STM JOURNALS

Journal of Artificial Intelligence Research & Advances

Volume 1, Issue 3
www.stmjournals.com

Video Surveillance and Object Tracking: A Survey

Akriti Sahu*, Rajesh Tiwari
Department of Computer Science, Shri Shakracharya Technical Campus (SSCET),
Junwani, 490009, Chhattisgarh, India

Abstract

The multiple object tracking from video sequences has been an open research question for so many years. It remained a demanding research for the tracking of motion and simultaneous object detection within a domain range of image processing and computer vision. The tracking methodologies involve object segmentation, background subtraction, feature descriptors like mean-shift, particle filter. Thus, the performance of such tracking methods varies with the computational complexity which relies on the background information. This paper puts forth a detailed survey of the state of the art attempts made in the direction with their positive and negative aspects.

Keywords: *background modeling, feature descriptor, object tracking, computer vision*

****Author for Correspondence*** E-mail: akriti.sahu08@gmail.com

INTRODUCTION

The importance of object tracking in video surveillance is to determine the motion trajectory of the object from the propagating frames of the video sequence while extracting information from each of the subsequent frames. Thus, the scenario of tasks involving with the object detection and its correspondence between several instances can be achieved jointly or separately, where the object detection algorithm extracts the features of the objects and in object correspondence algorithm the same object is performed separately on the subsequent frames. However, in the latter case the detection of object region and its correct estimation in moving frames is achieved jointly through iterative updating of object location.

The object detection and motion tracking has an emerging demand of application in automated video surveillance. Object tracking is a challenging research question in computer vision for real time videos sequences, where the performance and effectiveness of the applied method are directly proportional to the employed detection and tracking process. A general scheme of such process is outlined in Figure 1. Though there are several existing methods to accomplish the goal but these methods are categorized into three principal process of motion tracking, namely: contour-based models, region-based models and feature point-based models.

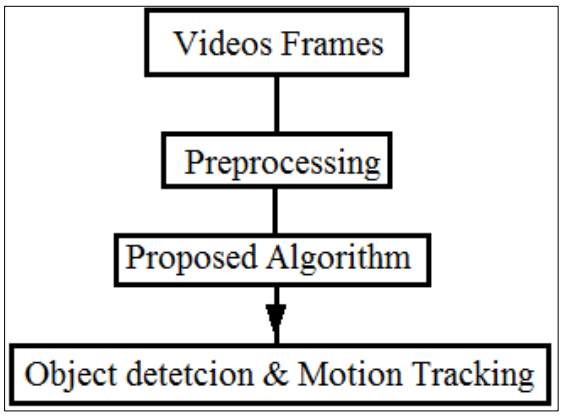

Fig. 1: *An Illustration of Typical Motion Tracking and Object Detection Algorithm in a Video Sequence.*

Contour-based Object Tracking Model

Contour based object tracking models are sued to extract the active contours outline from an image [1]. This method tracks the motion by dynamic update successively in frames of a video sequence. The discrete variants of this type of method are portrayed in active contour model. It offers an advantage from the point distribution model in order to limit the geometrical outline of the object. Though this method is highly sensitive to the initialization of tracking, this makes it difficult to automate the whole tracking process with it.

Region-based Object Tracking Model

In this model of object tracking, the emphasis is on color distribution of the requisite object to be tracked [2, 3]. Objects are represented based on its color variants. It gives high performance result for discrete color objects though there is a decline in its effectiveness when several objects move together in the sequences of video frames. Also, it is not possible for tracking of multiple objects accurately where the objects move due to occlusion, as the object tracking is dependent over the modeled background for the extracted outlines of the tracking object.

Feature Point-Based Tracking Algorithm

In this type of tracking method, the sets of feature points are required to describe the object geometrical interpretation [4, 5]. Feature point-based tracking algorithm involves three key steps. Firstly, the object is recognized through extraction of the key elements from it. Secondly, it involves the process of clustering them into a higher level.

The last step is to perform matching of this feature that has been earlier extracted between successive frames in a videos sequence. Thus, feature extracting and feature correspondence is the principle element in this type of object tacking method. The challenge in this type of technique relies with the feature correspondence as the probability of occurrence of the feature point in one image is higher to correlate with the other similar points in another image and thereby causing ambiguity.

