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Survey on Pedestrian Detection, Classification and Tracking

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Abstract— **Detection of human beings with accuracy in visual surveillance systems is important for various application areas like remote and mobile monitoring, traffic monitoring, public safety and abnormal event detection. The first step in detection process is to detect the object which is in motion and further classify it and track the objects. The paper further directs towards the detection and tracking of humans, so called pedestrians and a comprehensive review on the available techniques for Pedestrians in surveillance videos is presented in this paper.**

Keywords: **Object detection, Object tracking, pedestrian detection and Background subtraction.**

I. INTRODUCTION

Performance of an automated visual surveillance system is dependent on its ability to detect moving objects. A consecutive actions like detecting the objects, tracking the objects and analysing their motion, should be accurate. In Every tracking method, an object detection mechanism is essential either in every frame or when the object first appears in the video. The most commonly used method for object detection is to use information in a single frame, where in the video is divided into multiple sequences of frames. Some object detection methods use temporal information computed from a sequence of frames which reduces the chance of false detections [1].

The first step in many computer vision applications like event detection, robotics and video surveillance is identifying region of interest. An object detection algorithm is desirable, but extremely difficult to handle unknown objects or objects with significant variations in color, shape and texture. That is the reason many practical computer vision systems assume a fixed camera environment, which makes the object detection process much simpler [3]. An image from video sequence is divided into two complimentary sets of pixels. The first set comprises the pixels which correspond to foreground objects whereas the second set contains the background pixels. This output is represented as a binary image or as a mask. It is difficult to specify an absolute standard with respect to what should be identified as foreground and what should be marked as background because this definition is somewhat application specific. Generally, foreground objects are moving objects like people, cars and boats and everything else is background [11].

Basic steps for tacking an object are:

A. Object Detection

It identifies objects of interest in the video sequence and clusters pixels of these objects. Object detection can be done by different techniques such as optical flow, Background subtraction and frame differencing.

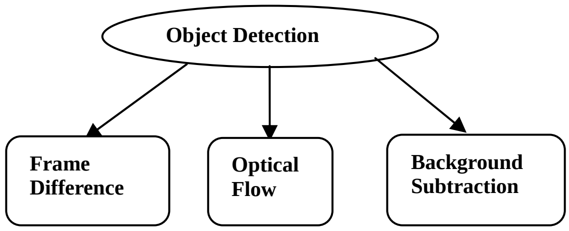

Fig 1a: Object detection [15]

B. Object Classification

Object can be classified as vehicles, birds, floating clouds and other moving objects. Different approaches to classify the objects are Shape-based classification, Color based classification, Motion-based classification, and texture based classification.

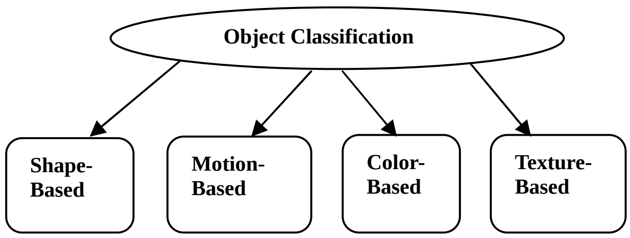

Fig 1b: Object Classification [15]

C. Object Tracking

Tracking, defined as the problem of approximating the path of an object in the image plane as it moves around a scene. The methods to track the objects are point tracking, kernel tracking and silhouette. Following are some of the challenges that should be taken care in object tracking [10] [15]

1. Loss of evidence affected by estimation of the 3D realm on a 2D image,
2. Imperfect and entire object occlusions
3. Difficult object motion,
4. Noise in an image
5. Complex objects structures.

