25 sec[1]	1.05 sec

V CONCLUSION

Video enhancement is one of the most crucial and difficult element of video security surveillance system. The increasing use of night operations requires more details and integrated information from the enhanced video. However, low quality video of most surveillance cameras is not satisfied and difficult to understand because they lack surrounding scene context due to poor illumination.
As going through all scenario of video enhancement and need of it in our life we are decided to work on this problem so that our efforts are able to provide better solution. therefore in this project we are basically improved the quality of the captured low light video by

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applying the different operations or algorithms such as Gaussian smoothing for smoothing of video then we used adaptive median filtering for removal of noise then as the input video is low light the contrast enhancement is applied to the video for this we use WTHE method and finally again the remaining noise removed by the Gaussian smoothing and enhanced video is obtained.

All the process is done in real time and we are able to achieve the better result in less processing time. Hence the proposed approach accomplishes a higher degree of visibility recovery for video captured in extreme low light condition. The present study is confined to the removal of noise and provide more visible video, but in future new algorithm can be developed to enhance video in extremlly low light condition or more haze condition. We leave this for future work so that a more efficient algorithm can be developed to low light video enhancement.

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