Moving Object Detection: Review of Recent Research Trends

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***Abstract*— Moving object detection is the task of identifying the physical movement of an object in a given region or area. Over last few years, moving object detection has received much of attraction due to its wide range of applications like video surveillance, human motion analysis, robot navigation, event detection, anomaly detection, video conferencing, traffic analysis and security. In addition, moving object detection is very consequential and efficacious research topic in field of computer vision and video processing since it forms a critical step for many complex processes like video object classification and video tracking activity. Consequently, identification of actual shape of moving object from a given sequence of video frames becomes pertinent. However, task of detecting actual shape of object in motion becomes tricky due to various challenges like dynamic scene changes, illumination variations, presence of shadow, camouflage and bootstrapping problem. To reduce the effect of these problems, researchers have proposed number of new approaches. This paper provides a brief classification of the classical approaches for moving object detection. Further, paper reviews recent research trends to detect moving object for single stationary camera along with discussion of key points and limitations of each approach.**

Keywords—Human Motion Analysis; Moving Object Detection; Object Classification; Tracking; Video Survillance

I. INTRODUCTION

A video is a group of basic structural units, such as scene, shot and frame associated with audio data. A frame is defined as a single picture shot of movie camera, led by many successive frames for seamless video [1]. Moving object detection is the act of segmenting non-stationary objects of interest with respect to surrounding area or region from a given sequence of video frames [2]. Determination of the moving target forms the basic step for classification and tracking process of object in motion. The main aim of moving object detection and tracking activity is to discover foreground moving target(s) [3] either in every video frame or at very first appearance of moving target in video [4]. In any video analysis activity there are three major phases: identification of the moving target (object), tracing of identified moving object in a given series of video frames and analysis of the moving target (object) in order to determine its behavior. Hence, identifying the moving object becomes significant step for any analysis process.

Moving object detection has become a central topic of discussion in field of computer vision due to its wide range of applications like video surveillance, monitoring of security at airport, law enforcement, video compression, automatic target identification, marine surveillance and human activity recognition [5]. Several methods have been proposed so forth for object detection, out of which Background Subtraction, Frame differencing, Temporal Differencing and Optical Flow [1] are extensively used traditional methods.

Moving object detection has always proved to be challenging task due to number of factors like dynamic background, illumination variations, misclassification of shadow as object, camouflage and bootstrapping problems. Much of the research work has been carried out in order to deal with above factors that is been discussed in next section.

Structuring of remaining paper is as follows. Section II classifies traditional techniques for moving object detection. Section III focuses on recent research trends in moving object detection and brief summary of the same is provided in appendix section. Furthermore, Section IV concludes the paper.

II. CLASSIFICATION OF TRADITIONAL APPROACHES OF MOVING OBJECT DETECTION

Traditional Approaches for moving object detection can be broadly categorized into four forms as Background Subtraction, Frame Differencing, Temporal Differencing and Optical Flow [1]. Fig. 1 shows a brief classification of traditional approaches.

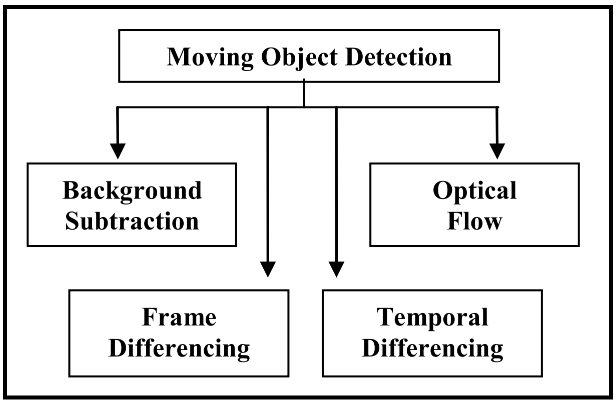

Fig.1 Traditional Approaches of Moving Object Detection

A. Background Subtraction

Background Subtraction Method is considered to be one of the most reliable method for moving object detection. Background subtraction works by initializing a background model, then difference between current frame and presumed background model is obtained by comparing each pixel of the current frame with assumed background model color map. In case difference between colors is more than threshold, pixel is considered to be belonging to foreground [6]. Performance of traditional background subtraction method mainly gets affected when background is dynamic, illumination changes or in presence of shadow. Numerous methods have been developed so forth to upgrade background subtraction method and overcome its drawbacks. Different methods of background subtraction as reviewed by Massimo Piccardi et al. [7] are: Concurrence of image variations, Eigen backgrounds, Mixture of Gaussians, Kernel density estimation (KDE), Running Gaussian average, Sequential KD approximation and Temporal median filter.

