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AUTOMATIC DETECTION OF MOVING OBJECTS USING KALMAN ALGORITHM

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Abstract:

Detection of objects in motion is one of the challenging task in computer science domain. Different techniques for detecting motion of objects have been applied in various fields. One of the interesting techniques is Kalman filter and its feature to estimate and predict moving object with the help of image sequence. The paper focuses on moving object detection with the help of Kalman filter algorithm. Detecting various objects in camera of surveillance system is important task of this algorithm but when complexity of occlusion becomes serious we need to extend the features of Kalman filter to decide the position of occluded objects. This paper proposes Kalman filter to know the position of moving object during motion.

Keywords: Object detection, Object tracking, Kalman filter, Surveillance system.

Introduction:

Moving object tracking and detection is backbone of Sports, video surveillance, traffic systems management, video annotations. It is impossible to imagine these fields without moving object detection and tracking. In last few years, attention for detection, segmentation, tracking and estimation of moving object is proliferating[7].Object detection and tracking can suffer the difficulties like non-fixed structures of objects, object to scene and object to object occlusion, changing sequence pattern of scene or object. For purpose of serving higher application object tracking is performed which requires shapes and locations of every object[10]. Detection of objects is complex process consist of two interrelated analysis functions. First function is object detection which incorporates detecting object in video sequence frames. Next function is actual tracking of moving objects according to their linear motion and finds spatial

changes in video.Thus, Detection of objects can be performed in many ways such as frame differences, background subtraction, Partial Least Squares Analysis, Histograms of Oriented Gradients (HOG), SIFT descriptors, Wavelets with SVM, active contours and Hough transforms. Object motion tracking can be performed in many ways such as use Mean-Shift algorithms, Kalman filtering, HMM, Optical Flow, contour tracking. Paper focuses on detection of moving object and tracking in static camera videos which are already recorded.As discussed above the proposed system identifies objects from videos or inputs of video frames but it is in the context of moving object i.e. it detects only moving object not static objects. Its main intention is to support moving object detection and tracking in fixed camera movies and hence it's so useful in video surveillance application. In general, the first step, image restoration, de-noising operations are two basic steps of video preprocessing. After that moving object identification is essential step executed on output of first step. Kalman filter is not efficiently working in the presence of occlusions. It's because there is no data available about the object for tracking and detection during occlusion. In addition, when there are multiple objects in surveillance system Kalman filter faces complex problems while detection of objects. In order to tackle these drawbacks, we propose some methods that can enhance the existing Kalman filter algorithm.

Related work:

Review of object detection methods:

Background subtraction: This method of object detection is also known as foreground detection. This is one of the simple technique for detection in which foreground of image is extracted from background for specific purposes like detection and tracking of objects[3]. Objects that human eyes can recognize are generally in foreground of images. This is one of the famous approach and widely used for object detection. Static camera videos make use of background subtraction method[2]. The main concept of detecting object is based on comparison between the current frame and previous frame. If difference between current frame and referenced frame is beyond threshold value, then method goes for object detection. The rationale in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called "background image", or "background model".[1] Background subtraction is mostly done if the image in question is a part of a video stream[5]. There are 4 approaches for background subtraction as below[9]

- Frame difference
- Mean filter
- Running Gaussian average
- Background mixture models

Histogram of Oriented Gradients (HOG): In image processing and computer vision HOG are descriptors used for detecting objects[4]. In localized area of image, the gradient orientation sequences are calculated with the help of this technique. The technique has similar characteristics as edge orientation and SIFT methods, but it is based on equally spaced density grid points which are based on normalization to give maximum accuracy.

SIFT descriptor: Acronym of SIFT is Scale-invariant feature transform. This algorithm helps in identifying feature points of images and subsequently describing those features[1]. This SIFT descriptor is useful in image stitching, multi-viewpoint image matching, object reorganization. There are 4 stages of SIFT descriptor are model verification by linear least squares, feature matching and indexing, scale invariant feature detection, cluster identification by Hough transform method.

Viola jones object detection framework: This method of object detection is first framework for detecting objects to provide good rate of object detection in real world application. This framework is consisting of three components feature evaluation and type, learning algorithm, cascade architecture. This method is using the summing of pixels within rectangular area of image which has similarity with Haarfunctions[8]. Whereas viola and jones method focuses on more number of rectangular area and hence more complicated. Framework used for detecting object relies on form of learning algorithm called "Adaboost" that is useful for training classifiers and selection of features. Learning process results in strong classifier which are arranged in cascaded order.