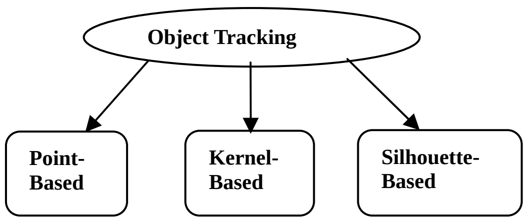

Fig 1b: Object Classification [15]

II. RELATED WORK

Tracking and detecting objects in video surveillance is quite complex. It also recognizes an object in video surveillance. There are few environment factors like sunlight, traffic lights, weather effects etc. The background subtraction is the first step in object detection and tracking. Centroid weighted kalman filter is used for object detection. This algorithm subtracts background image from foreground image and centroid is used to find the exact position of the object. Kalman filter is better opted one for object detection but accuracy is low in this compared to other algorithms. Pedestrian is considered as an object and Pedestrian safety is considered as the basic concern.6-D vision algorithm is used for pedestrian detection. In our survey, points are used to get the depth value of the object or pedestrian and then using the spatial position information the pedestrians are detected. Situation analysis and the vehicle control modules are merged to get the collision avoidance warning. By using vehicle control, lateral control for evasion is also implemented. This algorithm is useful because fusion of two algorithms give accurate result with zero false detection [8].

Object detection composed of motion detection or segmentation and object classification. These two are combined to detect true object results. Motion segmentation is basically background subtraction or frame subtraction. Once the object or the motion is extracted, the classifiers are used to detect a particular object.

Object delectation methods are categorized as: Motion based classification and Shape based classification. In many lighting conditions, skin color is extracted for better result. Hough Transform is used to detect pedestrian's head. But it cannot be implemented in crowded scenario because probability of occlusion is more in crowded environment. Blob based and contour based techniques also yields good results [6] [7]. This method uses bayes classifier to get better result for the position of the person. The combination of blob motion and HOG techniques give good results. Contour based detection is also one of the good options for accurate result. Canny edge detector is used to get the edges of the object after that the contour is extracted which is rough plot of the object. The SVM classifier is also good classifier for the object detection.

III. OBJECT DETECTION METHODS

Main step in the process of object tracking is identifying objects of interest in the video sequence and to cluster pixels of these objects, moving objects are the primary source of information, most methods focus on the detection of such objects [15].

A. Frame differencing

The presence of moving objects can be determined by computing the difference between two consecutive images. This calculation is simple and easy to implement. It is generally difficult to obtain complete outline of moving object.

B. Optical Flow

Optical flow method calculates the image optical flow field, and clusters processing according to the optical flow distribution image. This method gets the complete movement information and detect the moving object from the background in a better way, but sensitivity to noise, poor anti-noise performance.

C. Background subtraction

First step in background subtraction is background modeling. Background Modeling is like a reference model and it must recognize moving objects. This reference model is used in background subtraction in which each video sequence is compared against the reference model to determine possible Variation. These variations between current video frames to that of the reference frame (in terms of pixels) signify existence of moving objects. Mean filter and Median filter are background generally used to realize background modeling. The background subtraction method uses the difference method of the current image and background image for detecting moving objects, by a simple algorithm, but is sensitive to changes in the external environment and has poor anti-interference ability. However, it can provide the utmost complete object information in the case background is known. Background subtraction has mainly two sub categories

1) Recursive algorithm: Recursive techniques does not maintain a buffer for background estimation but they recursively update a single background model based on each input frame. Compared with non-recursive techniques, recursive techniques need less storage, on the other hand any error in the background model can linger for a much longer period of time. This technique includes different methods such as Gaussian of mixture, approximate median, adaptive background etc.

2) Non-Recursive Algorithm: A non-recursive uses a sliding-window approach for background estimation. It stores a buffer which contains the previous L video frames and which estimates the background image based on the temporal variation of each pixel within the buffer. Non-recursive techniques are extremely adaptive as they do not depend on the history beyond those frames stored in the buffer.

IV. PEDESTRIAN DETECTION USING SVM

Pedestrian detection is done by using SVMs. Two aspects are crucial in the deployment of SVM classifiers are, the training strategy and the classifier structure. [15] [20]

A. Training Strategy

The first step in the training strategy is to generate representative databases for learning and testing. The TSetBuilder tool is used to form training and test sets manually. Following things need to be considered while creating the training and test sets.

