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Enhanced Approaches to Rectify the Noise, Illumination and Shadow Artifacts

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Abstract—Enhancing the quality of two dimensional signals is one of the most important factors in the fields of video surveillance and computer vision. Usually in real-life video surveillance, false detection occurs due to the presence of random noise, illumination and shadow artifacts. The detection methods based on background subtraction faces several problems in accurately detecting objects in realistic environments: In this paper, we propose a noise removal algorithm using neighborhood comparison method with thresholding. The illumination variations correction is done in the detected foreground objects by using an amalgamation of techniques like homomorphic decomposition, curvelet transformation and gamma adjustment operator. Shadow is removed using chromaticity estimator with local relation estimator. Results are compared with the existing methods and prove as high robustness in the video surveillance.

Keywords—Chromaticity Estimator, Curvelet Transformation, Denoising, Gamma correction, Homomorphic, Neighborhood Assessment.

I. INTRODUCTION

IN RECENT YEARS with the improvement of technology, visual cameras are used for surveillance in various applications to monitor the movement of an object. The usefulness of surveillance cameras is primarily limited by the demand placed on human supervisors to monitor many real-life videos feed simultaneously and manually [1]. In addition, even with adequate man power, the number of cameras and area under surveillance often exceeds the monitoring capability of human operators. To overcome these limitations of traditional surveillance methods, a major effort is under way in the computer vision and artificial intelligence community to develop automated systems for the real-life monitoring of people, vehicles and other objects[2][3].

Based on the previous researches in video surveillance [4], we found that the main aim of researchers is to develop an intelligent video surveillance system to replace the traditional passive video surveillance. In other words, the goal of video surveillance is not only to put cameras to replace human operators, and also to attain the whole surveillance task as automatically as much as possible.

This paper deals with an active research topics in video surveillance in dynamic scenes with multimodal objects. This is a computationally challenging task to provide solution to detect, track certain objects from the image sequence and classifying the objects. Certain methods have already been proposed [5] [6] but they have a lack of factors such as noise removal, illumination variation correction and shadow removal. In this paper, we provide solution to these problems that improve the real-life monitoring process.

The remainder of this paper is organized as follows: Section II gives the overview of the related work. Section III describes the proposed methodology for noise removal, illumination variation correction and for shadow removal. Implementations and performance are analyzed in section IV. Section V contains the concluding remarks and future enhancement.

II. OVERVIEW OF THE RELATED WORKS

Machine vision has a large potential for the detection, tracking, classification of objects and for monitoring their position and interaction over time. In the literature, there are certain de-noising techniques were proposed for on-line tracking using Gaussian and Median filters [7]. The primary endeavors of these filters are to strain out the high frequency components from the image's pixels. The edges of the image tend to be blurred when the aforesaid filters are utilized. In [8], temporal exposure was employed for motion de-blurring based on spatially coded apertures. Veearaghavan et al. [9] proposed a simplify defocus image restoration. Sophisticated de-noising methods such as multi-resolution analysis and wavelet domain processing were proposed in [10] and [11], respectively. Other techniques, as suggested in [12], employed anisotropic non-linear diffusion, but this work has a recursive procedure with more time complexity. In this paper, we propose the neighborhood comparison method which provides solution to the above said problems. In [12][13], a segmentation procedure recovers shadow regions with photometric gain smaller than unity roughly constant. In these cases, a priori assumptions are made, so that the approach detects only shadows occupying a large area with respect to the object. In [14], derive an invariant RGB shadow-free image on the assumptions that illumination varies slowly and small gradients in each frame are due to illumination, whereas large gradients depend on reflectance changes. In this paper, we address the aforesaid problem by utilizing YRGBT color space conversion, curvelet decomposition with Gamma adjustment for illumination variation correction. Furthermore shadow removal issue is addressed by chromaticity estimator, brightness estimator with morphological operation. In addition, the main contribution of this paper is to integrate the knowledge of detected objects and enhance the segmentation process by deploying above said endeavors.

III. PROPOSED METHODOLOGY

In real-life video surveillance, due to the external environment sensor system, capturing image always has some

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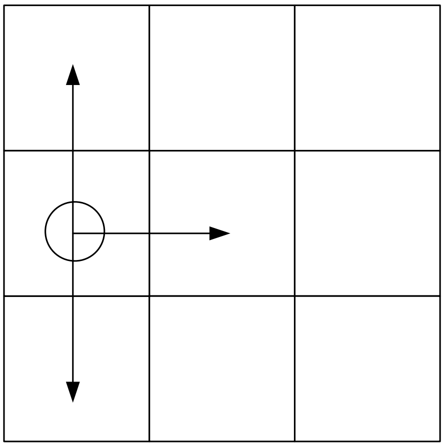

Fig. 1. Initial estimation of the window region.

