Comparative Analysis of Different Enhancement Techniques on CCTV Camera's Video

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Abstract—Main objective of image enhancement is to modify visual quality of an image in order to make it more suitable for a given task. The enhancement techniques presented so far provide extensive choices to improve the visual quality of the images. The principle goal of this research is to propose appropriate choice of such techniques for CCTV image enhancement greatly influenced by the imaging environment. The experiments were performed using CCTV video clips, recorded in both indoor and outdoor surveillance systems, with varying environmental conditions. The process of enhancement started with extraction of image frames from the video clips. After extraction of frames different enhancement techniques were experimented. After lots of random experiment, this paper presents a set of such techniques which can improve the visual quality of CCTV video clips for specific environmental conditions.

***Index Terms*— Image Enhancement, CCTV Videos**

I. INTRODUCTION

Many years ago video surveillance was something used by government and large wealthy companies. Now a days we can see that video cameras are present everywhere around us, weather we are in a market or in a restaurant and even while walking in the streets too, in others words we are living in era where we are surrounded by surveillance systems. Video surveillance is rather a broad concept. Apart from security and safety, it has got diverse range of applications in several other aspects of life. To ensure public safety, automated surveillance systems have got significant popularity in recent years as compared to past few years [1]. Video surveillance as wide variety of applications such as, public safety, disaster and crime prevention, management of secure environments, tracking of different objects and humans and their motion. For instance, video surveillance, can provide a lot of assistance in social environments like helping disabled peoples and increasing manufacturing productivity. Other applications include homeland security and crime prevention through indoor and outdoor monitoring and monitoring of critical infrastructures, highways, parking garages, and shopping malls.

A new generation of video surveillance is emerging with innovative functionalities aided by new scientific rigor in areas such as communication, compression, data mining, content based video retrieval, machine learning and pattern recognition [1]. The quality of visual information in video surveillance systems is often low due various conditions and it do not fulfill the application requirements. The possible conditions causing degradation of the image quality in CCTV surveillance systems are changing weather or lightning conditions and low resolution cameras. The noise added during transmission also effects the quality of the video. Hence there is need for image enhancement in order to make them more appropriate for further processing [2].

As CCTV videos are meant for safety, security and many other such applications. In order to ensure the maximum performance of surveillance systems we need to enhance quality of video. Enhancement is a subjective process and it varies with the nature of application being used. We need to enhance the video data in almost every application, without knowing the amount of degradation. Principle objective of video enhancement in surveillance systems is to bring out hidden details or to increase overall contrast of the video. Image enhancement is a common approach to improve the quality of images in terms of human visual perception [3]. In others word in image enhancement we try to ensure "color constancy". Color constancy is a feature of human color perception system which ensures that the perceived color of a certain object by a human being remains relatively constant in various changing illumination conditions [4]. Hence it is difficult to standardize image enhancement and to give a definition of good quality image.

Many solution have been presented to address image enhancement both in spatial domain and frequency domain. In [2] a method for CCTV image enhancement is proposed using sub-images homomorphic filtering. In [5] histogram equalization method is discussed for application of video

surveillance. Many other image enhancement techniques are discussed in [5] like log transformation, power law transform, contrast stretching and filter based approaches etc. In [6] an approach to enhance low lighting videos was presented for traffic monitoring. A survey of image enhancement techniques in spatial domain and frequency domain can be found in [7] and [8].

This research is focused on the comparative analysis of different enhancement techniques on CCTV video clips. In this research, different enhancement techniques were experimented for enhancement of CCTV videos. After lots of experimentations a comparative analysis of these techniques was performed. After that a set of techniques are proposed for CCTV enhancement mainly influenced by the changing environmental conditions. Hybrid approach to image enhancement was followed in this research i.e. instead of applying single technique we applied more than two techniques on a single video clip for better results.

II. PROPOSED METHODOLOGY

The first step in our proposed methodology towards CCTV video enhancement is pre-processing, in this step individual frames are extracted from the video clip. After extraction of frames the next step is to apply the enhancement techniques on the individual frames. Final step in our proposed method is post processing in which extracted frames are again combined in order to get the enhanced video. All of these steps are shown in Figure 1.