The ratio between positive and negative samples has to be set to an appropriate value. A very large number of positive samples in the training set may lead to a high percentage of false-positive detections during online classification and a very large number of negative samples produce miss-learning.

The size of the database is a crucial factor to take care of. As long as the training data represent the problem well, the larger the size of the training set, the better it is for simplification purposes. The value of the regularization coefficient *C* [3] is important since this parameter controls the over learning degree. Thus, a small value of *C* allows a large separation margin between classes, which reduces over learning and improves generalization. The dimension of the database has been designed in order to achieve real generalization. [19]

The quality of negative samples has a strong effect in the DR. Negative samples have to be properly selected to account for ambiguous objects, such as poles, trees, advertisements etc. Only by following this strategy when creating the training sets can a really powerful classifier be achieved in practice.

A sufficiently representative test set must be created for verification. The test set contains characteristics similar to those of the training sets in terms of variability, ratio of positive/negative samples, and quality of negative samples.

B. Classifier Structure

A two-stage classifier is proposed to cope with the components-based approach. In the first stage of the classifier, features computed over each individual fixed sub-region are fed to the input of individual SVM classifiers. Thus, there are six individual SVM classifiers corresponding to the six candidate sub-regions. Each classifier specialized in recognizing separate body parts corresponding to the pre-specified candidate sub-regions. It must be clearly stated that no matching of parts is carried out. Instead, each individual SVM is fed with features computed over its corresponding candidate sub-region and provides an output that indicates whether the analyzed sub-region corresponds to a pedestrian part (+1, in theory) or not (−1, in theory). In the second stage of the classifier, the outputs obtained by the six individual SVMs are combined. Two different methods have been tested to carry out this operation. The first method implements simple-distance criterion. A simple addition is calculated as

Sdistance-based =_6i=1Si (7)

Where S_i represents the real output of the SVM classifier (not strictly contained in the ideal range [−1, +1]) that corresponds to sub-region *i*. In theory, sub-regions corresponding to non-pedestrians or missing parts should contribute with negative values to $S_{\text{distance-based}}$. Likewise, sub-regions corresponding to pedestrian parts should contribute with positive values to the final sum, then a threshold value *T* is established in order to perform candidate classification. This threshold is parameterized for producing the *Receiver Operating Characteristic (ROC)*.The difference between pedestrians and non-pedestrians is set depending on the distance between *T* and $S_{\text{distance-based}}$. Thus, if $S_{\text{distance-based}}$ is greater than *T*, the candidate is considered to be pedestrian. Otherwise, it is considered as non-pedestrian. This simple mechanism is what we denote as distance-based criterion.

The second method that has been tested to implement the second stage of the classifier relies on the use of another SVM classifier. A second-stage SVM classifier combines the outputs of the six individual first-stage SVM classifiers and provides a single output representing the candidate classification result. The resulting global structure is denoted as two-stage SVM classifier. The second-stage SVM classifier has to be trained with supervised data. The training set for the second stage SVM classifier has been built as follows. First, the six individual first-stage SVM classifiers are properly trained using training set DS (which contains 15 000 samples) in which the desired outputs (pedestrian or non-pedestrian) are set in a supervised way. Then, a new training set is constructed by taking as inputs the outputs produced by the six already trained first-stage SVM classifiers (in theory, between −1 and +1) after applying the 15 000 samples contained in DS and taking as outputs the supervised outputs of DS. The test set for the second-stage SVM classifier is created in a similar way using test set TDS (containing 5505 samples).

Along with, an optimal kernel selection for the SVM classifiers has been performed. For this purpose, the paper [9] used a small training set of 2000 samples for which the well-known Gaussian (Radial Basis Function), sigmoid, polynomial, and linear kernels were tested. The Gaussian kernel was finally chosen as the optimal one after the trials.

V. OBJECT CLASSIFICATION METHODS

The extracted moving region may be various objects such as humans, vehicles, birds, floating clouds and moving objects [7]. As per literatures, approaches to classify the objects are as follows:

A. Shape-based classification:

Different descriptions of shape information of motion regions such as representations of points, boxes and blob are available for classification of moving objects. Network input features are mixture of image-based and scene-based object parameters such as image blob area, aspect ratio of blob and camera zoom. Classification is performed on blob at every frame and results are kept in histogram [14].