Review of object tracking methods

Mean-Shift algorithms: This is method is based on feature space which is non parametric technique. To identify the clusters in image processing this method is truly helpful. This algorithm is also known as mode seeking algorithm. With the help of discrete sample data, mean shift method locates the density function's maxima[6]. For detecting density modes, it is basic approach.

Hidden Markov model (HMM): Tools like HMM are used model data which depends upon time series data modeling. This model is mostly used in various applications like reorganization of speech or patterns, artificial intelligence, data compression. Recently this method has made successful path in image processing application like object tracking and image sequence modeling[2]. This HMM is application which finds out probability of distribution of observation's sequences.

Contour tracking: In order to extract the boundaries of images in tracking particular object contour tracking is utilized. Contour tracking is also known as boundary following method[6]. For extracting information regarding the

shapes of objects in image contour tracing helps by performing various operation on images. After contour points detection and extraction, the characteristics are examined. These characteristics are used as main features subsequently used as classification of patterns. Thus overall process of contour detection results in producing result which are accurate in terms of accuracy and efficiency.

Optical Flow: Optical flow or optic flow is the pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer (an eye or camera) and the scene[11]. demonstrated the role of the optical flow stimulus for the perception of movement by the observer in the world; perception of the shape, distance and movement of objects in the world; and the control of locomotion[12].Recently the term optical flow has been co-opted by robotics to incorporate related techniques from image processing and control of navigation, such as motion detection, object segmentation, time-to-contact information, focus of expansion calculations, luminance, motion compensated encoding, and stereo disparity measurement.

Methodology:

Technique of Kalman Filter

Kalman filter is basically based on estimation of repetitive prediction and correction cycle. To compute the estimate of live state of object, the current measurement and previous state of object are required. Hence, it is independent of history of estimates. Basic characteristics of Kalman filter technique are that it is purely mathematical model and as stated previously it is repetitive or recursive procedure. There are two basic models for Kalman filter which are measurement model and system state model. Equations for two models can be given as follows

$$s(t)=O(t-1)*s(t-1)+w(t) \quad \ldots\ldots(1)$$

$$z(t)=H(t)*s(t)+v(t) \quad \ldots\ldots(2)$$

H(t) → measurement matrix and O(t-1) → state transition matrix. w(t) and v(t) are noise of Gaussian with zero average.

Kalman filter is based on two modules correction and prediction module. Prediction is nothing but getting the estimate based on the forward projection of current state. Correction phase working is based on feedback.

By adding actual result into estimate of prediction step it achieves the improved result of posterior estimate.The repeated process of prediction and correction is continued. It is necessary to have measurement error and gain of Kalman to be in inverse proportion. Smaller the error more the Kalman gain and vice versa. It should be noted that the actual parameters are not trusted more as compared to predicted result.

Algorithm steps:

After collecting the videos of multiple objects we will follow following steps for detection and tracking of the objects.

1. *First step takes previous frame and current frame.*
2. *Calculate the variation between them in terms of intensity, scaling etc.*
3. *Determine the threshold.*
4. *Variation between the images is greater than the determined threshold.*
5. *The centroid of object must be computed*
6. *Creation of template and axis determination of template*
7. *Obtain the position of the match and pass to analysis.*
8. *How object moves horizontally or vertically, that direction must be acknowledged.*
9. *On based of movement within certain dimension it decides movement of Object in clockwise or anticlockwise*
10. *Else go to step 1.*

Precision is main criteria to decide the robustness and Performance of the above object detection and tracking algorithm.

Block diagram for overall architecture:

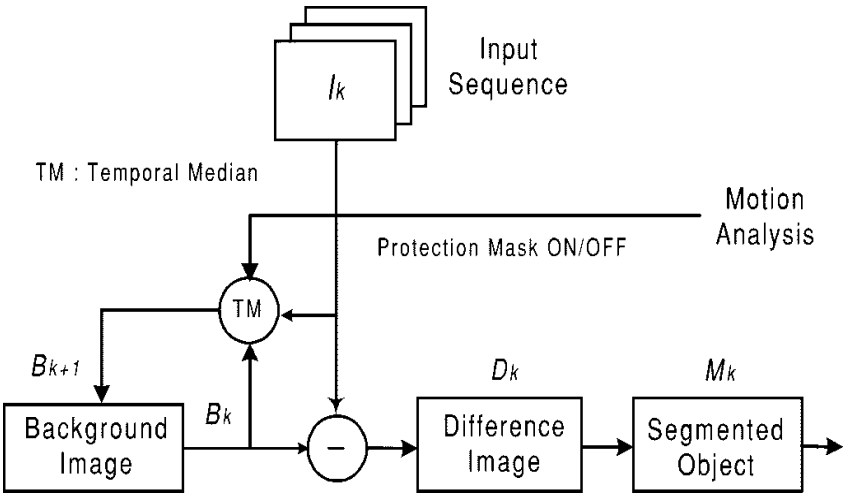

Figure 1. Overall architecture

I_k→ frame of video sequence

B_k → Background image

M_k→Mask of moving object

Threshold process of image frames and background frames at the same time, result in creation of Mask of moving object (Mk).