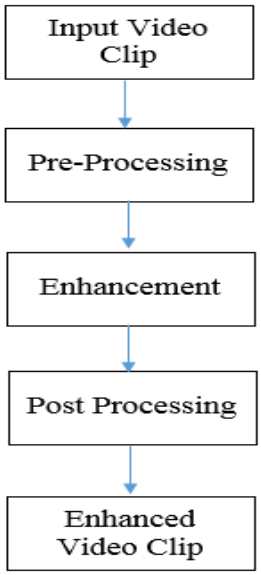

Fig. 1. Proposed Methodology

The enhancement techniques which we experimented are as follows.

A. Histogram Equalization

Histogram equalization is good for enhancing low contrast images [9]. Histogram equalization transforms the low contrast areas into high contrast by spreading out the most frequently occurring intensity values. The results are shown in figures shown below.

Fig. 2. Before Histogram Equalization

Fig. 3. After Histogram Equalization

B. Logarithmic Transformation

The mathematical equation for logarithmic transformation is given in eq. (1).

$$S = c \text{ Log } (1 + r) \quad (1)$$

Where **c** is a constant and it is assumed that $\mathbf{r} \geq 0$. The **S** is the output intensity and **r** is the input intensity value [10]. For varying value of **r,** the graph for eq. (1) is given in Fig. 4.

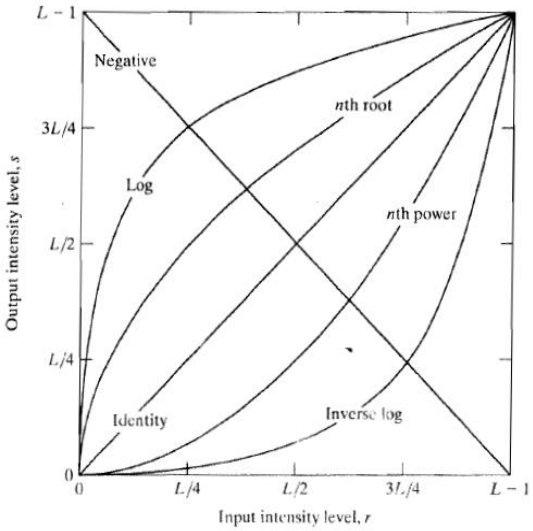

Fig. 4. Logarithmic Transformation Graph [5]

Results of applying logarithmic transformation are shown in figures as follows.

Fig. 5.Before Log Transformation

Fig. 6. After Log Transformation

C. Power Law Transformation

The mathematical equation for power law transformation is given in eq. (2) [11].

$$S = cr^{\gamma} \quad (2)$$

Where **c** and **γ** are positive constants and **S** is the output and **r** is input intensity. The graph for the various values of **S** and **r** is shown in Fig. 7. Unlike log transformation in power law transformation a family of transformation curves can be obtained by just changing the γ in small interval.

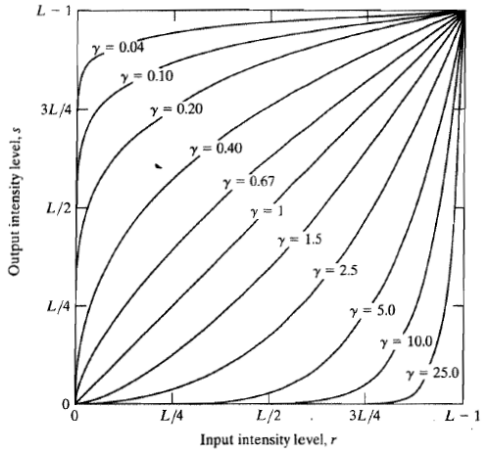

Fig. 7. Plots of eq. 1 for c=1 and varying γ [5]

Results of applying power law transformation are shown in figures as follows.

Fig. 8. Before Power Law Transformation

Fig. 9. After Power Law Transformation

D. Median Filtering

Median filter is the best know order statistic filter, which replace the value of pixel by the median of the intensity

levels in neighborhood of that pixel [5]. It is commonly used to remove salt and pepper noise from the image or video.

E. Contrast Stretching

Contrast stretching improves the overall contrast of the input image by darkening the pixels with low intensity below a threshold **m** and brightening pixels above **m** [12]. Multiple thresholds values can be used as illustrated in Fig. 10.

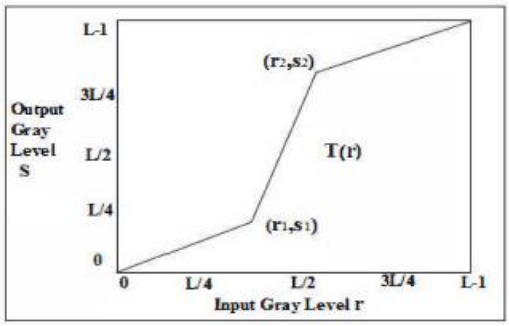

Fig. 10. Plot for Contrast Stretching [12]

Results of applying contrast stretching are shown in figures as follows.