LITERATURE SURVEY

Contour Based Object Tracking

Xu and Ahuja proposed a contour based tracking algorithm to determine the object location, geometrical representation, and tracking it in a video sequence [6]. In this algorithm, the segmentation of active contours is achieved using graph-cut method; followed by initialization of resultant contours in each of the subsequent frames. The contours of the new object are determined through and derived from the difference between intensity values of the current and previous frame. Dokladal proposed a contour-based model for the solution of the problem of tracking the driver's face by using a combination of weighted gradient of features and contour of the objects [7]. In this method for achieving the segmentation, they calculated the gradient of the given current frame; latter they also carried out the computational experiments with gradient-based attraction field for the tracking of objects. However, in another study carried out by Chen the model is implemented with neural-fuzzy network to compute object's feature vectors [8].

Here, in this method for training and recognizing of motion vectors, a self-constructing neural-fuzzy hybrid network is used where the network is trained through the data taken from the histogram of silhouette of a human posture both vertical and horizontal projection only to latter transform it by using Discrete Fourier Transformation (DFT). Chen suggested an object tracking technique where it is divided into two stages [9]. In the first step, kernel based method is adopted to determine the object location and thereby enhancing the robustness of the tracking algorithm by partially eliminating the problems posed by partial occlusions, clutter etc.

In the next step, they employed contour-based method using Kalman filter and Bhattacharya coefficient is evaluated to initialize target position in order to precisely localize and predict the target location. Zhou *et al.*, employed color features in integration with the contour information in the particle filter for their multi-hypothesis based object tracking algorithm [10]. Here, for contour detection they had used sobel operator with the shape similarity which is deterministic from the sample position and observing position by adding the inherited matching points. In the study of Ling *et al.*, the object's approximate location is determined from the multi-feature fusion strategy [11]. For high accuracy and robustness of their tracking algorithm, they used the region-based contour extraction of the objects by evaluating the color histogram and article filter is implemented through Harris corner features fusion method. This model of applied in the steps involved with detection of contours while giving a resultant of rough location of tracked object. Also, this method is known by the name of region-based temporal differencing object tracking algorithm.