B. Frame Differencing

Frame difference method identifies the presence of moving object by considering the difference between two consecutive frames [8]. The traditional approach makes use of image subtraction operator that obtains output image by subtracting second image frame from first image frame in corresponding consecutive frames. Frame differencing method lacks in obtaining the complete contour of the object as a result of which morphology operations are general used to obtain better results.

C. Temporal Differencing

Temporal differencing method detects the moving target by employing pixel-wise difference method among two successive frames [2]. Traditional temporal difference method is flexible to dynamic changes in the scenes but results degrade when moving target moves slowly since due to minor difference between consecutive frames, object is lost. Moreover, trailing regions are detected wrongly as moving object (ghost region) because of fast movement of object, additionally incorrect detection will result where objects preserve uniform regions [1].

D. Optical Fow

Optical flow approach [2] of moving target detection is based on calculation of optical flow field of image (or video frame).Clustering is performed on the basis of the obtained optical flow distribution information obtained from the image (video frame).This method allows obtaining complete knowledge about the movement of the object and is useful to determine moving target from the background. However, this method suffers from some of drawbacks like large quantity of calculations are required to obtain optical flow information and it is sensitivity to noise.

III. Recent Research Trends

Moving object detection involves locating moving object in the frame of a video sequence. It has always been a challenging task in field of video processing since results of moving object detection techniques are highly affected by variations in illumination and background changes. Moreover, difference in shape, motion and speed of moving target makes the task more complicated. Multitude of work is done to acquire accurate results considering the mentioned challenges. This section describes some of recent research approaches developed for moving object detection to acquire higher performance with reduced errors.

Dong et al. [9] presents new approach based on RGB color space along with edge ratio that allows determining moving object and shadow separately. It is achieved in three consecutive steps. Initially, specific characteristics of moving target and shadow are analyzed in three dimensional RGB color space. Subsequently, object and shadow are differentiated based on the chromaticity and brightness distortion of the pixels of current image and background image. Ultimately, misclassified object and shadow are treated by area and edge ratio of each region.

Choi et al. [10], introduces a novel approach for moving object identification under fast illumination changing condition. The proposed approach is depended on chromaticity model and brightness ratio model. The main focus of the proposed approach is to eliminate false foreground pixels detected by Gaussian mixture model under fast illumination variations. At the outset, probability distribution of false foreground pixels is determined by chromaticity difference model in order to separate pixels as foreground pixels of moving target and candidate false foreground pixels. However it is possible that candidate false foreground pixel may contain moving target pixel because of zero chromaticity difference. These pixels are then separated by brightness ratio model. As a result of which pixel indicating the actual moving target are identified with elimination false foreground pixels.

A fast and robust approach originated from combined spatio-temporal background and foreground modeling is presented by Hao et al. [11]. In order to adapt changes with background in each video frame, prior probabilities are estimated. Firstly, by making use of kernel density estimation; temporal and spatial information are obtained for background modeling. Secondly, to develop foreground model, Gaussian formulation is used to depict the spatial correlation between targets in motion. Lastly, a fusion background frame is produced along with proposal of updating rates.

An enhanced version of traditional three-frame differential method approach has been proposed by Gang et al. [12]; where in Canny edge detection algorithm is being combined along with three frame differential approach to obtain more complete information regarding moving object. Firstly, by making using of canny edge detector and noise removal technique, reasonably clear boundary image of object is obtained. Secondly, dilation operation is applied in which background points are merged with object. Secondly, local boundary connection is applied to gain the clarity of boundary of moving object. In final stage of the proposed method, black and white connected domain area of moving target and background is converted into binary form.

