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A STUDY ON OBJECT TRACKING USING FILTERING OF KALMAN

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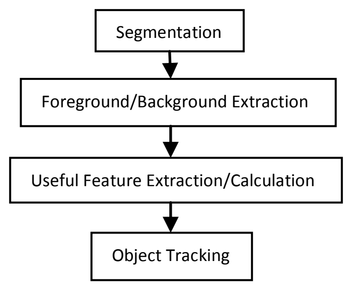
Abstract

This paper proposed a new reliable way for video object tracking using the Kalman Filter. Video object are defined as group of image pixels coherent spatially. This will impact of the quality of unsurprised region and merge segmentation, affect the accuracy of the tracker. Video object segmentation for object based video coding according to MPEG-4 should be able to combine many features of image sequence to achieve high quality object segmentation. This technique for continuous tracking of moving object observed by multiple heterogeneous cameras. The motion model is obtained using a Kalman Filter, Which predict the position of moving object. Kalman filter and estimated parameter of adaptive Kalman filter are stable by occlusion ratio adaptively. Has strong capability to track any moving object in the consecutive frames under some kind of real scenarios complex situations such as the moving object disappearing totally or partially due to occlusion by other ones such as, rapid moving object, changing lighting etc. The proposed method is an efficient video object tracking algorithm.

Introduction

The information technologies developed over the last several years have been heavily technology based, while decision-making remained a human thinking process. "Video Object tracking can be defined as the process of track an object from any video sequence using segmentation, an object of interest from a video scene and keeping track of its motion, orientation, occlusion etc. in order to extract useful information". Basic steps in object tracking can be listed as:

- Segmentation
- Foreground /background extraction
- Camera modeling
- Feature extraction and tracking



Segmentation

Segmentation is the process of detecting and identifying an object from the image. Segmentation is based upon the operations such as boundary detection, connected component labeling, thresholding etc. Boundary detection finds out edges in the picture. Any differential operator can be used for boundary detection.

Foreground Extraction/ Background Extraction

As the name suggests this is the process of separating the foreground and background of the image. Here it is assumed that foreground contains the objects of interest. Some of the methods for foreground extraction are:-

- Use of difference images:- In this method we use subtraction of images in order to find objects that are moving and those that are not. The result of the subtraction is viewed as another grey image called difference image.
- Kalman filtering: - This method employs 'Kalman filter' for predicting the image at t_{i+1} based on some noise model. This Kalman Filter is used for noise distribution and system dynamics are linear.

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This filter is also used for estimate the speed at each time instant. The difference between predicted and actual intensities is thresholded to classify the image pixel as foreground or background. One advantage of this method is it considers effect of noise, which is very important feature in real world applications. For example an automatic road traffic management system may detect false objects due to bad weather, wind etc. Once foreground is extracted a simple subtraction operation can be used to extract the background.

Camera Modeling

Camera model is an important aspect of any object-tracking algorithm. All the existing objects tracking systems use a preset camera model. In words camera model is directly derived from the domain knowledge.

Feature Extraction and Tracking

Finally, the feature is extracted out of the image and object is tracked using Kalman Filter Object tracking is useful in a wide range of applications: surveillance cameras, vehicle navigation, perceptual user interface, and augmented reality. However, most of the research on tracking an object outperforms using selective algorithms that are applicable for fixed settings. The focus of this thesis is tracking a general object selected in a real time.

There are some situations for video in a real world environment, including camera lens is fixed or not, multiple moving objects, rigid object, or non-rigid object, occlusion by the other objects, one or many cameras, full automatic or semi-automatic semantic object tracking, etc. According to the above discussion, to conclude, we will encounter the following three problems for tracking moving object.

- Initial moving object segmenting problem.
- Detection of moving object.
- Tracking the moving target in occlusion.