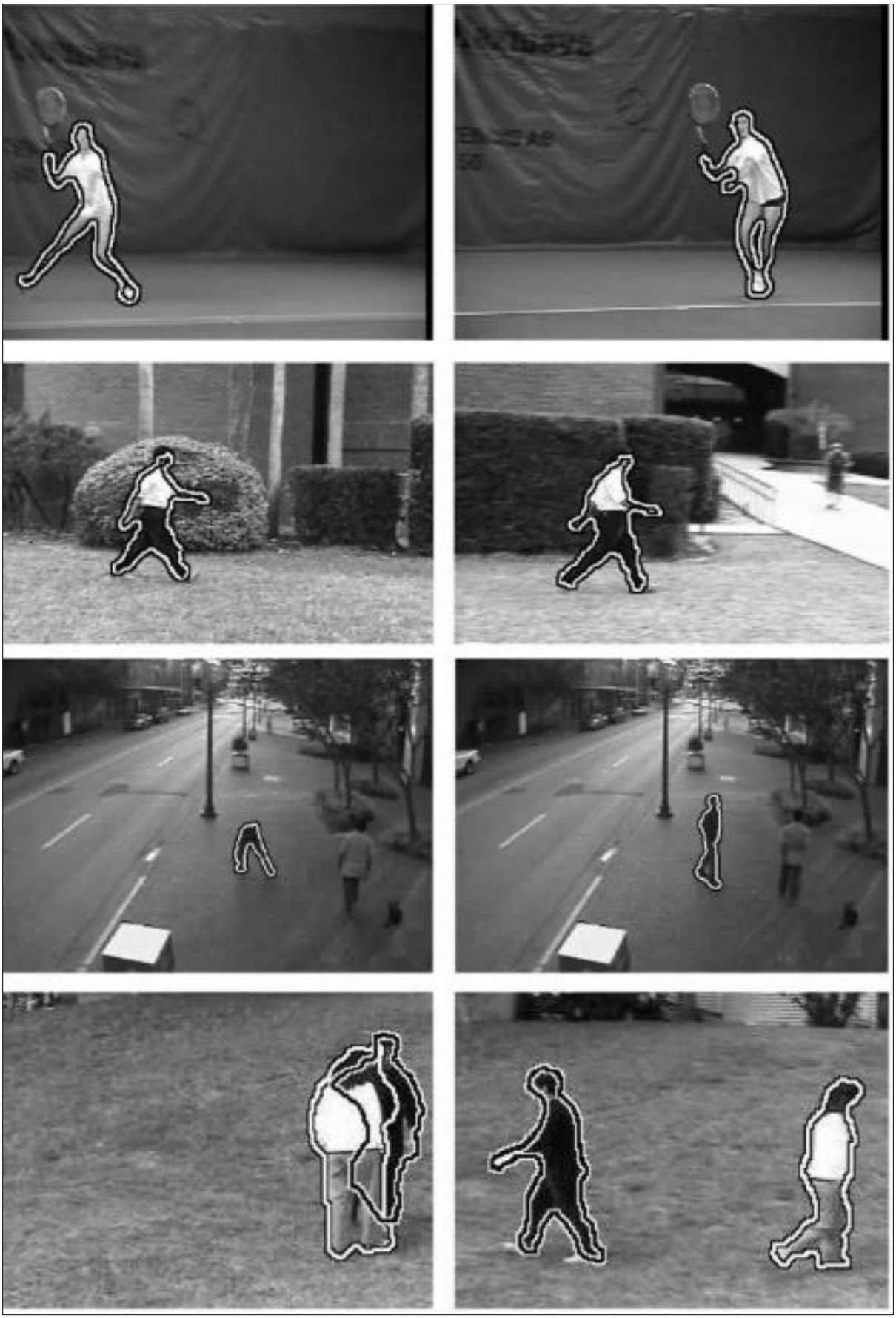

Fig. 2: *Contour-based Object Tracking Algorithm.*

Hue *et al*. proposed an effective model for contour-based object detection which integrates different models such as tracking initialization algorithms, color-based evolving contours and adaptive shape based contour evolution and Markov model-based detection of optical flow [12]. Wherein, the color-based evolution algorithm is correlated between the neighboring pixels for estimating the values influenced with posterior probability from Markov Random field (MRF) which is incorporated into the probability of segmentation. Its adaptive shape-based contour evolution algorithm combines the features of the colors alone and shape prior to obtain the final contour making the updation of contours flexible to varying conditions or periodical motions. Rajabi & Nahvi proposed a framework for multi-object tracking using point process technique [13]. This, model is implemented for tracking the people in indoor locations by using Gaussian Mixture Model (GMM) for modeling of background estimation.

Feature-Based Tracking

In Lie *et al.*, the study was proposed for determination of object localization using corner feature using Adaptive Kalman Filter [14]. In order to computationally representing moving objects corner features are employed whereupon the variation in corner points automatically adjusted the parameters of Kalman filters in each consecutive fame sequences. In Xue *et al.*, the discriminative features are used which is determined from the background separation through a voting strategy [15]. However, latter similar approaches of object tracking are improved with the implementation of mean-shift algorithm. Latter Yang *et al.* put forward a framework based on Forward Looking Infrared (FLIR) imagery where the dependency of it is relied over mean-shift algorithm and feature matching step using Harris detector to extract template-based object area [16]. Also, they had success in improving Hausdroff distance to determine the similarity of feature points. Aibin *et al.* presented a self-adaptive algorithm which is based on the center of target location and Normalized Moment of Inertia (NMI) feature are combined to track the objects in real time [17].