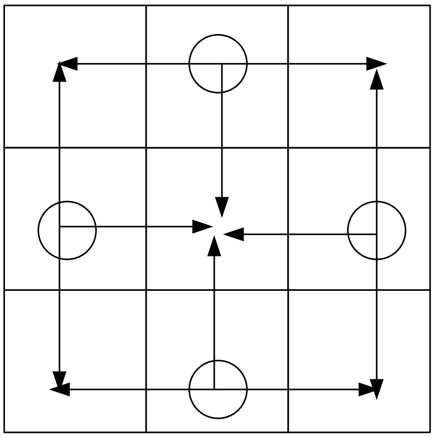

Fig. 2. Logical 'AND' operation performed in vertical and horizontal directions.

sort of noise occluded. In outdoor systems, the change in illumination with the time of day alters the appearance of the scene and causes deviation from the background model. This results in a drastic increase in the number of fallaciously detected foreground regions. Presence of objects shadows, might also pose difficulty because of the illumination change in the shadow region that has to be removed. Usually, in video surveillance, false detection occurs due to the presence of random noise, illumination and shadow. Only after the correct handling of these issues, the sophisticated objects will be detected, which can then be segmented for tracking and classification. This section presents the methods used for this purpose.

A. Noise Removal

Due to imperfection during acquisition unwanted pixels called noise often degrade the quality of the video frames. The presence of noise effect objects detection in a negative manner and hence has to be handled carefully. One of the existing noise removal techniques in video surveillance employed morphological operations [15][16], which has the following cons.

1. It is very difficult to find the efficient kernel size and the operations' sequence.

2. Application of morphological operations often deletes small regions that may be important during analysis.

3. Finally, the morphological operations may introduce shape and contour distortion.

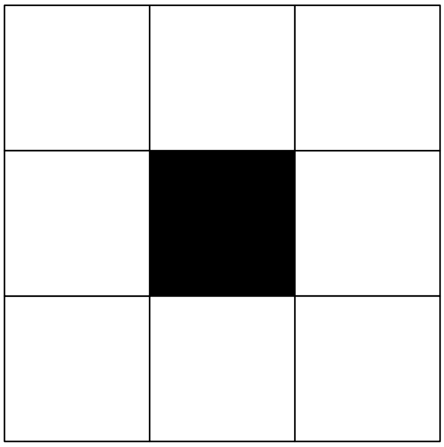

Fig. 3. Replacement value of the AND operation.

In order to solve these problems, we propose a neighbourhood comparison and thresholding method for de-noising. The primary objective is to measure a pixel's belongingness to a structured windowed region as shown in Fig. 1. A logical 'AND' between the pixel pointed by the circle and its neighbours are performed. Then, each of the horizontal and vertical directions are considered and the upshot of all the AND operations is used to put back the noisy pixel as shown in Fig. 2. The algorithm thus removes all isolated noises and leads to full regions with well defined and continuous edges as shown in Fig. 3.

Step 1. Let the base structure of the window region.

Step 2. Perform a logical "AND" between the pixel pointed by the circle and each one of its three neighborhoods.

Step 3. Search for the basic structure in each direction (i.e., horizontal, vertical)

Step 4. Increase and replace the value of the central pixel that is denoted as black pixel in Fig. 3. It represents the outcome of all these "AND" operations.

The algorithm removes all isolated noises and leads to full regions with well defined and continuous edges.

B. Illumination Correction

In real-life systems, the change in illumination with the time of day alters the appearance of the scene and causes deviation from the background model. This results in a drastic increase in the number of fallaciously detected foreground regions. This shortcoming makes automated surveillance unreliable under changing illumination conditions and therefore methods to solve this issue has to be developed.

The illumination variations in the detected foreground objects are removed by using an amalgamation of techniques like homomorphic decomposition, curvelet transformation and gamma adjustment operator. First, an RGB color space is transformed into a color space that handles illumination and reflection in a better manner. Next, the illumination and reflectance values are separated using homomorphic decomposition based on illumination-reflectance model. Locating the details of reflectance are preserved using curvelet transform. Finally, the dynamic range of reflectance is refined using Butterworth filtering. After removal of illumination the image is converted back to the original RGB color space. The block diagram of the proposed method is shown in Fig. 4.

C. Shadow Removal

Presence of objects shadows, might also pose difficulty because of the illumination change in the shadow region and hence has to be uninvolved.

