Image Processing Techniques for Object Tracking in Video Surveillance- A Survey

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***Abstract*—Many researchers are getting attracted in the field of object tracking in video surveillance, which is an important application and emerging research area in image processing. Video tracking is the process of locating a moving object or multiple objects over a time using camera. Due to key features of video surveillance, it has a variety of uses like human-computer interactions, security and surveillance, video communication, traffic control, public areas such as airports, underground stations, mass events, etc. Tracking a target in a cluttered premise is still one of the challenging problems of video surveillance. A sequential flow of moving object detection, its classification, tracking and identifying the behavior completes the processing framework of video surveillance. This paper takes insight into tracking methods, their categorization into different types, focuses on important and useful tracking methods. In this paper, we provide a brief overview of tracking strategies like region based, active contour based, etc with their positive and negative aspects. Different tracking methods are mentioned with detailed description. We review general strategies under literature survey on different techniques and finally stating the analysis of possible research directions.**

Keywords—Motion segmentation, object detection, object representation, object tracking, video surveillance.

I. INTRODUCTION

Image processing is a form of processing with input as image such as photograph or video frame and output can be characteristics or parameters related to image. Computer vision is an area that consists of methods for incorporating, analyzing and visualizing images. Surveillance stands for monitoring the behaviour, activities, and other changing information, usually of people for the purpose of influencing, directing and protecting them. The process of locating moving object using a camera is video tracking. In simple terms, tracking means associate target objects in consecutive video frames. Difficulties arise especially when objects are moving rapidly as compared to frame rate or when the tracked object changes direction over time. A sequential flow of object detection, object tracking, object identification and its behavior completes the process framework of tracking.

Intelligent crime system, terrorists' attacks and increasing security related issues have alarmed each nation of the globe. Manual analysis process consists of number of limitations like it is to be costly, prone to errors, labor intensive, limited human resources, and sometimes failure of human resources to monitor continuous signals [1]. Due to time constraint, resource crunches, technology advancement of criminal attacks, it is very difficult to provide 24x7 monitoring, resulting in knocking the opportunity of smart and intelligent based video surveillance system. Outcome of all this, new opportunities knocking the doors in the video surveillance market. FIFA World Cup 2014 and Olympics 2016 have captured maximum market for video tracking in Brazil. According to 6W research, the Brazil video surveillance market is expected to reach $362.69 million by 2016. Facial recognition technology was effectively used in 2001 Super Bowl in law enforcement surveillance. In January 2001, the faces of over 100000 fans entering the stadium to watch the Super Bowl in Tampa, Florida, were recorded by local law enforcement on video cameras. These facial images were then checked electronically against a criminal computer database. According to Marcus Nieto [2], in the California, many local public agencies deploy CCTV surveillance systems with the primary function to protect property rather than monitoring public movement. In cloud video surveillance report 2014, Dean Drako [3], mentioned that besides security concerns, video surveillance's important target is operations improvement within two years. Moreover the main benefit of a cloud-managed video surveillance system is off-site redundancy and flexible storage capacity. According to Axis Communications [4], IP-based video system usage noted down considerable impact on many applications other than security. Mainly retailers, who use the same, have seen positive impact on operations and merchandising.

Object tracking in video surveillance is a very important aspect of computer vision and pattern recognition. The common architecture of classification consists of three main steps: Motion segmentation, object tracking and classification. Kalman Filter is an estimator that uses measurements observed over time to produce estimates. It is having many applications in control, navigation, computer vision, etc. Main features of Kalman filter are prediction in object's future location, noise reduction, able to track single as well as multiple objects. In [5] it showed that the Kalman filter achieves the efficient tracking of multiple moving objects under the confusing situations. Particle filter can be applied to any state-space model and it also simplifies the traditional Kalman filter methods [6]. Optimal and suboptimal Bayesian algorithm was reviewed and focused mainly on particle filter. Along with particle filter, other forms like SIR, ASIR and RPF were introduced. A Mittal

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and L Davis [7] proposed a fully auto-mated multi-camera tracking method, using region based stereo algorithm that is capable of handling fully and partial occlusions caused by dense location of objects. J Ge, Y Luo and G Tei [8] in 2009, have introduced night vision for real time pedestrian detection and tracking from a moving vehicle. A system is cascade of three modules viz. ROI generation, object classification and tracking; each one taking help of visual features to differentiate the objects from the cluttered background. It has been observed that, single feature extractor fails to deal with combination of multiple image scenarios. To overcome this, ensemble method [9] is proposed to create synergistic approaches to compensate the individual inability of the component classifiers. We are discussing multiple methodologies for object tracking in later sections.