While in Rahman *et al*. the improved study is presented for tracking method for both single object and multi-object tracking, where the movements can be fast or slow [18, 19]. As the method is based on background subtraction and feature matching through SIFT features. Herein, the object is detected through the background subtraction and matching of motion features from SIFT features aiding detection and tracking of the object. Fazli *et al*. proposed a new framework for the object detection and tracking which is a combination of SIFT feature and combinations of color features with particle filter [20]. Local feature vector is derivable from the transformation of the image, though the local feature vectors are invariant of scaling of images, its rotation and the changes in illumination field. In the study presented by Bai, the novel object tracking algorithm relies over Mean Shift and an on-line feature selection [21]. In this method, the 4-D state space of the target space is defined for features which are dependent over the color pixel values in R, G & B. The most prominent feature space distinguishable for object and background scenes is detected for tracking. Also, Kalman filter is used to achieve the state estimation of the tracking objects. Mia *et al*. proposed a novel process for object tracking through on-line boosting by adaptive for the matching of key points in the consequent frame sequence [22]. Fan *et al*. presented a robust method for real-time processing at mobile devices which holistically uses Harr like features with an aid of online features updating scheme integrated with color filters [23].Combining background information-based block matching for feature extraction and motion detection is achieved through Shape Control Points (SCPs) by detecting edges in the neighboring directions [24, 25]. It has eliminated the inaccuracy posed by block matching algorithm with an aid of adaptive method of background generation. There was also a method which stores the geometrical appearance of the object as templates as a candidate for matching the similar object in the subsequent frames [26]. In this study, it was shown that the feature-based method for object detection can be stretched to non-planar objects with pose variation by adding and switching templates through online strategy of updation with the encounter of new objects.