B. Motion-based classification:

Non-rigid articulated object motion shows a periodic property and this has been used as a strong cue for moving object classification. Optical flow is also very helpful for object classification. Residual flow can be used to analyze rigidity and periodicity of moving entities. It is estimated that rigid objects would present little residual flow where as a non-rigid moving object such as human being had higher average residual flow and even displayed a periodic component [14].

C. Color-based classification

Unlike many other image features (e.g. shape) color is constant under viewpoint changes and also easy to be acquired. Though color is not always appropriate as the sole means of detecting objects and tracking these objects, but the low computational cost of the algorithms proposed makes color a desirable feature to be used when necessary. To detect and track objects or pedestrians in real-time color histogram based technique is used. Mixture Model is created to describe the color distribution within the sequence of images and to segment the image into background. Object occlusion was handled using an occlusion buffer.

D. Texture-based classification

Texture based technique counts the occurrences of gradient orientation in localized portions of an image, is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy.

VI. PEDESTRIAN CLASSIFICATION METHODS

There are certain methods of classification. Pattern classifiers are selected in such a way that they form decision boundary instead of density estimation (e.g., Bayes Decision Theory or Parzen Classifier), The LRF features involves the training of a neural network. Subsequently applied feed-forward neural network to PCA and Haar wavelet features as well.

Support Vector Machines (SVM) has been evolved a standard tool for a broad range of classification tasks, which constitutes pedestrian classification [21]. The main advantages is, direct optimization of the margin of the decision boundary, and so minimizes the classification error, contrary to the minimization of some artificial error term like mean squared error for neural networks. Kernel function determines the complexity of the decision boundary

There are many classification techniques that can be applied to object detection problem. Some of the commonly used classification techniques are support vector machine and Adaboost. SVM is one of the most reliable and popular classifiers which has proven to be a promising generalization capacity. The linear SVM is the best user friendly and simplest to adopt. As known, linear reparability is a strict condition [22]. Kernels are combined to form margins to relaxed this restriction. SVM extends to deal with linearly non-separable problems by mapping the training data from the input space into a high-dimensional and infinite-dimensional, feature space. SVM classifiers with three different kernel functions, linear, quadratic and RBF kernels, can be combined with features that are calculated from previous tasks.

VII. OBJECT TRACKING METHODS

Tracking, the problem of approximating the path of an object in the image plane as it moves around a scene has a purpose of an object tracking to generate the route for an object above time by finding its position in every single frame of the video. Object is tracked for object extraction, object recognition and tracking, and for decisions about activities. Object tracking is classified into point tracking, kernel based tracking and silhouette based tracking. The point trackers involve detection in every frame whereas kernel based tracking or contours-based tracking require detection only when the object first appears in the scene. Tracking methods can be divided into following categories:

A. *Point Tracking*

In the structure of an image, during tracking moving objects are represented by their feature points. Point tracking is a tedious problem specifically in the incidence of occlusions and false detections of object. Recognition is done, by thresholding, at identification points.

1) Kalman Filter: These type are based on Optimal Recursive Data Processing Algorithm. It performs the restrictive probability density propagation. Kalman filter, set of mathematical equations providing an efficient computational (recursive) means for estimating the process state in several ways: it supports estimations of past, present, and even future states, and can do the same even after the precise nature of the modeled system is not known. The Kalman filter estimates a process by making use of feedback control. The filter also estimates the process state at particular time and then obtains feedback in the form of noisy measurements. The equations for Kalman filters grouped in two forms: time update equations and measurement update equations. The time update equations projects forward (in time) the current state and estimates error covariance to obtain the priori estimate for the next step. The updated equations of the measurement are responsible for the feedback. Kalman filters are seen to give optimal solutions.