The paper is organized as follows. Section II and III focuses on object representation and feature descriptors. Section IV, covers the motion segmentation. A detailed analysis mentioned here with positive and negative aspects of different methods. Object classification with different types, tracking categorization into different groups with detailed analysis of related work mentioned in the later sections. Finally, we validate the performance, defining the problem domain and proposing our method followed by conclusion.

II. Object Representation

An object is an entity of interest that we have to track, such as birds, animals in forest or zoo, aeroplanes, vehicles for traffic controlling, human-beings walking at low or high speed. Objects can be represented by their shape and size. Fig. 1 shows the representation of object [10].

A. Points

An object can be characterised in terms of set of points that occupy small region of interest used for small area tracking purpose. Object may also be represented as a single point called as centroid of a person.

B. Geometric shapes

This is most suitable for simple rigid-objects. The shape of object can be represented as rectangle or ellipse, also used for non-rigid object tracking.

C. Object silhouette

The area inside the contour represents the silhouette of an object. Contour represents borderline of an object. Both contour and silhouette are used for complex non-rigid shape tracking.

D. Skeletal Model

Object skeletal used to model articulated and rigid objects. It can be extracted by medial axis transform, to object silhouette. Medial axis represents the distance to the boundary. Every point P in a region R finds the nearest neighbour in the boundary, and its point belong to medial axis of the region. It is used in modelling purpose for articulated and rigid objects.

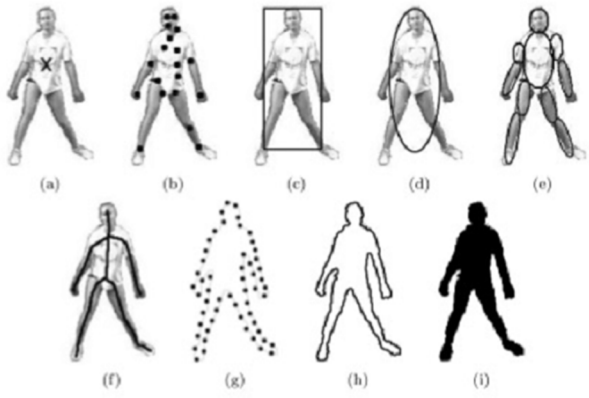

Fig. 1. Object representations [10] (a) Centroid, (b) multiple points, (c) rectangular patch, (d) elliptical patch, (e) part-based multiple patches, (f) object skeleton, (g) complete object contour, (h) control points on object contour, (i) object silhouette

A shape representation is combined with appearance feature of an object for tracking. The commonly used appearance features are listed below:

E. Probability density appearance model

This model is used in Gaussian mixture models and histogram. The probability density of image such as color, texture etc., can be computed from image regions.

F. Multiple-view object recognition

This approach models an object with the series of view; each view contains information about small range of viewing condition. The representation can be completed in two processes: one is sample images must be clustered into group that represents different view of an object. Second is the group members are widespread to form model-view characteristics.

G. Templates

Geometric shape represents a template, which contains both spatial and appearance information. It is mainly used for object tracking purpose.

III. Feature Descriptors

In image processing, a feature is in simple terms, a piece of information relevant for sorting out the computational task related to a specific application. Features may be specific structures related to the image like edges, points, objects, texture, etc. In complex scenarios sometimes only one type of feature may not give sufficient information of the image data, which results in two or more features to be extracted. Most of the color object tracking algorithms use HSI color of the object and are robust to lightning variations. The classification accuracy for color feature vectors is better while using RGB features, but these features are sensitive to lightning changes. Scale Invariant Feature Transform (SIFT) is used for extraction of local feature descriptors. SIFT is robust local invariant feature descriptor and designed mainly for gray images [11]. Edge features are found to be less sensitive to illumination changes than color descriptors. With the expense of additional computational time and processing steps texture features may also be used. A variety of more feature descriptors exists such as biological features, optical flow etc. Features are used to differentiate between foreground object and background object [12].