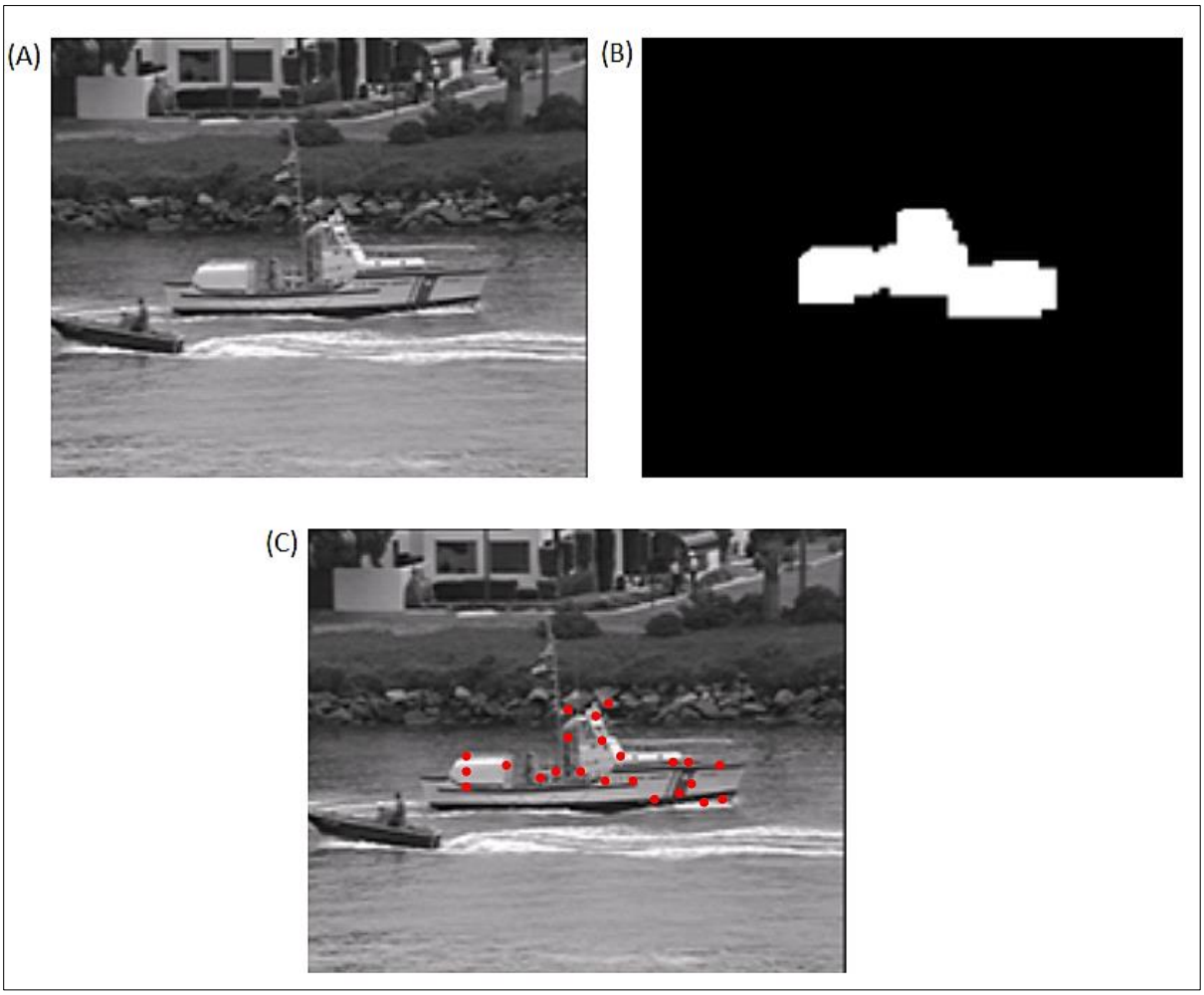

Fig. 3: *An Illustrative Example of Feature-based Tracking for the Cost Guar Sequence Depicted in (A), (B) Feature Mask of the Given Sequence (C) Tracked Feature Points of the Detected Feature of the Given Frame.*

In another study by Alvarez and Regazzoni, they implemented the feature-based model with sparse shape points for the data association and sampling through particle filters [27]. Additionally, this particle filter helps them in estimating the velocity of the object and its position. There were other algorithms that were implemented with the nearest neighbor classifier with the mean shift algorithm in regression to achieve a balance of object tracking for the weighted features through Monte Carlo simulation and Markov Chain-based model for location prediction in the subsequent frames of the video sequences [28–32].

Region-Based Tracking

Xu *et al*. proposed a supervised object segmentation technique where the user input for the geometrical outline is considered as video object for region-based segmentation [33]. Though, active contour model is also employed for contour fine-tuning. Gu & Lee used background region-based classification [34]. It consists of five steps pre-processing of region, extraction of region, motion estimation based on region, region classification and post processing of the region; as all are formed using a combination of morphological segmentation tool with human assistance. Hariharakrishnan and Schonfeld avoid segmentation because of the initialization of object partition [35, 36]. Here, tracking is achieved through block motion vectors by updating object contours. In Andrade *et al*., a novel technique is proposed using region-based descriptors to partition the homogenous regions of the image in series [37]. In another study, object tracking consist of two trackers, i.e., Adaboost-based global color feature

selection and K-means clustering for pixel-wise tracking and region-wise tracking [38]. There were other techniques that propose the hybrid of the above models using color region tracking and other statistical methods [39–41]. Wu *et al*. introduced a 3D tracking model [42]. This model can extract motion while not relying on motion trajectory under controlled environment. They developed two algorithms for motion-based segmentation and region-based mean shift tracking while fussing the two by using Karman filter. There were also a few supervised learning-based background subtraction methods that are also attempted for object detection and tracking [43–54]. For such methods, the techniques based on classification problem is mainly used the resolve the problem by generating a function that maps inputs and desired output for a given learning problem [55–58].

Fig. 4: *An Illustrative Sample of Region-based Object Tracking in Context of Face Recognition and Gesture Recognition.*

CONCLUSION

In this article, we present an outline of literature survey for object tracking approaches attempted in the past and also give a brief review of related principal topics. Herein, we'd divided the object tracking techniques into three categories, contour, region and feature-based techniques. The tracking of object is divided into two fragments, i.e., object detection and a strategy for motion tracking. We expect that the rich theoretical contents of this survey will give valuable contribution in warping up the present work in one documentation to easily avail the literature to the other researchers and encourage new research.