A novel approach is introduced by Zhang et al. [13] in order to deal with dynamic scenes. A combined version of five-image difference algorithm and background subtraction algorithm is provided to provide complete contour of moving object. Proposed approach is mainly divided into three consecutive steps i.e., pre-processing, target identification and rectangular contour modeling. In very first step video is pre-processed by median filter technique for noise removal. Secondly, five frame differential technique; an enhanced version of inter-frame differential technique is applied. Thirdly, background subtraction algorithm is applied on the actual image sequence and output is achieved using the dissimilarity between current video frame and assumed background model; which is then followed by binarization operation. In last stage, rectangular contour model is applied to eliminate cast shadow effect.

A robust algorithm named as 3dSOBS+ to detect moving object is been introduced by Maddalena et al. [14]. Proposed approach is based on neural background model. Self organizing method is used for automatic generation of neural background model. Initially, neural background model is built which contains **n** images that are referred as layers and each layer consist of weight-vector for corresponding pixel. Then forth, neural background model is initialized by changing all layers of the model by background model estimated using temporal median method. In next stage each pixel of the current frame is compared to pixels of neural background model; if weight vector of the pixel in current frame is close enough to estimated model then the pixel is estimated to be foreground pixel else it is considered as background pixel. Lastly, model is updated by revising best matching weight vector and its neighboring weight vector on the basis of weighted running average.

An approach based on Gaussian mixture model and blob detection for vehicle recognition and tracking is proposed by Bhasker et al. [15]. The proposed work firstly separates foreground image pixels from background image pixels by learning the background from the presumed model, using Gaussian mixture strategy. Subsequently, movement of the object is traced within the frame by blob detection. To recognize area of the blob and to calculate detected region and its centroid, blob detection makes use of contrast in binary image. The pixels identified by Gaussian mixture model are grouped into disconnected classes through contour detection algorithm. The disconnected classes and its surrounding contours are tagged as candidate blob. In order to reduce false detection, the small candidate blobs are removed. The positions of contour blob are compared by using k-means clustering that identifies centre of clusters to detect vehicles in each region. Some morphological operations are applied for elimination of noise. The blob analysis puts a rectangular box around the potential objects. Finally, the counting of vehicles within the baseline is done based on the identified blob regions.

Wang et al. [16] presented a three step method based on temporal information for moving object detection. Firstly, based on the continuous symmetry difference of the adjacent frames temporal saliency map is generated .Secondly, temporal saliency map is binarized and candidate areas are obtained by calculating threshold using maximum entropy sum method. Most salient point are considered as attention seed and based upon obtained attention seed, fuzzy approach is performed on saliency map to grow attention seeds, until entire contour of the moving objects are acquired.

Moving object detection along with the elimination of shadow and changing illumination condition has been introduced in by Xiang et al. [17] where in combined approach of local intensity ratio and Gaussian mixture model has been proposed. Firstly, in order to eliminate shadow pixels of the video are replaced by normalized local intensity that allows determining the moving target without shadow via Gaussian mixture model. Secondly, in order to remove noise and scattered shadow, erosion operation is applied. Thirdly, contour enhancement method is used to obtain entire contour enhancement of moving target. Lastly, local foreground density and counter orientation is used to fill up the holes in the obtained moving target.

Appendix A summarizes above approaches providing addition knowledge about positive aspects and limitations of each approach.

IV. CONCLUSION

Moving Object Detection is very momentous and efficient research field that is powerfully motivated by number of applications. The Paper purport is to present an outline of established tactics for moving object detection and study of recent growth in corresponding theme is depicted with the focus on the shortcomings of conventional method.