2) Particle Filtering: The particle filtering generates all the models for one variable before moving to the next variable. Algorithm has an advantage when variables are generated dynamically and there can be unboundedly numerous variables. It also allows for new operation of resampling. One of the limit in Kalman filter is that the assumption of state variables are normally distributed (Gaussian). That's why the Kalman filter has poor approximations of state variables which do not have Gaussian distribution. This restriction can be overcome by particle filtering. This algorithm uses color features, contours or texture mapping. The particle filter is a Bayesian sequential importance Sample technique. It constitutes two phases: prediction and update similar to Kalman Filtering. It was popularly applied to tracking problems, also known as the Condensation algorithm

3) Multiple Hypothesis Tracking (MHT): In this algorithm, several frames have been observed for better tracking outcomes. MHT, an iterative algorithm and Iterates with a set of existing track hypotheses. Each hypothesis is a group of mutually separate tracks. For each hypothesis, a prediction of object's position in the succeeding frame is made. These predictions are then compared by calculating a distance measure. MHT is capable of tracking multiple objects, handles occlusions and Calculating of Optimal solutions.

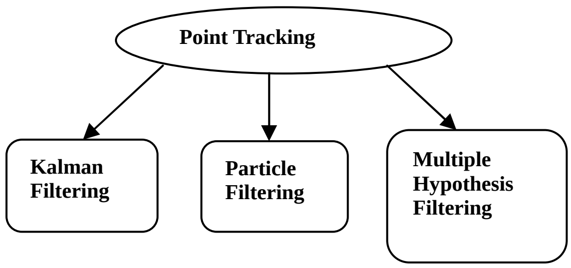

Fig 1a: Point Tracking [15]

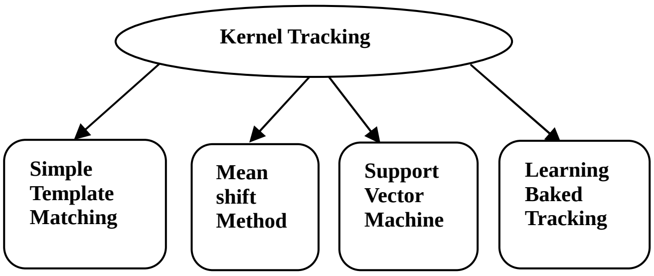

Fig 2b: Kernel Tracking [15]

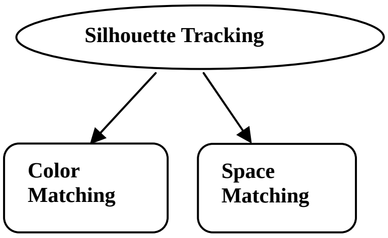

Fig 2c: Silhoutte Tracking [15]

B. Kernel Based Tracking

Kernel tracking [9] is usually performed by computing the moving object, which is represented by an embryonic object region. The object motion is usually in the form of parametric motion such as translation, conformal, affine, etc. These algorithms diverge in terms of the presence representations used, objects tracked, and the method used for estimation of the object motion. In real-time, illustrating object using geometric shape is common. But one of the restrictions is that parts of the objects may be left outside of the defined shape while portions of the background may exist inside. They are large tracking techniques based on representation of object, object features, appearance and shape of the object.

1) Simple Template Matching: Template matching [9] [4] is a brute force method of examining the Region of Interest in the video. In template matching, a reference image is verified with the frame that is separated from the video. Tracking can be done for single object in the video and then the overlapping of such object is done partially. Template Matching is the most common used technique for processing digital images to find small parts of an image that matches, or equivalent model with an image (template) in each frame. The matching procedure contains the image template for all possible positions in the source image and calculates a numerical index that specifies how well the model fits the picture that position. It must be capable of dealing with tracking single image and partial occlusion of object.

2) Mean Shift Method: Mean-shift tracking tries to find the area of a video frame that is locally most similar to a previously initialized model. The image region to be tracked is represented by a histogram. A vintage procedure is used to move the tracker to the location that maximizes a similarity score between the model and the current image region. In object tracking algorithms target representation is mainly rectangular or elliptical region. It contains the target model and target candidate. To characterize the target color histogram is chosen. Target model is generally represented by its probability density function (pdf). Target model is regularized by spatial masking with an asymmetric kernel.