REFERENCES

1. Serby D, Meier EK, Gool LV. "Probabilistic Object Tracking Using Multiple Features", *IEEE Proc. of International Conf on Pattern Recognition Intelligent Transportation Systems*. 2004; 6: 43-53p.
2. Li L, Ranganath S, Weimin H, Sengupta K. "Framework for Real-Time Behavior Interpretation from Traffic Video." *IEEE Tran. On Intelligen Transportation Systems*. 2005; 6(1): 43-53p.
3. Kumar P, Weimin H, Gu IU, Tian Q. "Statistical Modeling of Complex Backgrounds for Foreground Object Detection." *IEEE Trans. On Image Processing*. Nov. 2004; 13(11): 43-53p.
4. Zivkovi Z. "Improving the selection of feature points for tracking." *In Pattern Analysis and Applications*. Copyright Springer-Verlag London Limited, 2004; 7(2).
5. Lou J, Tan T, Hu W, Yang H, Maybank SJ. "3D Model-Based Vehicle Tracking." *IEEE Trans. on Image Processing*. Oct. 2005; 14: 1561-9p.
6. Xu N, Ahuja N. 'Object contour tracking using graph cuts based active contours.' *Proceedings of International Conference on Image Processing.* 2002; 3: 277-80p.

7. Dokladal P, Enficiaud R, Dejnozkova E. 'Contour-based object tracking with gradient-based contour attraction field.' *Proceedings of EEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP '04)*. 2004: 17-20p.
8. Chen T. 'Object Tracking Based on Active Contour Model by Neural Fuzzy Network', *Proceedings of IITA International Conference on Control Automation and Systems Engineering*. 2009; 570-4p.
9. Chen Q, Sun QS, Heng PA, Xia DS. 'Two-Stage Object Tracking Method Based on Kernel and Active Contour.' *IEEE Transactions on Circuits and Systems for Video Technology*. 2010: 605-9p.
10. Pu B, Zhou F, Bai X. 'Particle Filter Based on Color Feature with Contour Information Adaptively Integrated for Object Tracking.' *Fourth International Symposium on Computational Intelligence and Design*. 2011; 359-62p.
11. Lu X, Song L, Yu S, Ling N. "Object Contour Tracking Using Multi-feature Fusion based Particle Filter." *Proceedings of IEEE Conference on Industrial Electronics and Applications (ICIEA)*. 2012: 237–42p.
12. Hu W, Zhou X, Li W, Luo W, Zhang X, Maybank S. 'Active Contour -Based Visual Tracking by Integrating Colors, Shapes, and Motions.' *IEEE Transactions on Image Processing*. 2013; 22(5): 1778–92p.
13. Rajabi H, Nahvi M. 'Modified contour-based algorithm for multiple objects tracking and detection.' *Proceedings of 3th International eConference on Computer and Knowledge Engineering (ICCKE)*. 2013: 235-9p.
14. Li N, Liu L, Xu D. Corner feature based object tracking using Adaptive Kalman Filter, Signal Processing, 2008. *ICSP 2008. Proceedings of 9th International Conference*. 2008: 1432–5p.
15. Xue C. Image Process. Lab., CAS, Changchun ; Ming Zhu; Ai-hua Chen, A Discriminative Feature-Based Mean-shift Algorithm for Object Tracking, Knowledge Acquisition and Modeling Workshop, 2008. KAM Workshop 2008. *IEEE International Symposium.* 2008: 217–20p.
16. Yang W, Li J; Liu J, Shi D. A Novel Layered Object Tracking Algorithm for Forward-looking Infrared Imagery Based on Mean Shift and Feature Matching, Computer Science and Information Technology, 2009. *ICCSIT 2009. Proceedings of 2nd IEEE International Conference*. 2009: 188–191p.
17. Aibin C, Zixing C, Deyi D. An Image Tracking Algorithm Based on Object Center location and Image NMI Feature, Fuzzy Systems and Knowledge Discovery, 2009. *FSKD '09. Proceedings of Sixth International Conference*. 2009; 5: 359–63p.
18. Rahman MS, Saha A, Khanum S. "Multi-Object Tracking in Video Sequences Based on Background Subtraction and SIFT Feature Matching", Computer Sciences and Convergence Information Technology, 2009. *ICCIT'09 Proceedings of Fourth International Conference*. 2009: 457–62p.
19. Fazli S, Pour HM, Bouzari H. Particle Filter based Object Tracking with Sift and Color Feature, Machine Vision, 2009. *ICMV '09. Proceedings of the Second International Conference*. 2009: 89–93p.
20. Bai KJ. A new object tracking algorithm based on Mean Shift in 4-D State Space and On-line Feature Selection, *Information and Computing (ICIC), 2010 Third International Conference*. 2010: 39–42p.
21. Miao Q, Wang G, Lin X, Wang Y. Scale and rotation invariant feature based object tracking via modified on-line boosting , *Image Processing (ICIP), 2010 17th IEEE International Conference*. 2010: 3929–32p.
22. 22 Fan L, Riihimaki M, Kunttu I. A feature-based object tracking approach for realtime image processing on mobile devices *Image Processing (ICIP), 2010 17th IEEE International Conference*. 2010: 3921–4p.
23. Kim T, Lee S, Paik J. Combined shape and feature-based video analysis and its application to non-rigid object tracking, *IET Image Processing*. 2011; 5(1): 87–100p.