Temporal information based methods like background subtraction, frame difference and temporal difference were witnessed as chiefly used approaches for determination of object in motion for video sequence recorded using stationary single camera. During survey it was identified that shadow, illumination variation and dynamic background are the major problems which are worked over since these problems lead to reduction in the accuracy of successive steps of analysis process i.e., classification and tracking. Abundant of work has been done so forth to deal with shadow and illumination variation using background subtraction model. Though the enhanced work provides better result compared to conventional approaches, but require more computational time and need additional algorithm to deal with complex environment. Improvisation in frame difference method allows to obtain entire contour of the object with comparatively less computational time than background subtraction model but it is vulnerable to dynamic changes and yet no well established method specific to frame difference for shadow elimination and illumination variation is developed. Advancement in temporal difference method determines entire contour of object with dynamic changes, but still alike frame difference method, no particular method for shadow purging and changes in lighting conditions for temporal difference method was recognized.

In future, new techniques can be developed using strength of recent trends for better performance results. For instance, shadow elimination and illumination variation methods used with background model can be incorporated with temporal and frame difference method with aim to improve the recent approaches.

APPENDIX A :

TABLE I : RECENT RESEARCH TRENDS OF MOVING OBJECT DETECTION

Publication / Year	Title	Overview	Positive Aspects	Limitations
IEEE / 2009	Moving Object and Shadow Detection Based on RGB Color Space and Edge Ratio [7]	Separation of object, shadow and background using RGB color space model considering chromaticity and brightness ratio model combined with edge ratio model for treatment of misclassified object and shadow	+ Moving object and shadow are determined separately + Fast enough for utilization in real time analysis	- Darker shadow areas or moving target having similar color information to that of background area will lead to failure
ELSEVIER / 2011	Robust moving object detection against fast illumination change [8]	Identification of moving target under fast illumination variations using Gaussian mixture model for object detection and chromaticity and brightness ration model for elimination of false foreground pixels.	+ Does not require training sequence + Automatic adjustment of the parameters	- Results degrades in complex environment that has piled snow, puddles or in specular regions
IEEE / 2012	Spatio-Temporal Traffic Scene Modeling for Object Motion Detection [9]	Approach for traffic surveillance using Bayesian fusion method where in kernel density estimation is used for background modeling and Gaussian formulation is carried out for foreground model.	+ Requires less computational time + Works well with rapidly and slowly changing background	- Object's feature identical to that of background are abolished
IEEE / 2013	An Improved Moving Objects Detection Algorithm [10]	Enhanced three frame differential method combined with canny edge detection to gain complete information related to moving target	+ Ghosting effect is eliminated + Algorithm beats the empty phenomenon and edge deletion problems of standard three-frame differential method	- The result is not ideal in the environment with strong light and obvious shadow - Results degrade for dynamic background
IEEE / 2013	A Moving Target Detection Algorithm Based on Dynamic Scenes [11]	Five frame differential approach combined with background subtraction method for detection of target in motion	+ Moving target can be extracted more accurately and completely from dynamic scenes	- It cannot eliminate leaves flutter noise - Cannot identify multiple moving targets
ELSEVIER / 2014	The 3dSOBS+ algorithm for moving object detection [12]	Moving target is detected by Neural background model which is automatically created by self organizing method	+ Works well with dynamic backgrounds + Accurately adjust with gradual illumination variations, and shadows cast by moving objects +Robust against false detections	- Accuracy cannot be obtained in case of sudden illumination variations and reflection
IEEE / 2014	Image Processing Based Vehicle Detection and Tracking Method [13]	Vehicle recognition and tracking using Gaussian mixture model and blob detection	+ Vehicle counting is done automatically + Robust for low and medium traffic	- In case of overcrowding and high traffic flow situation performance breaks down - To obtain best performance significant amount of parameter tuning is required
IEEE / 2014	Moving Object Detection Based on Temporal Information [14]	Makes use of temporal information for generation of motion saliency which is then followed by maximum entropy and fuzzy growing method to identify moving target	+ No prior knowledge of the background model is required + Robust to mild background motions and camera jitters + No user interaction for parameter tuning is required. + Efficiently deals with the perturbations of the background	- Shadow is determined along with moving object which may be misclassified as object itself
HINDAWI / 2014	Moving Object Detection and Shadow Removing under Changing Illumination Condition [15]	Local intensity ratio model used for elimination of shadow followed by Gaussian mixture model for moving object detection	+ Successful moving target identification without shadow and changing illumination condition.	- Performance drops significantly in case where background is same as foreground and foreground is similar to shadow - Cannot accommodate with back to back illumination changes like light on/off.

