Foreground Extraction for Real-time Crowd Analytics in Surveillance System

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***Abstract*—In this paper, we propose an adaptive background modeling algorithm for crowd surveillance system. We employed Approximate Median Method (AMM) along with the Phase congruency edge detector to develop the background model. The resulting foreground of the proposed model was obtained by applying a logical AND operation between binary maps of the (foreground) of the AMM image and the gradient information of the (Phase congruency edge detector) PC. Experimental results demonstrate that the proposed method is highly accurate while providing a processing speed of 24.8 fps allowing its implementation for real time application.**

I. Introduction

Crowd surveillance systems have become one of the interesting prospects of the computer vision community. The importance of safety and security in public and private sectors and the availability of inexpensive devices and processors has become the greatest motivation in this field [1]. Crowd analytic based consumer surveillance system is a demanding application which is highly required at public places such as malls, train stations, airports, etc. [2]. Nevertheless, the replacement of traditional surveillance systems aided by humans to computer aided crowd analytic based surveillance system, usually demands a refurbishment of the devices which is costly for the consumer [3].

Therefore the major requirement for the consumer is that the crowd analytic based surveillance system should be integrated to the existing surveillance system. Previous crowd analytic based surveillance systems suffered in adapting from static to dynamic environments under real time constraints[4].

In this paper we propose a non-parametric background modeling method to determine the foreground by employing AMM along with the PC to extract foreground objects while achieving high accuracy, precision and sufficiently fast processing to be applied in real time application.

II. Proposed Method

The leading inspiration to formulate the background modeling method utilizing AMM along with phase congruency edge detector was due to the fact that phase texture information is invariant to illumination variance [5].

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Indeed, illumination invariance is one of the main drawbacks that have to be overcome by surveillance systems [4]. Consequently, the model has been formulated by employing AMM to determine the foreground from the scene using pixel intensity information. The Phase congruency edge detector was used to extract the phase edge information from the scene. The final extracted foreground from the proposed model, was computed by using a logical AND function, involving the binary maps of the (foreground) from the AMM image along with the gradient information of the Phase congruency edge detector as shown in Fig 1. The detail of the model is outlined within subsections for foreground extraction and phase congruency edge detector respectively.

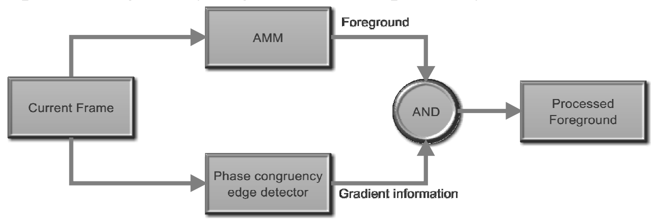

Fig. 1.Blockdiagram of the proposed method

A. *Foreground extraction*

AMM based on Histogram selection is used to extract the foreground in which the method is formulated by taking a reference frame 'F_r' and a null foreground frame 'F_F'. Then, a Threshold '*T*' is acquired by taking the median of the threshold value of all the pixels of the reference frame which is extracted from the histogram functions. On modeling the background for a current frame 'F_c', the absolute difference between the current frame and the reference frame is obtained and stored in a new frame 'F_B' as shown in eq.(1).

$$F_B = |F_c - F_r| \tag{1}$$

The foreground is modeled based on a similarity evaluation, where the pixels of the frame 'F_B' is stored in 'F_F' if the pixel intensities are greater than the median threshold value 'T ', or else the pixel would be removed as described in eq.(2):

$$F_F = F_B > T \tag{2}$$

After the foreground extraction the reference frame is updated based on the pixel values of the current frame. Here If the pixel value on the current frame is greater than the reference frame, the reference frame is updated by adding this pixel, and if the pixel value on the current frame is lesser than the reference frame then the reference frame is updated by removing this pixel.

B. *Phase congruency edge detector*

Phase Congruency (PC) is a dimensionless quantity which delivers data that are robust to the intensity variation in an image. Thus PC enables the magnitudes in the primary instances associated with PC to obtain edges and corners of the scene which is invariant to illumination. The resulting operator will be highly localized along with the invariance from the correspondences to image intensity. This leads to robust and repeatable feature detection within diverse illumination conditions having fixed threshold.