24. Fan L. "A Feature-based Object Tracking Method Using Online Template Switching and Feature Adaptation, *Image and Graphics (ICIG), 2011 Sixth International Conference*. 2011: 707–13p.
25. Alvarez MS, Regazzoni CS. 'Extended feature-based object tracking in presence of data association uncertainty." *Proceedings of International Conference on Advanced Video and Signal-Based Surveillance (AVSS), 8th IEEE*. 2011: 136–41p.
26. Biresaw TA. Online failure detection and correction for Bayesian sparse feature-based object tracking, *Advanced Video and Signal-Based Surveillance (AVSS), 8th IEEE International Conference*. 2011: 320–4p.
27. Oh CM, Lee CW, Lee GS. 'Multi-Part SIFT feature based particle filter for rotating object tracking', *Informatics, Electronics & Vision (ICIEV), International Conference*. 2012: 1016–20p.
28. Shen HY, Sun SF, Ma XB, Xu YC, Lei BJ. 'Comparative study of color feature for particle filter based object tracking.' *Proceedings of International Conference on Machine Learning and Cybernetics (ICMLC)*. 2012: 1104–10p.
29. Xiao Q, Liu X, Liu M. 'Object Tracking Based on Local Feature Matching Computational Intelligence and Design (ISCID), *2012 Fifth International Symposium*. 2012; 1: 399–402p.
30. Mahendran S, Vaithiyanathan D, Seshasayanan R. 'Object tracking system based on invariant features' *Proceedings of International Conference on Communications and Signal Processing (ICCSP)*. 2013: 1138–42p.
31. Ning J, Yu W, Yang S. An active contour tracking method by matching for ground and background simultaneously, 2013.
32. Liu Y, Lu Y, Shi Q, Ding J. 'Optical Flow Based Urban Roawd Vehicle Tracking, *Computational Intelligence and Security (CIS), 2013 9th International Conference*. 2013: 391-5p.
33. Xu D, Hwang JN, Yu J. 'An accurate region based object tracking for video sequences', *IEEE 3rd Workshop Multimedia Signal Processing*. 1999: 271-6p.
34. Chuang G, Ming-Chieh L. 'Semantic video object tracking using region-based classification, *International Conference on Image Processing (ICIP'98)*. 1998; 3: 643p.
35. Hariharakrishnan K, Schonfeld D. "Fast object tracking using adaptive block matching" *IEEE Transactions on Multimedia*. 2005; 7 (5): 853–9p.
36. Andrade EL, Woods JC, Khan E, Ghanbari M. Region-based analysis and retrieval for tracking of semantic objects and provision of augmented information in interactive sport scenes. *IEEE Transactions on Multimedia*. Dec. 2005; 7 (6): 1084-96p.
37. Wei FT, Chou ST, Lin CW. 'A region-based object tracking scheme using Adaboost-based feature selection.' *IEEE International Symposium on Circuits and Systems*. 2008; I: 2753–6p.
38. Kim HB, Sim KB. 'A particular object tracking in an environment of multiple moving objects.' *Proceedings of International Conference on Control Automation and Systems (ICCAS)*. 2010: 1053–6p.
39. Khraief C, Bourouis S, Hamrouni K. Unsupervised video objects detection and tracking using region based level-set. *Proceedings of International Conference on Multimedia Computing and Systems (ICMCS)*. 2012: 201–6p.
40. Varas D, Marques F. 'A region-based particle filter for generic object tracking and segmentation', *Proceedings of 19th IEEE International Conference on Image Processing (ICIP)*. 2012: 1333–6p.
41. Kumar S, Narayanan MS, Singhal P, Corso JJ, Krovi V. "Product of tracking experts for visual tracking of surgical tools." *Proceedings of IEEE International Conference on Automation Science and Engineering (CASE)*. 2013: 480–5p.
42. Wu X, Mao X, Chen L, Compare A. "Combined Motion and Region-Based 3D Tracking in Active Depth Image Sequence." *Green Computing and Communications (GreenCom), 2013 IEEE and Internet of Things (iThings/CPSCom), IEEE International Conference on and IEEE Cyber, Physical and Social Computing*. 2013: 1734–9p.