The method with the Kalman filter technique which predicts the detecting range to reduce the computational complexity can not be applied to solve the target in occlusion. Therefore, for tracking the moving target in occlusion, our paper proposes the adaptive Kalman filter to estimate the motion information under a deteriorating condition as occlusion. The tracking algorithm needs to satisfy the two qualities: simplicity and robustness. Simplicity implies that the algorithm is easy to implement and has the minimum number parameters. Robustness implies the ability of the algorithm to track objects under different conditions which include: severe occlusions, lighting changes, object orientation changing, background clutter, a moving camera, zooms, and rotations.

Review of Literature

Many researchers have tried various approaches for object tracking. Nature of the technique used largely depends on the application domain. Some of the research work done in the field of object tracking includes:

Shiuh-Ku Weng, Chung-Ming Kuo, Shu-Kang Tu [1] has studied the object tracking algorithm in which a moving object selected by the user is segmented and the dominant color is extracted from the segmented target. In tracking step, a motion model is constructed to set the system model of adaptive Kalman filter firstly. Then, the dominant color of the moving object in HIS color space will be used as feature to detect the moving object in the consecutive video frames. The detected result is fed back as the measurement of adaptive Kalman filter and the estimate parameters of adaptive Kalman filter are adjusted by occlusion ratio adaptively.

Ning Li, Lu Liu, De Xu [3] has studied the prototype of Kalman filter and proposed a corner feature based Adaptive Kalman Filter (AKF) for moving object tracking. Unlike pixel-level feature corner feature is insensitive to dynamic change of outdoor scenes such as water ripples, plants and illumination. Thus, the corner feature can robustly describe MO in outdoor area. The main contribution is to take advantage of corner points to describe MO and then use the variation in the number of occluded corner points across consecutive frames to design an AKF.

Nimmakayala Ramakoti,Ari Vinay, Ravi Kumar Jatoth has presented the idea of kalman [5] filter that tracks the object by assuming the initial state and noise covariance. For efficient tracking by any filter like Kalman filter noise covariances must be optimized. They propose tuning of noise covariances of Kalman filter for object tracking using particle swarm optimization (PSO).

Mohand Said Allili, Djemel Ziou [2] has studied novel object tracking algorithm for video sequences, based on active contours. The tracking is based on matching the object appearance model between successive frames of the sequence using active contours. They formulate the tracking as a minimization of an objective function incorporating region, boundary and shape information. Further, in order to handle variation in object appearance due to selfshadowing, changing illumination conditions and camera geometry, they propose an adaptive mixture model for the object representation.

One simple feature based object tracking method was explained by Yiwei Wang, John Doherty and Robet Van Dyc [4] The method first segments the image into foreground and background to find objects of interest. Then four types of features are gathered for each object of interest. Then for each consecutive frame the changes in features are calculated for various possible directions.

Proposed Method

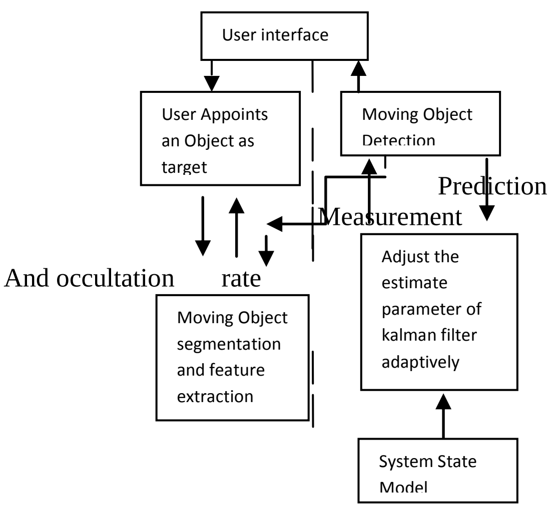
The main steps of the proposed tracking algorithm are listed as follows:

Initialization: This involves in:

1. Moving object segmentation by frame difference and region growing.
2. Object feature extraction.

Tracking by adaptive Kalman filter: This involves in:

1. Motion model construction to build the system state model of adaptive Kalman filter.
2. Moving object detection in consecutive frames for the correction step of adaptive Kalman filter.