REFERENCES

[1] Soharab Hossain Shaikh, Khalid Saeed and Nabendu Chaki.(2014). Moving Object Detection Using Background Subtraction.[Online]. Available: http://link.springer.com/book/10.1007%2F978-3-319-07386-6

[2] Weiming Hu, Tieniu Tan, Liang Wang, and Steve Maybank, "A Survey on Visual Surveillance of Object Motion and Behaviors," IEEE Trans. on Systems, Man, and Cybernetics—Part C: Applications and Reviews,vol. 34, no. 3, pp. 334-352, August 2004.

[3] Bahadir Karasulu and Serdar Korukoglu (2013). Performance Evaluation Software: Moving Object Detection and Tracking in Videos. [Online]. Available: http://link.springer.com/book/10.1007%2F978-1-4614-6534-8

[4] Dipali Shahare and Ranjana Shende, "Moving Object Detection with Fixed Camera and Moving Camera for Automated Video Analysis," International Journal of Computer Applications Technology and Research, vol. 3, issue 5, pp. 277-283, 2014.

[5] J. M. Chaqueta, E.J.Carmonaa and A.F. Caballerob, "A survey of video datsets for human action and activity recognition," Computer Vision and Image Understaning, vol. 117 (6), pp. 633-659, 2013.

[6] Nicholas A. Mandellos, Iphigenia Keramitsoglou and Chris T. Kiranoudis, "A background subtraction algorithm for detecting and tracking vehicles," Expert Systems with Applications, pp. 1619-1621, 2011.

[7] Massimo Piccardi, "Background subtraction techniques: a review," IEEE International Conference on Systems, Man and Cybernetics, pp. 3099-3104, 2004.

[8] Jain, R. and H. Nagel, "On the Accumulative Difference Pictures for the Analysis of Real World Scene Sequences," IEEE Tran. on Pattern Anal. Mach. Intell., pp. 206-221, 1979.

[9] Xia Dong, Kedian Wang and Guohua Jia, "Moving Object and Shadow Detection Based on RGB Color Space and Edge Ratio," IEEE 2nd International Conference, on Image and Signal Processing, pp. 1-5, Oct. 2009.

[10] JinMin Choi, Hyung Jin Chang, Yung Jun Yoo and Jin Young Choi, "Robust moving object detection against fast illumination change," Computer Vision and Image Understanding, pp. 179-193, 2012.

[11] JiuYue Hao, Chao Li, Zuwhan Kim, and Zhang Xiong. "Spatio-Temporal Traffic Scene Modeling for Object Motion Detection," IEEE, Intelligent Transportation Systems, 2012.

[12] Liu Gangl , Ning Shangkun ,You Yugan ,Wen Guanglei and Zheng Siguo, "An Improved Moving Objects Detection Algorithm," in Proceedings of the 2013 IEEE International Conference on Wavelet Analysis and Pattern Recognition, pp. 96-102, 14-17 July, 2013.

[13] Huijuan Zhang and Hanmei Zhang, "A Moving Target Detection Algorithm Based on Dynamic Scenes," IEEE Conference on Computer Science & Education, pp. 995-998, April 2013.

[14] Lucia Maddalena and Alfredo Petrosino, "The 3dSOBS+ algorithm for moving object detection," Computer Vision and Image Understanding, pp. 65–73, 2014.

[15] Prem Kumar Bhaskar and Suet-Peng Yong, "Image Processing Based Vehicle Detection and Tracking Method," IEEE, 2014.

[16] Zhihu Wang, Kai Liao, Jiulong Xiong, and Qi Zhang, "Moving Object Detection Based on Temporal Information," IEEE Signal Processing Letters, vol. 21, no. 11, pp. 1404-1407, November 2014.

[17] Jinhai Xiang, Heng Fan, Honghong Liao,Jun Xu,Weiping Sun and Shengsheng Yu, "Moving Object Detection and Shadow Removing under Changing Illumination Condition," Hindawi Publishing Corporation, Mathematical Problems in Engineering, pp. 1-10, February 2014.