A. Color

In image processing RGB (red, green and blue) color feature space is used to represent color. The RGB space [13] uses combination of color and contour feature in particle filter based object tracking. Color is influenced by two physical factors which are spectral power distribution and surface reflectance properties. Hue, saturation (lightness) and value (brightness) (HSV) are the three components of HSV space is also one of the uniform color space but it is sensitive to noise [14].

B. Edges

Edge detection is used to identify changes in image intensity. As compared to color feature edges are less sensitive to illumination changes [10]. [15] States that it is used in 3-D model based algorithm which uses edge point as the feature selection. To track the boundary of an object edge feature is used.

C. Texture

It is used for surface variation and segmentation of image with properties such as smoothness and regularity. Image texture gives the information about spatial arrangement of colors. Two categories uses it they are region based and boundary based. The local binary pattern (LBP) texture is one of the famous pattern analysis for gray-scale images [16]. Some of the tracking based algorithm such as CAM Shift is based on LBP texture for moving object tracking [17].

D. Moment

A moment based region feature is used for object recognition and determine the gender of a strange person by walking appearance.

IV. Motion Segmentation

Object detection is a computer vision technology that deals with identifying instances of objects such as human, vehicle, animal or bird and other moving objects. Object detection is one of the initial steps for object tracking. State-of-art of object detection includes face detection and pedestrian detection. In computer vision object recognition means to identify the target host. Recognition is obtained by combining the features of an object and model of an object. The complexity of object recognition depends on several factors like scene constancy, number of objects in image and possibility of occlusion as shown in Fig. 2, etc.

A video surveillance system for stationary cameras generally includes some part of motion detection. Few approaches for motion segmentation are described herewith:

A. Background Subtraction

Background subtraction is a widely used approach for detecting moving objects from a static camera. Objects can be detected by finding the difference between the current frame and background frame. Background modelling can be categorised into two categories which are non-recursive and recursive techniques. For background estimation recursive technique includes frame differencing, median filter, linear predictive filter, and nonparametric model. Recursive technique is based on median filter, Kalman filter, and mixture of Gaussian.

Fig. 2. People undergoing partial occlusions

Halevi and Weinshall [18] proposed a fast algorithm based on disturbance map that is obtained by linearly subtracting the temporal average of the previous frames from the new frame. Tracking results have been provided using stabilized and moving cameras. In 1999 [19] proposed Wallflower algorithm to solve the problems that occur at a variety of spatial scale, images have been processed at pixel, region and frame-level. Heikkila and Silven [20], described camera based automated system based on Kalman filter in tracking and Learning Vector Quantization (LVQ) for classification to pedestrians and cyclists. In 2003 [21], a research continued in the field of automatic tracking and intruder-detection in a surveillance system. A tracking system includes background generation and subtraction method, can be affected by global intensity variations using a PTZ camera. The new region created when a camera view changes need to be updated for predefined images for detecting the object. H Galoogahi [22], proposed a method that handles the event such as object merging and splitting using forward and backward matching. Main focus on tracking a group by following some events such as entering, merging, splitting, leaving and corresponding between the set of objects RGB histogram is used for uninterrupted tracking process. Background modelling is the heart of background subtraction, mean filter and median filter are most popularly used to recognize background modelling. R Zhang and J Ding [23] used median filter to achieve the background image of a video and adaptive background subtraction method is used to detect and track moving object. A morphological filtering method [24] is used to remove the noise from the background and it results in clear and sharp image, at the end contour projection analysis is combined with shape analysis to remove the shadow of an object. In 2013 research paper [25], human motion detection and tracking for real time security system was formulated.

B. Temporal Differencing

Temporal differencing methodology is based on frame difference. With the help of difference of consecutive frames in a video sequence, this method detects the moving regions. This is highly adaptive to dynamic environments and computationally economical, but generally does a poor job of extracting the complete shapes of certain types of moving objects. It may also results in appearing small holes in moving

objects for which a resolution is mentioned in [26] when using temporal difference method.

C. Optical Flow

Optical flow is a vector-based method that estimates motion in video by matching points on objects over multiple frames. It is a vector field that describes the velocity of pixels in an image progression. In [27], using optical flow, a way of detecting obstacles in a mobile robot environment by separating them from the ground floor in an image sequence is proposed. The optical flow algorithm used to detect any possible movement pixels in the video image. Algorithm based on optical flow field and self-adaptive threshold segmentation is proposed in [28] to detect moving object area precisely.