3) Support Vector Machine (SVM): SVM [13] is a broad classification method which gives a set of positive and negative training values. For SVM, the positive samples contain tracked image object, and the negative samples consist of all remaining things that are not tracked. It can handle single image, partial occlusion of object but necessity of a physical initialization and necessity of training.

4) Layering based tracking: This is another method of kernel based tracking where multiple objects are tracked. Each layer consists of shape representation (ellipse), motion such as translation and rotation, and layer appearance, based on intensity. Layering is achieved by first compensating the background motion such that the object's motion can be estimated from the rewarded image by means of 2D parametric motion. Every pixel's probability of calculated based on the object's foregoing motion and shape features [13]. It can capable of tracking multiple images and fully occlusion of object.

C. Silhouette Based Tracking Approach

Some object will have complex shape such as hand, fingers, shoulders that cannot be well defined by simple geometric shapes. Silhouette based methods [9] afford an accurate shape description for the objects. The aim of a silhouette-based object tracking is to find the object region in every frame by means of an object model generated by the previous frames. Capable of dealing with variety of object shapes, Occlusion and object split and merge.

1) Contour Tracking: Contour tracking methods [9], iteratively progress a primary contour in the previous frame to its new position in the current frame. This contour progress requires that certain amount of the object in the current frame overlay with the object region in the previous frame. Contour Tracking can be performed using two different approaches. The first approach uses state space models to model the contour shape and motion. The second approach directly evolves the contour by minimizing the contour energy using direct minimization techniques such as gradient descent. The most significant advantage of silhouettes tracking is their flexibility to handle a large variety of object shapes.

2) Shape Matching: These approaches examine for the object model in the existing frame. Shape matching performance is similar to the template based tracking in kernel approach. Another approach to Shape matching [10] is to find matching silhouettes detected in two successive frames. Silhouette matching, can be considered similar to point matching. Detection based on Silhouette is carried out by background subtraction. Models object are in the form of density functions, silhouette boundary, object edges. Capable of dealing with single object and Occlusion handling will be performed in with Hough transform techniques.

VIII. PEDESTRIAN TRACKING

Pedestrian tracking is necessary to determine the pedestrian correspondences between frames. In real-time tracking works in two stages: prediction step and matching step. The prediction step is determining the search area in which the pedestrian might be seen in next frame. A search window is defined for each precious object, which centers on its predicted centroid and has an area adapted to the scale of the measurement error in the Kalman model. The matching step is to search the corresponding object in the predicted area. The feature vectors of detected pedestrians in the search window are compared with integrated templates. If it matches, the relation between objects in two consecutive frames would be recorded. [16]

A. Prediction

Kalman Filter is used to predict the location of pedestrian in next frame. This model is used to reduce the cost of search operation. The Kalman filter model is composed of system state model and measurement model as follows:

Xk = A.xk-1 + B.uk + wk (1)

Zk = H.xk + vk (2)

Where Xk is the state vector with n dimensions; Zk is the measurement vector with m dimensions; Xk is the control vector; A and H are the state transition matrix and measurement matrix. Wk and Vk are random variables representing the process and measurement noise.

B. Matching in the Prediction area

In previous frame, a bounding box is drawn around a detected pedestrian and the corresponding centroid is got which is used to define extended search windows in the current frame. The size of search window is obtained by adding measuring errors to the length and width of their corresponding bounding box in the previous frame. The candidate matched pedestrians are those whose bounding boxes intersect the search window.

IX. CONCLUSION

In this paper, we briefly discussed various techniques for detecting, classifying and tracking the objects. Available techniques for these phrases have been explained in detail Further we identify these objects as human, so called pedestrians.

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REFERENCES

[1] Abhishek Kumar Chauhan, PrashantKrishan, “Moving Object Tracking Using Gaussian Mixture Model And Optical Flow”, International Journal of Advanced Research in Computer Science and Software Engineering, April 2013.

[2] M.Sankari, C. Meena, “Estimation of Dynamic Background and Object Detection in Noisy Visual Surveillance”, International Journal of Advanced Computer Science and Applications, 2011.