Fig. 11. Before Contrast Stretching

Fig. 12. After Contrast Stretching

F. Unsharp Masking / High Boost Filtering

Unsharp masking consists of three steps which are as follows [5].

1. Blur the original image
2. Subtract the blurred image from original (Resulting difference is mask)
3. Add the mask to original image

Results of applying unsharp masking are shown in figures as follows.

Fig. 13. Before Filtering

Fig. 14. After High Boost Filtering

G. Hybrid Approach

In this type of approach two or more techniques are applied on the same image in a prescribed order. The order of the techniques applied is of great importance, as by changing the order the desired results may not be obtained [13]. We followed this type of approach in this research and detailed discussion is given in section three of this article. Motivation for hybrid approach originates from the fact that the desired enhancement cannot be obtained by using only a single enhancement technique.

III. EXPERIMENTATION RESULTS AND DISCUSSION

The dataset for this research was collected from surveillance system of Computer Engineering Department of University of Engineering and Technology, Taxila (Pakistan). The data set comprises of 100 video clips of different cameras deployed in the Computer Engineering Department for surveillance purpose. We divided dataset into five categories according to different environmental conditions, which are as follows.

1. Indoor videos taken in high illumination
2. Indoor videos taken in low illumination

3. Outdoor videos taken in high illumination
4. Outdoor videos taken in low illumination
5. Outdoor videos taken in night time

There are two ways to measure the quality of enhanced image, objective and subjective measures. In objective measures, mean square error and peak signal to noise ratio are used to measure quality of enhanced image. The mathematical formulas for mean square error and peak signal to noise ratio are given in eq. (3) and (4) respectively.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\|^2 \qquad (3)$$

$$PSNR = 20\log_{10}\left(\frac{MAX_I}{MSE}\right) \qquad (4)$$

Where in eq. (3), $I(i,j)$ and $K(i,j)$ represents the input and output image intensities respectively at location *i* and *j*. And in eq. (4) MAX_I represents the maximum intensity in input image.

The second approach to measure quality of enhanced image is subjective in which the original and enhanced images or videos are shown to different subjects to rank them. This approach was followed in the proposed work. In this research, lots of random experimentation was done on many videos from each of five categories on hit and trail basis. The dataset was most challenging one as it was captured through low resolution camera. So, after many trails, five different algorithms were proposed to enhance the video clips. In those algorithms, a set of enhancement techniques was proposed which have to be implemented in the given order. The proposed order of those techniques against each category is given in Table 1. The result obtained was comparatively good from the original ones, some of video frames before and after enhancement are shown in figures from Fig. 15-28.

TABLE 1: PROPOSED ORDER OF TECHNIQUES

Sr. No	*Video Environment*	*First*	*Second*	*Third*
1	Indoor with high light	Power law transformation	High Boost Filtering	-
2	Indoor with low light	Log Transform	Median Filtering	High Boost Filtering
3	Outdoor with high light	Histogram Equalization	High Boost Filtering	Median Filtering
4	Outdoor with low light	Histogram Equalization	High Boost Filtering	Power law transfor mation
5	Outdoor Night time video	Power law transformation	Median Filtering	High Boost Filtering

Fig. 15. Before Enhancement

Fig. 16. After Enhancement

Fig. 17. Before Enhancement

Fig. 18. After Enhancement

Fig. 19. Before Enhancement

Fig. 20. After Enhancement

Fig. 21. Before Enhancement

Fig. 22. After Enhancement

Fig. 23. Before Enhancement

Fig. 24. After Enhancement

Fig. 25. Before Enhancement

Fig. 26. After Enhancement

Fig. 27. Before Enhancement

Fig. 28. After Enhancement

IV. CONCLUSION

The images or video clips captured through CCTV surveillance system are highly degraded due to various atmospheric conditions. To make them suitable for further processing we need to enhance quality of contrast and brightness. The enhancement is a subjective process it depends upon the subject or the nature of the application being designed. This paper proposed the video enhancement methods using hybrid approach for videos of different categories. The experiments was tested and compared with original image. It showed that quality of enhance image is relatively better then original ones using subjective measures. However it can give good results on videos taken with good resolution camera.

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