V. Object Classification

Classification is a process in which individual items like objects, patters, image regions, pixels, etc are grouped based on the similarity between the item and the description of the group. In general, object classification in video surveillance, they are shape-based, motion-based, color-based and texture-based classifications.

A. Shape-Based Classification

Shape-based classification applies purely to the geometry of an object, not to the structural analysis. Depending upon geometry of the extracted regions like boxes, blobs, etc containing motion, objects can be classified. [29] Explores the study of various shape features with accuracy and performance measurements. T Zhao and R Nevatia [30] presented a method to track humans in crowded scene, with occlusion by making use of human shape models in addition to camera models. A combination of Bayesian framework and extension of the mean-shift tracking with shape model puts a principled approach to simultaneously detect and track humans. According to [31], shape-based classification is moderate in accuracy and computational time is also considerably low compared to other classification methods.

B. Motion-Based Classification

Motion-based classification [32] is helpful in reducing the reliance on the spatial primitives of the objects and offers a robust method for classification. It [33] does not require predefined pattern templates but it struggles to identify a non-moving object. Though motion-based classification is moderate in accuracy, this is computationally expensive way of classification. S Johnsen and A Tews [34] proposed a vision based system tracking and classifying objects. This is capable of handling occlusions and showed good results over multiple objects in varying weather conditions.

C. Color-Based Classification

Color space or color feature representation is the most efficient way to reveal the similarity of color image. Color is found to be somewhat constant and easy to acquire feature element compared to other features. In content-based image retrieval systems [14] the most efficient and simple searches are the color-based searches. In 2010 [35], a vision based moving object tracking system with wireless surveillance system has been proposed, based on color image segmentation and color histogram with background subtraction for tracking objects. Object occlusions were also removed by using Bhattacharya coefficients. According to [33] for color-based classification, both accuracy and computational time are high.

D. Texture-Based Classification

Assignment of unknown image to one of the known texture class in important objective of texture classification. In the existence of multiple classifiers, the key task is to develop extraction of effective features from textured image. Texture based classification consists of two phases viz. learning phase and the recognition phase. Texture-based methods such as histograms of oriented gradient (HOG) [36] use high dimensional features based on edges and use support vector machine (SVM) to detect human regions. As per [33], it gives improved quality of accuracy with the expense of additional computation time.

VI. Object Tracking

Tracking means to follow a particular object that is moving. In simple terms tracking is the problem of estimating the trajectory of an object in the image plane as it moves around a scene. Alternatively, a tracker assigns consistent labels to the tracked objects in different video frames. Depending upon tracking domain, method and algorithm, a tracker can also provide object centric information like area, orientation and shape of an object. Once objects are detected, the next task in video surveillance process is to track the objects from one frame to another. Tracking objects can be complex due to complex object shapes, object motion, non-rigid nature of object, scene illumination changes, partial or full object occlusions, etc. These can be simplified by a simple constraint like the object motion is smooth with no abrupt changes, prior knowledge about number, size of objects, object appearance and shape. There are various tools available for object tracking including Blob tracking, Kernel based tracking, feature matching, Kalman filter, the Condensation algorithm, the dynamic Bayesian network, the geodesic method, etc. Tracking procedures are mainly divided into types: region based tracking, active-contour-based tracking, feature-based tracking and model-based tracking.

A. Region-Based Tracking

Methodology works on tracking objects as per deviations of the image sections for moving objects. For our understanding, if we consider example of vehicle detection, it detects each vehicle blob using a cross correlation function. Based upon background subtraction, motion regions are typically identified by subtracting the background from the current image. M Kilger [37] used the same method in his study of real-time traffic monitoring system for detection of moving vehicles. It is difficult to detect the vehicles under congested traffic, because vehicles partly occlude with one another. In number of research methodologies, a Gaussian distribution of pixel values is used to model both human body and background scene. To detect person's body parts such as head, hand, etc. is a crucial part. C R Wren and Ali [38] came

with a solution to develop a real-time system called as pfinder (person finder) that solves the problem of single person using a fixed camera.

A combination of color and gradient information is used that is obtained from background subtraction method to deal with shadow and unpredictable color clues. To distinguish between the objects during occlusion color clues are used. Instead of using a human body method, [39] paper presents a color based tracking system. The visual parts depend on clothing of a person and vary with person's mode of dress. There are some situations like two objects have dressed similarly then the tracker will fail to track when they form a group.