Though the original measure of PC does not offer good localization and furthermore is vulnerable to noise, Kovesi [5] developed an improved algorithm comprising the difference of cosine and sine magnitudes from the phase changes, intrinsically leading to a more localized response. Furthermore the improved computation of the PC including noise compensation is shown in eq. (3), as follows:

$$PC_2(x) = \frac{\sum_n W(x)[A_n(x)\alpha_1 - |\alpha_2| - T_{PC}]}{\sum_n A_n(x) + \varepsilon} \tag{3}$$

where ‘ α_1 ’denotes $(\cos(\phi_n(x) - \bar{\phi}(x))$ and ‘ α_2 ’ denotes $(\sin(\phi_n(x) - \bar{\phi}(x))$ the term $W(x)$ is a factor that weights for frequency spread.

III. EXPERIMENT RESULTS

The proposed background modeling criteria was assessed along with three other popular background modeling methods [4] on the PETS data set 2010 that is specifically formulated for visual surveillance research in crowd behavior [6]. The proposed algorithm responses have been assessed with respect to static and dynamic background scenarios. The assessments were carried out qualitatively and quantitatively. Precision Recall [4] was used to quantify the ability, to extract the true positive and eliminate the true negative detection of the implemented models.

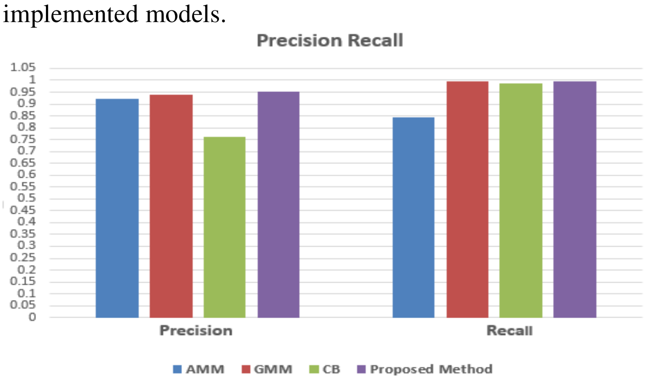

Fig. 2. Quantitative analysis using Precision Recall for the foreground extraction of the proposed method

The foreground extraction of AMM, Gaussian Mixture Model (GMM) and Codebook (CB) along with the proposed method is shown in Fig 2 & 3. It can be observed that the proposed method outperformed in comparison to other popular methods by eliminating the effect of sudden illumination and shadows. Furthermore the proposed method was able efficiently segregate the individual objects in dense crowds, while providing a greater Precision Recall rate compared to other existing methods. The proposed method provided a processing speed of 23.8 fps.

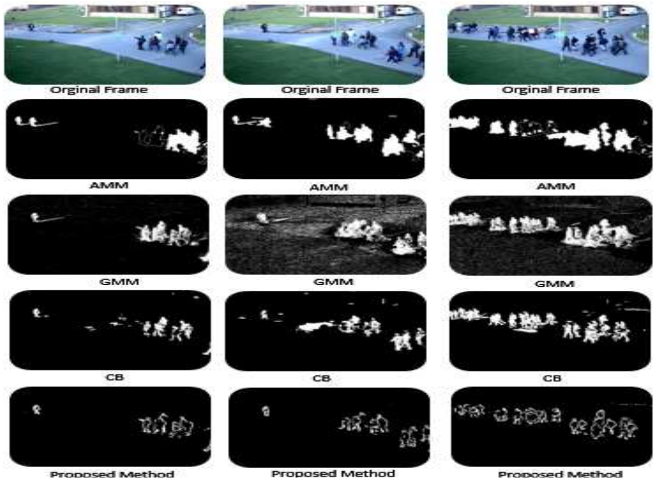

Fig. 3. Results of the foreground extraction of the proposed method for static and dynamic background

IV. CONCLUSION

This paper proposed a background modelisation incorporating AMM and PC edge detector to adapt to unconstrained environment conditions. The analysis provides more accurate background/foreground subtraction and is able to efficiently segregate the individual objects in dense crowds. Moreover, the model efficiently compensates the effect of sudden and gradual illumination and eliminates shadows. Future works will focus on enhancing the pixel density on the silhouette of the objects.

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