Initialization
Adaptive Kalman Filter

Fig2: The Structure of Proposed Method using Adaptive Kalman Filter

Initial Moving Object Segmentation And Feature Extraction by Frame Difference and Region Growing Method

Frame difference is a simple method to segment the moving object in image video. After the user appoints a moving object as target, the target is segmented by the differences of frames in t -1, t, and t + 1. It uses the difference of consecutive frames to detect the change area of frames

$$FD(x, y, t) = \begin{cases} 0 & \text{if } |f(x, y, t+1)-f(x, y, t)| \leq \text{threshold}, \\ 1 & \text{otherwise} \end{cases}$$

Region growing method is used at the segmented moving object which the user appoints. The region growing method consists of two basic morphological methods. In first iteration,

$$MO_k = (MO_{k-1} \oplus SE) \cap MRS; \; k = 1; 2; 3; \ldots ;$$

If the initial point is not located in one of the segmented regions, we select the segmented region that is closest to the user's selector locating point. The 3 · 3 block is used as the structuring element to group the object points. The iterations do not terminate until the connected region is extracted, i.e., $MO_n=MO_{n-1}$ at nth iteration, and then the other segmented objects will be given up. In second iteration, the points of segmented moving object is defined as:-

$$MR(x, y, t) =FD(x, y, t-1) \cap FD(x, y, t).$$

The set of segmented moving object area is described as:-

$$MRS= \{(x, y) \mid MR(x, y, t) =1\}$$

Once a connected segmented region is found, another morphological method called region filling is applied to dilate the MO_n. The region filling is expressed as:-

$$OR_k = (OR_{k-1} \oplus SE) \cap MO^c_n$$

where $OR_0=MO_0$ is the initial point and OR_k is the result of the k_{th} iteration

Dominant Color Feature Extraction

To find the dominant color, we process feature extraction in the RGB color space. The RGB color space is represented by a 3-dimensional cube with red, green, and blue additive primaries. When color clustering by K-means method operates in RGB space, it can directly use identical weighting in every dimension to calculate, since the RGB color space forms a cube and the clustering does not need to consider the special property of every dimension. For example, the cyclic property of the hue component in HSI color space needs to be considered. Therefore, the RGB color space is very suitable for dominant color extraction.

First, the moving object colors in RGB components are classified by K-means.The K is experimentally set as 5. The color pixels of moving object are classified into different K groups by color and the average color of the every group in frame t is defined as MC_k (t). If the group d is the highest density (minimum distance summation) one, the MC_d (t) is set as the dominant color feature.

Tracking the Moving Object by the Proposed Adaptive Kalman Filter

For the tracking problem, if we have to estimate the motion information of object under such a deteriorating condition as occlusion, a simple detecting method will not be able to measure and track the moving object correctly. In the paper, we propose an adaptive Kalman filter to implement. In the proposed adaptive Kalman filter, a moving model is constructed to set the system state model and the result of the moving object detection in consecutive frames is fed back as the measurement for correction. In addition, the estimate parameters of Kalman filter are adjusted adaptively.Kalman filter has two steps:-

- Prediction step

$$s^-(t) = O\ (t-1)\ s^+(t-1)$$
$$P^-(t) = O\ (t-1)\ P^+\ (t-1)\ O\ (t-1)^T + Q\ (t-l)$$