B. Active Contour Based Tracking

Active Contour based tracking method track moving objects by representing their outlines as bounding contours and keep updating it dynamically. It reduced computational complexity compared to the region based detection. Paper [40] combines both motion information and appearance information to detect a pedestrian. Motion information can be extracted from chain of images. The benefit of these simple filters is their computation time is low as compared with other. [41] Uses counter based approach for which during occlusion the shape of an object is recovered by maintaining a shape-prior that is built online. To provide safety to drivers and to avoid accidents that is caused by dim rear light of lamps, a novel image processing technique [42] is used that deals with vehicle rear-lamp pair for detection and tracking. Lamps are symmetric and paired using a color cross-correlation symmetry analysis and tracked using Kalman filter.

C. Feature Based Tracking

This method targets detection and tracking with elements extraction, clustering and matching features of images. It tracks sub-features such as distinguishable points or lines on the object. Effectiveness of feature based tracking can be efficiently improved by adding common motion constraint. Partial occlusion problem may get resolved up to some extent with some of the sub-features remains visible. Polana and Nelson in [43] show the recognition of repetitive motion activity like walking can be accomplished by bottom-up processing. This repetitive motion activity is a very strong clue that the actor can be segmented, normalised and recognised. The activity recognition fails when rigid normalisation cannot be carried out.

VII. Problem Domain And Future Work

As explained detailed herewith in object tracking section, complexity increases with shape, size, orientation and variety of such factors. Challenges like, segmentation errors, difficulty in tracking complex objects like faces, etc., effect of change of lightning condition and shadows. There might be strong possibility of disturbance in object tracking due to other objects. To handle multiple structures and interaction between them from a noisy, irregular clustered data-set a unified computational framework is introduced called as tensor voting. It is a non-iterative method that handles the surface and curve inference from 2-D or 3-D point [44] [45]. Tensor voting is a robust method and as no limitation on surface topology. Fig. 3 explains the working of tracking process from object detection, recognising to object tracking. The input is in the form of video captured using a static camera. Stepwise process goes like detect object, recognise the object of interest, use of background subtraction method to extract foreground and providing bounding box. Color based modelling is done for each pixel which is termed as a tensor and voting process is carried out based on scale. The resulting tensor contains magnitude and orientation information. This is given as an input to Gaussian component that compares the color model in connecting frames. If the comparison is successful then object is tracked successfully but if matching is dissimilar then a new object has entered the scene.

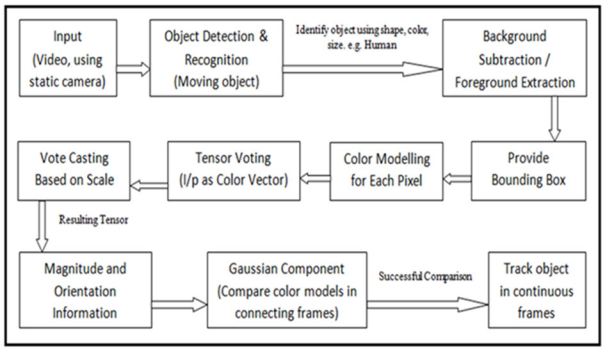

Fig. 3. Block diagram of object tracking using tensor voting framework

VIII. Conclusion

In this paper, we started with how objects can be represented with important feature descriptors. We explained tracking process in detail from detection and recognition with different approaches including background subtraction, temporal differencing and optical flow, till object tracking. In the later sections, we described object classification process with different categories, object tracking types such as region based, active contour based and feature based. Our further research will focus on to develop a color based tracking method which can deal with both partial and complete occlusion effectively by modelling color clothing using tensor voting framework.

References

[1] R. Jain, R. Kasturi and B. G. Schunck, "Machine Vision," McGraw-Hill, Inc., ISBN 0-07-032018-7, Chapter 15, pp. 459-491, 1995.

[2] M. Nieto, K. Johnston-Dodds and C. W. Simmons, "Public and Private Applications of Video Surveillance and Biometric Technologies," PhD, Research Paper, CRB 02-006, 2002.

[3] D. Drako, President and CEO, "Cloud Video Surveillance Report 2014," Eagle Eye Networks, 2014.