Detected moving object may include shadow which degrades the performance. To overcome this problem we have proposed method called adaptive shadow estimator with connected component analysis.

The proposed method consists of the following steps. A chromaticity estimator is first determined on the detected foreground moving objects. These are termed as first set of shadow pixels, by means of which the brightness difference is estimated (Second set of shadow pixels). The local relation estimator is then employed to identify the final candidate set. To remove small shadow objects retained near boundaries of the moving objects a post processing procedure is included. Fig. 5 shows block diagram of the proposed shadow removal method.

IV. Implementation and Performance Analysis

Real-life video sequences are used to demonstrate accuracy of the proposed framework. CCTV camera was employed to acquire video shots. Implementation has been done in Java and result analysis was performed in MATLAB. Natural acquisition has been done in the routine life scenario and highways directly. We employed five video sequences for the experiment.

First video (V1) has 7 seconds duration, 25 frames per seconds, and each frame has 16:9 aspect ratio. The scenario of V1 consists of human cycling with dog alongside background of moving vehicles.

Second video (V2) was captured from the center line of the national highway along with fast moving heavy and light weight vehicles. Pan angle of the camera was slightly turned to 30 degree in the right hand direction with 4 seconds duration, 30 frames per seconds, and each frame has width x height of 320x240.

TABLE I
Result of noise removal for video sequences using PSNR computation of proposed Neighbourhood comparison and existing morphological methods.

Video Scenario	Morphological Method db	Proposed Neighbourhood Comparison	PSNR in db
V1	37.66	39.44	1.78
V2	40.51	41.26	0.75
V3	38.54	40.36	1.82
V4	37.98	40.94	2.96
V5	34.62	36.25	1.63
Mean PSNR in db	37.862	39.65	1.788

Video (V3) was acquired from midst of the natural traffic along with light weight vehicles moving and pedestrian crossing. It was 60 degree of pan angle of acquisition, 8 seconds duration, 25 frames per seconds and each frame has 320 x 240.

The fourth scenario (V4) was acquired in an outdoor with single person walking with self-shadow occurring on the present objects of the scene. It has five second duration, 15 frames per second with dimension of 360x240.

Video (V5) was acquired in the noon time at highways with animal crossing the road when vehicles are moving. Duration of the video was 4 seconds with 30 frames per second and each frame had a width x height of 640x360 pixels. Fig. 6 shows sample degraded video frame from noised scenario V2 and Fig. 7 shows the result of sample frame of de-noised scenario V2.

Table I shows the PSNR value of existing and proposed method of de-noise algorithm for video surveillance. Due to varies factors such as capturing timing, angle variation, number of objects in the scene, diverse variation of PSNR improvement obtained in the result of noise removal method.

The proposed de-noising algorithm showed 4.51% PSNR efficiency gain when compared with the existing algorithm. Illumination variation correction is done using Curvelet transformation. Because of over lighting the performance may be degraded. In the normal lighting condition good performance were achieved. This is shown in the Table II.

Fig. 8 shows the illumination corrected image using curvelet transformation and Gamma correction over the image. Bended shading and variation of illumination on the image is removed since this video is taken during day time.

Even though it might be less robust to high variation in light or unusual light change our method is faster compare to other existing methods.

The proposed illumination algorithm showed 4.42% efficiency gain with respect to PSNR.

Detected moving object may include shadow which degrades the performance of the system. To overcome this problem we have proposed method called Adaptive Shadow Estimator (ASE) with Connected Component Analysis (CCA).

Fig. 9 shows the shadow detected from scenario V2 and Fig. 10 depicts the result of shadow correction done using our proposed algorithm. When the uneven lighting is present it is very difficult to identify the shadow.