It is necessary to differentiate the actual motion of object and noisy temporal clutters motion. The object to be detected and tracked has features like edge, shape, boundaries, colors etc. After detection of moving object, it is convenient in the process of tracking of moving object on the basis of next points in image space with respect to observed points in the image space.

Result and analysis:

As shown in figure, the output window consists of four square regions. Among which first square i.e. upper left part indicates original frame from video.

Second frame i.e. lower left indicates background for the object as captured in camera of traffic monitoring. Third square upper right indicates separation of object and background.

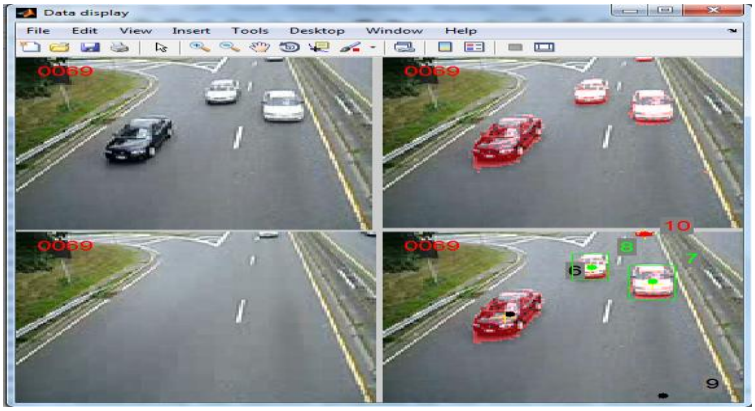

Figure 2. Moving cars detection and tracking from static video.

Finally, the last square i.e. lower right is showing the actually detected and tracked object i.e. cars from frame. Thus overall process is responsible for detection and tracking of moving object. If the object is replaced by another object it is marked as red otherwise the object is marked as green.

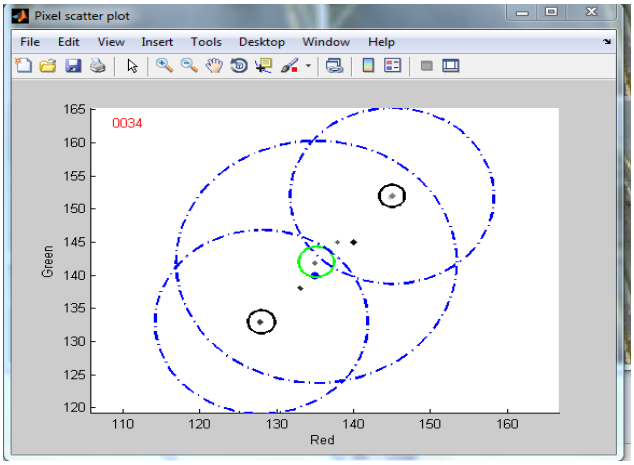

Figure 3. Cluster of moving objects.

Dashed circle indicates the similar boundary imposed by standard deviation from threshold value. Above figure shows cluster of moving objects. In which according to pixel intensity of moving objects it plots the graph. If object is fully detected its pixel intensity is high and if it is partially detected its pixel intensity is low. According to all experiments above, Kalman filter performs well for detection and tracking of objects in order to find objects from static videos.Finally, after detection and tracking of moving object, cropping of moving object is done. For the process of cropping the object from frames created by Kalman filter are selected. Kalman filter helps to create bounding box on the moving object and that bounding box undergoes cropping process to get the final images of moving objects.

Figure 4. Cropped moving objects from video.

From analysis it is clear that if video size is increased to provide high definition statistics of moving object the system does not support high definition video and it fails to detect and track the object. In addition, System does work efficiently in the presence of occlusions. It's because there is no data available about the object for tracking and detection during occlusion.

Conclusion:

Kalman filter technique of object detection and tracking has been proposed, and this method helps to detect object which is not static although it varies in its position, angle, occlusion and velocity. Typical Kalman filter is typically susceptible to failure in case of occlusion due to lack of information about object. Hence it is advisable to go for enhancement in Kalman feature algorithm. Experimental result shows that approach is naval approach and it has effective outcome. The enhancement in technique can be done by improving the outlier map by realizing non-occlusion to occlusion smooth transformation.

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