[4] Study: Retailers Use IP Video Surveillance for Loss Prevention Today, Business Performance Tomorrow, Chelmsford, Mass. And NRF BIG Show, NY (booth 943), Axis Communication, Jan. 14, 2013.

[5] X. Li, K. Wang, W. Wang and Y. Li, "A multiple object tracking method using Kalman filter," IEEE International Conference on Information and Automation, Harbin, pp 1862-1866, 2010.

[6] M. S. Arulampalam, S. Maskell, N. Gordon and T. Clapp, "A tutorial on particle filters for online nonlinear/non-Gaussian Bayesian tracking,"

IEEE Trans. on Signal Processing, Vol. 50, Issue 2, pp. 174-188, Feb 2002.

[7] A. Mittal and L. Davis, "M2tracker: A multi-view approach to segmenting and tracking people in a crowded scene," International Journal of Computer Vision, 51, pp. 189-203, 2003.

[8] J. Ge, Y. Luo and G. Tei, "Real-time pedestrian detection and tracking at nighttime for driver-assistance systems," IEEE Trans. on Intelligent Transportation Systems, Vol. 10, Issue 2, pp. 283-298, 2009.

[9] L. Oliveira, U. Nunes and P. Peixoto, "On exploration of classifier ensemble synergism in pedestrian detection," IEEE Trans. on Intelligent Transportation Systems, Vol. 11, Issue 1, pp. 16-27, 2009.

[10] A. Yilmaz, O. Javed and M. Shah, "Object tracking: A survey," ACM Computing Surveys, Vol. 38, No. 4, Article 13, 2006.

[11] A. E. Abdel-Hakim and A. A. Farag, "CSIFT: A SIFT descriptor with color invariant characteristics," IEEE Conference on Computer Vision and Pattern Recognition, Vol. 2, pp. 1978-1983, 2006.

[12] K. A. Joshi and D.G. Thakore, "A survey on moving object detection and tracking in video surveillance system," International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Vol. 2, Issue 3, July 2012.

[13] B. Pu, F. Zhou, X. Bai, "Particle filter based on color feature with contour information adaptively integrated for object tracking," Fourth International Symposium on Computational Intelligence and Design, Vol 2, pp. 359-362, 2011.

[14] S. Sergyn, "Color content-based image classification," 5th Slovakian-Hungarian Joint Symposium on Applied Machine Intelligence and Informatics, Poprad, Slovakia, Jan 2007.

[15] H. Yang, J. G. Lou, H. Z. Sun, W. M. Hu, and T. N. Tan, "Efficient and robust vehicle localization," in Proc. IEEE Int. Conf. Image Processing, Vol. 2, pp. 355-358, 2001.

[16] B. Deori and D. M. Thounaojam, "A survey on moving object tracking in video," International Journal on Information Theory (IJIT), Vol. 3, No. 3, July 2014.

[17] B. Karasulu and S. Korukoglu, "Moving object detection and tracking in videos," Performance Evaluation Software, SpringerBriefs in Computer Science, 2013.

[18] G. Halevi and D. Weinshall, "Motion of disturbances: detection and tracking of multi-body non-rigid motion," Proc. IEEE Conference on Computer Vision and Pattern Recognition, San Juan, pp. 897-902, 1997.

[19] K. Toyama, J. Krumm, B. Brumitt and B. Meyers, "Wallflower: Principles and practice of background maintenance," IEEE International Conference on Computer Vision, Kerkyra, Vol. 1, pp. 255-261, 1999.

[20] Heikkila J and Silven O, "A real-time system for monitoring of cyclists and pedestrians,"Visual Surveillance, IEEE Workshop on Visual Surveillance, pp. 74-81, 1999.

[21] S. Kang, J. Paik, A. Koschan, B. Abidi and M. A. Abidi, "Real-time video tracking using PTZ cameras," Proc. of SPIE 6th International Conference on Quality Control by Artificial Vision,, Vol. 5132, pp. 103-111, Gatlinburg, TN, 2003.

[22] H. K. Galoogahi, "Tracking groups of people in presence of occlusion," IEEE, Fourth Pacific-Rim Symposium on Image and Video Technology, Singapore, pp. 438-443, 2010.

[23] R. Zhang, J. Ding, "Object tracking and detecting based on adaptive background subtraction," International Workshop on Information and Electronics Engineering (IWIEE), Procedia Engineering 29 (2012) 1351-1355, 2012.