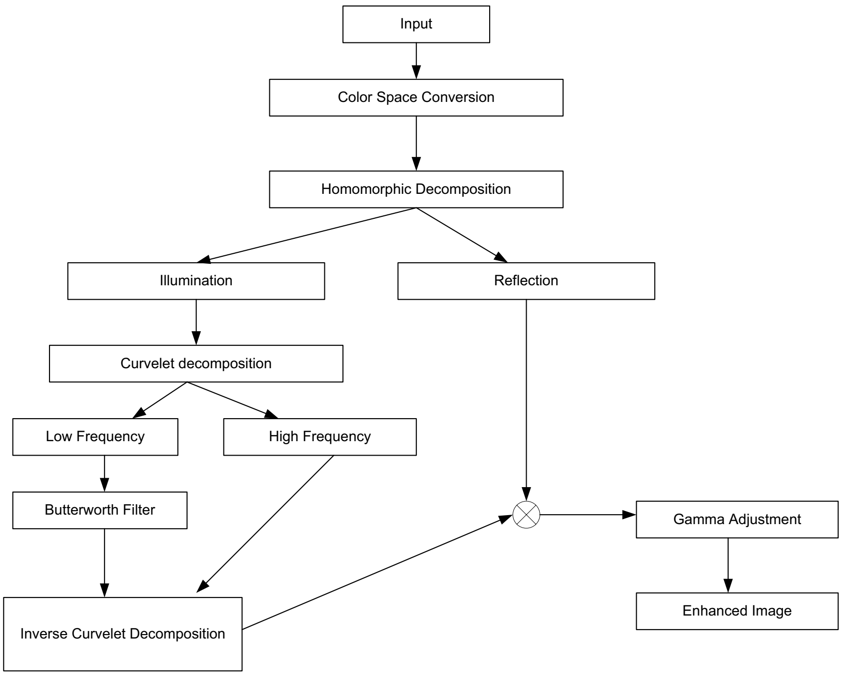

Fig. 4. Block diagram of the illumination variation correction.

TABLE II
RESULT OF ILLUMINATION VARIATION CORRECTION FOR VIDEO SEQUENCES USING PSNR COMPUTATION FOR PROPOSED CURVELET METHOD COMPARISON WITH EXISTING WAVELETS METHODS.

Video Scenario	Wavelet (db)	Curvelets (db)	PSNR improvement in db
V1	35.72	37.26	1.54
V2	38.81	40.26	1.45
V3	36.53	38.33	1.80
V4	37.64	38.74	1.1
V5	32.88	34.40	1.52
Mean PSNR in db	36.316	37.798	1.482

Experiments shows that the proposed algorithm outperform well compared with the existing algorithm using varies video sequences by calculating shadow detection and shadow discrimination rate as described in (1) and (2), respectively.

$$\eta = \frac{TP_s}{TP_s + FN_s}, \quad (1)$$

$$\xi = \frac{TP_f}{TP_f + FN_f}, \quad (2)$$

where TP_s and TP_f are the number of pixels which are determined correctly as shadow pixels and object pixels respectively. FN_s is the number of errors in which a shadow pixel is defined as an object pixel, and FN_f is the number of false detection which identified an object pixel as a shadow pixel. Fig. 11 and Fig. 12 depict the results of shadow detection rate and shadow discrimination rate of various scenarios.

The average shadow detection of the proposed algorithm showed an increased performance of 87.38% when compared to the existing algorithm (85.92%). The average shadow discrimination rate of the proposed algorithm was 89.02% which has increased when compared with the existing algorithm (88.46%).

The proposed algorithm shows that if illumination changes quickly the detection rates are not good. But, the proposed shadow removal algorithm set the threshold value adaptively in an automatically and it is possible to apply the method to an illumination variation environment. Compare to other methods our algorithm performs well.

V. CONCLUSION

In this paper, AVSS based de-noising, illumination variation correction and the shadow detection, and shadow discrimination algorithms were proposed. These algorithms have been implemented and evaluated in real-life video images. Based on these algorithms, existing surveillance

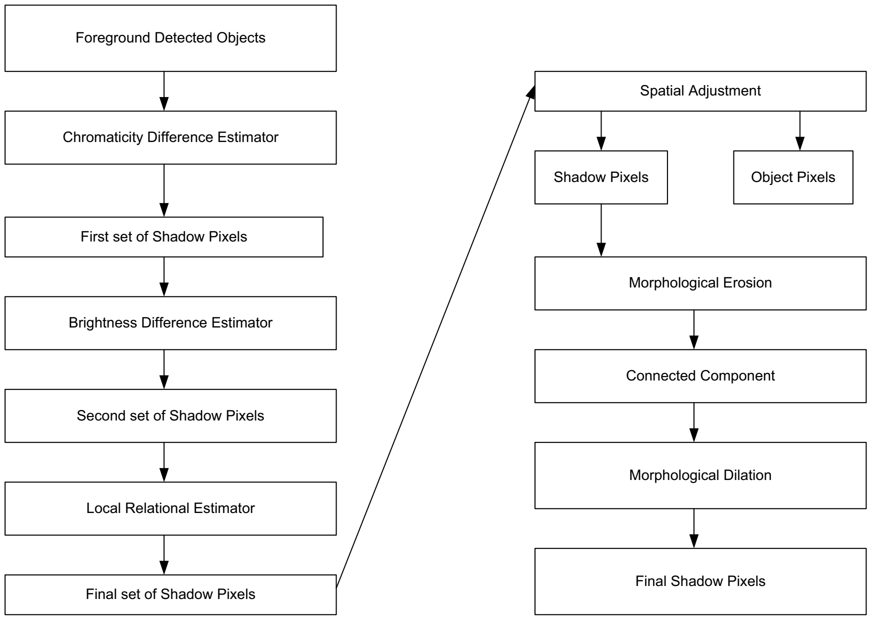

Fig. 5. Block diagram of the proposed shadow removal method.