[3] Cheng-Laing Lai; Kai-Wei Lin, "Automatic path modeling by image processing techniques," Machine Learning and Cybernetics (ICMLC),2010 International Conference on , vol.5, no, July 2010.

[4] Saravanakumar, S.; Vadivel, A.; Saneem Ahmed, C.G., "Multiple human object tracking using background subtraction and shadow removal techniques," Signal and Image Processing (ICSIP), 2010 International Conference on , vol, no, Dec. 2010

[5] Ruolin Zhang, Jian Ding, “Object Tracking and Detecting Based on Adaptive Background Subtraction”, International Workshop onInformation and Electronics Engineering, 2012.

[6] K.Srinivasan, K.Porkumaran, G.Sainarayanan, “Improved Background Subtraction Techniques For Security In Video Applications”.

[7] RupaliS.Rakibe, BharatiD.Patil, “Background Subtraction Algorithm Based Human Motion Detection”, International Journal of Scientific and Research Publications, May 2013.

[8] Jae-Yeong Lee; Wonpil Yu, "Visual tracking by partition-based histogram back projection and maximum support criteria," Robotics and Biomimetics (ROBIO), 2011 IEEE International Conference on, vol., no, Dec. 2011

[9] Mr. Joshan Athanesious J; Mr. Suresh P, ”Implementation and Comparison of Kernel and Silhouette Based Object Tracking”, International Journal of Advanced Research in Computer Engineering & Technology, March 2013.

[10] J.Joshan Athanesious, P.Suresh, “Systematic Survey on Object Tracking Methods in Video”, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) October 2012.

[11] Sen-Ching S. Cheung and Chandrika Kamath, “Robust techniques for background subtraction in urban traffic video”.

[12] Greg Welch, Gary Bishop,” An introduction to the Kalman Filter”, In University of North Carolina at Chapel Hill, Department of Computer Science. Tech. Rep. 95-041, July-2006.

[13] Rahul Mishra, Mahesh K. Chouhan, Dr. Dhiiraj Nitna, “Multiple Object Tracking by Kernel Based Centroid Method for Improve Localization”, International Journal of Advanced Research in Computer Science and Engineering, July-2012.

[14] Hitesh A Patel, Darshak G Thakore, “Moving Object Tracking Using Kalman Filter”, International Journal of Computer Scienceand Mobile Computing, April 2013.

[15] Himani S Darshak, Darshak G Thakore, “Survey On Object Detectioin and Tracking Methods”, International Journal of Innovative Researchin Computer and communication Engineering, February 2014.

[16] P Sathyanarayana Bhat, Shripad Kondra Sankalp Kallakuri. “Real-time Multiple Pdestrian Tracking framework Using Kernels”, Industrial and Information Systems (ICIIS), Dec 2014.

[17] Gang Zheng, Youbin Chen “A Review on Vision Based Pedestrian detection”, Global High Tech Electronics, 2012.

[18] Stoleo M A, Parra I, Fernandez D, Naranjo E “Pedestrian Detection Using SVM and Multi-feature Combination”, IEEE Intelligent Transportation Systems Conference, 2006.

[19] Chen D, Cao X B, Xu Y W, Qiao H “An Evolutionary Support Vector Machines Classifier for Pedestrian Detection”, IEEE Intelligent Transportation Systems Conference, 2006.

[20] Ignacio Parra Alonso, David Fernández Llorca, Miguel Ángel Sotelo “Combination of feature Extraction Methods for SVM Pedestrian Detection”, IEEE Transactions on Intelligent Transportation Systems, June 2007.

[21] Junil Tao, Klette R, “Integrated Pedestrian and Direct Classification Using a random decision Forest”, Computer Vision Workshops (ICCVW) IEEE International Conference, Dec 2013.

[22] Junil Tao, Klette R, “Vision Based Pedestrian Detection-Improvement and Verification of feature Extraction Methods and SVM-Based Classification”, Intelligent Transportation Systems Conference, ITSC Dec 2011.