[24] R. S. Rakibe, B. D. Patil, "Background subtraction algorithm based human motion detection," International Journal of Scientific and Research Publications, Vol. 3, Issue 5, ISSN 2250-3153, 2013.

[25] R. Shaalini, C. Shanmugam, R. N. Kumar, G. Myilsamy, and N. Manikandaprabu, "Human motion detection and tracking for real-time security system," International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 3, Issue 12, 2013.

[26] W. Shuigen, C. Zhen, L. Ming and Z. Liang, "An improved method of motion detection based on temporal difference," IEEE International Workshop on Intelligent Systems and Applications, Wuhan, pp. 1-4, 2009.

[27] C. Braillon, C. Pradalier, J. L. Crowley and C. Laugier, "Real-time moving obstacle detection using optical flow models," IEEE Conference on Intelligent Vehicles Symposium, Tokyo, Japan, pp. 466-471, 2006.

[28] S. Wei, L. Yang, Z. Chen, Z. Liu, "Motion detection based on optical flow and self-adaptive threshold segmentation," Advanced in Control Engineering and Information Science, Procedia Engineering, Vol. 15, pp. 3471-3476, 2011.

[29] R. N. Hota, V. Venkoparao and A. Rajagopal, "Shape based object classification for automated video surveillance with feature selection," IEEE, 10th International Conference on Information Technology, Orissa, pp. 97-99 Dec 2007.

[30] Y.-T. Tsai, H.-C. Shih, and C.-L. Huang, "Multiple human objects tracking in crowded scenes," IEEE Conference on Pattern Recognition, Vol. 3, pp. 51-54, 2006.

[31] J.-Y Lee and W. Yu, "Visual tracking by partition-based histogram back projection and maximum support criteria," IEEE Conference on Robotics and Biomimetics, pp. 2860-2865, Dec 2011.

[32] O. Javed and M. Shah, "Tracking and object classification for automated surveillance".

[33] H. S. Parekh, D. G. Thakore and U. K. Jaliya, "A survey on object detection and tracking methods," International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 2, Feb 2014.

[34] S. Johnsen and A. Tews, "Real-time object tracking and classifcation using a static camera," Proc. of the IEEE ICRA 2009 Workshop on People Detection and Tracking Kobe, Japan, May 2009.

[35] T. Mahalingam and M. Mahalakshmi, "Vision based moving object tracking through enhanced color image segmentation using Haar classifiers," IEEE Conference on Trendz in Information Sciences and Computing, pp. 253-260, Dec 2010.

[36] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," IEEE Conference on Computer Vision and Pattern Recognition, Vol. 1, pp. 886-893, Jun 2005.

[37] M. Kilger, "A shadow handler in a video-based real-time traffic monitoring system," IEEE Workshop on Applications of Computer Vision, pp. 11-18, 1992.

[38] C. R. Wren, A. Azarbayejani, T. Darrell and A. P. Pentland, "Pfinder: real-time tracking of the human body," IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 19, Issue 7, pp. 780-785, 2002.

[39] S. J. McKenna, S. Jabri, Z. Duric, H. Wechsler and A. Rosenfeld, "Tracking groups of people".

[40] P. Viola, M. Jones and D. Snow, "Detecting pedestrians using patterns of motion and appearance," Mitsubishi Electric Research Laboratories, TR2003-90, 2003.

[41] A. Yilmaz, L. Xin and M. Shah, "Contour-based object tracking with occlusion handling in video acquired using mobile cameras," IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 26, Issue 11, pp. 1531-1536, 2004.

[42] R. O'Malley, E. Jones and M Glavin, "Rear-lamp vehicle detection and tracking in low-exposure color video for night conditions," IEEE Trans. on Intelligent Transportation Systems, Vol. 11, Issue 2, pp. 453-462, 2010.

[43] R. Polana and R. Nelson, "Low level recognition of human motion (or How to get your man without finding his body parts)," Proc. of IEEE Workshop on Motion of Non-Rigid and Articulated Objects, pp. 77-82, 1994

[44] G. Medioni, C. -K. Tang and M. -S. Lee, "Tensor voting: theory and applications".

[45] P. Mordohai and G. Medioni, "Dimensionality estimation, manifold learning and function approximation using tensor voting," Journal of Machine Learning Research 11, pp. 411-450, 2010.