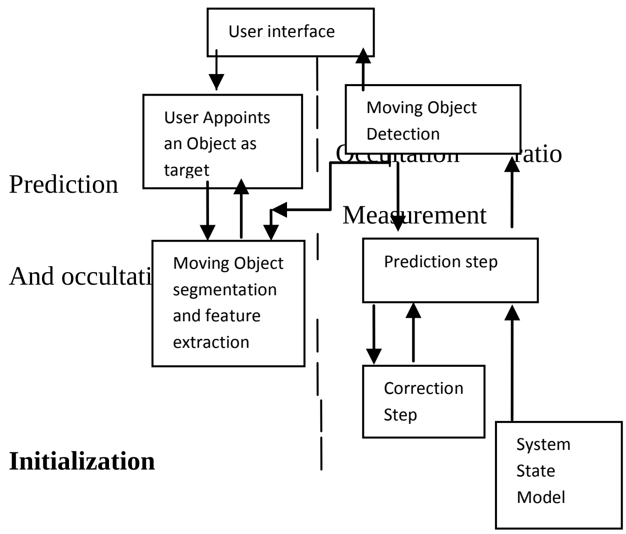
- Correction step

$$K(t)= P^-(t)H(t)^T(H(t)P^-(t)H(t)^T+R(t))^{-1}$$
$$s^+\ (t) = s^-(t)\ K\ (t)\ (z\ (t)-H\ (t)\ s^-(t))$$
$$P^+\ (t) = (I- K\ (t)\ H\ (t))\ P^-(t)$$

where $s^-(t)$ is priori estimate, s^+ (t) is posteriori estimate, $P^-(t)$ is priori estimate error covariance and P^+ (t) is posteriori estimate error covariance

Therefore, the system will get near optimal result, if we can decide which one we will trust. The prediction-correction cycle of Kalman filter is repeated. For developing the proposed adaptive Kalman filter, firstly, the moving model of object is constructed and is used as the system state model of Kalman filter. The moving model will be applied in the prediction step of Kalman filter. Then, for the correction step of Kalman filter, a moving object detection method is proposed.

After constructing the motion model and achieving the measurement by moving object detection, we can apply the adaptive Kalman filtering to track the object in video sequences. The system state model in adaptive Kalman filtering is built by the motion model and it is used in prediction step. The so called adaptive Kalman filter is to let the estimate parameters of Kalman filter adjust automatically. Since the measurement error and occlusion ratio are in direct rate, therefore, in correction step, the occlusion rate is used to adjust the estimate parameters of adaptive Kalman filter.



Adaptive Kalman Filter

Fig3: The Structure of Proposed Method using Adaptive Kalman Filter

According to Equations, the Kalman gain K (t) is in an inverse proportion to the measurement error R(t). If the occlusion rate is less than the threshold, then the value of R(t) is set as occlusion rate a(t) and the prediction error Q(t - 1) is 1 - a(t). Otherwise, it is reasonable to let the measurement error R(t) and the prediction error Q(t-1) be infinity and zero, respectively, thus the Kalman gain K(t) is a zero value. According to the occlusion rate, the Kalman filter system is adjusted adaptively. That is to say, if the occlusion rate is less than the threshold, then the measurement result will be trusted more than predicted one. Otherwise, the system will trust the predicted result completely. By this way, the Kalman filter can be adjusted automatically to estimate the moving object.

Finally, we summarized the proposed tracking algorithm using adaptive Kalman filter again. In the initialization, moving object segmentation and feature extraction are included. First, the frame difference and region growing are used to segment moving object. Then, the dominant color is extracted from the segmented moving object. In the tracking procedure of adaptive Kalman filter, a motion model is constructed to build the system state and is applied to prediction step. In addition, the measurement of system is provided by moving object detection using HSI matching method. In addition, the occlusion ratio is applied to adjust the prediction and measurement errors adaptively. The two errors will make the adaptive Kalman filter system to trust prediction or measurement more and more

Conclusion

In this paper, an effective adaptive Kalman filter is proposed to track the moving object. In the proposed adaptive Kalman filter, the occlusion rate is used to adjust the error covariance of Kalman filter adaptively. The method can track the moving object in real-time. It successfully estimates the object's position in some kinds of real-world situations such as the fast moving object, partial occlusion, long-lasting occlusion, changing lighting, changing the direction and orientation of the moving object, and changing the velocity of moving object suddenly. Furthermore, to consider the situations of tracking multiple objects, every one of multiple objects can be set an adaptive Kalman filter to track it. Since the processing time using the proposed method to track the single object is short therefore, the systems implemented by the proposed method can afford to track multiple objects in real time.

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