Fig. 6. Depiction of the degraded video frame form a scenario V2.

Fig. 7. Illustration of one of the de-noised video frame form a scenario V2.

Fig. 8. Result of illumination variance correction method for a scenario V2.

Fig. 9. Representation of a sample frame of shadow detection method from a scenario V2.

Fig. 10. Representation of a sample frame of shadow removal from a scenario V2.

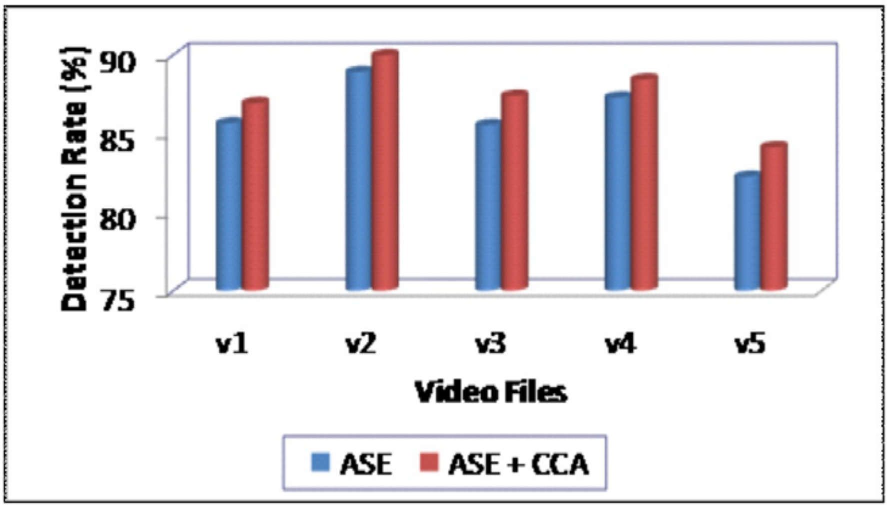

Fig. 11. Result of shadow detection rate for video sequences using PSNR (db) computation for proposed Neighbourhood comparison and existing morphological methods for all scenarios.

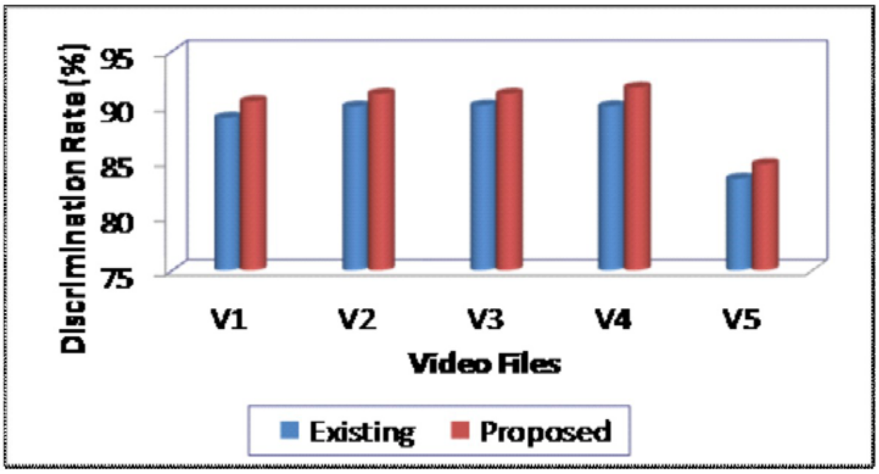

Fig. 12. Result of shadow discrimination rate for video sequences using PSNR (db) computation for proposed Neighbourhood comparison and existing morphological methods for all scenarios.

system's performance has been improved significantly especially for real-life video images. Furthermore, object identification in Automated Video Surveillance System (AVSS) was enhanced. The experimental results of each phase proved that all the proposed methods were robust and enhanced the recognition of objects in video images. This paper opens a new avenue in AVSS research work. In further development, this system can be improved to identify various objects by including factors such as scale, rotation, pan and tilt angles and a new approach will be suggested to adopt these factors in the real-life video images.

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