43. Yilmaz A, Javed O, Shah M. "Object Tracking: A Survey." *ACM Computing Surveys*. 2006; 38(4).
44. Yang WB, Fang B, Tang YY, Shang ZW, Li DH. "Sift features based object tracking with discrete wavelet transform." *Proceedings of International Conference on Wavelet Analysis and Pattern Recognition, ICWAPR. 2009:* 380-5p.
45. Yang H, Shao L, Zheng F, Wangd L, Song Z. "Recent advances and trends in visual tracking: A review." *Elsevier Neurocomputing*. 2011; 74 : 3823–31p.
46. Yi F, Moon I. "Image Segmentation: A Survey of Graph-cut Methods." *Proceedings of International Conference on Systems and Informatics (ICSAI 2012),* 2012.
47. Shi J, Malik J. Normalized cuts and image segmentation. *IEEE Trans. Patt. Analy. Mach. Intell*. 2000; 22(8): 888–905p.
48. Comaniciu D, Meer P. Mean shift: A robust approach toward feature space analysis. *IEEE Trans. Patt. Analy. Mach. Intell*. 2002; 24(5): 603–19p.
49. Pham V, Vo P, Thanh HV, Hoai BL. "GPU Implementation of Extended Gaussian Mixture Model for Background Subtraction." *IEEE-RIVF 2010 Proceedings of International Conference on Computing and Telecommunication Technologies*. Nov. 01-4, 2010.
50. Stauffer C, Grimson W. Learning patterns of activity using real time tracking. *IEEE Trans. Patt. Analy. Mach. Intell*. 2000; 22(8): 747–67p.
51. Rittscher J, Kato J, Joga S, Blake A. A probabilistic background model for tracking. In *European Conference on Computer Vision (ECCV)*. 2000; 2: 336–50p.
52. Stenger B, Ramesh V, Paragios N, Coetzee F, Burmann J. Topology free hidden markov models: Application to background modeling. In *IEEE International Conference on Computer Vision (ICCV)*. 2001: 294–301p.
53. Viola P, Jones M, Snow D. Detecting pedestrians using patterns of motion and appearance. In *IEEE International Conference on Computer Vision (ICCV).* 2003: 734–41p.
54. Papageorgiou C, Oren M, Poggio T. "A general framework for object detection". In *IEEE International Conference on Computer Vision (ICCV).* 1998: 555–62p.
55. Tanizaki H. "Non-gaussian state-space modeling of nonstationary time series." *J. Amer. Statist. Assoc.* 1987; 82: 1032–63p.
56. Isard M, Blake A. "Condensation - conditional density propagation for visual tracking. *Int. J. Comput. Vision.* 1998; 29(1): 5–28p.
57. Ziani D. "Feature Selection on Boolean Symbolic Objects." *Int J of Comput Sci and Info Technol (IJCSITY).* 2013; 1(4).
58. Choi Y, Sharifahmadian E, Latifi S. "Performance analysis of contourlet-based hyperspectral image fusion methods." *Int J on Info Theory (IJIT).* Oct. 2013; 2(1/2/3/4).