Human Movement Tacking using Centroid Weighted Kalman Filter

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Abstract— Video surveillance system supports object classification and object tracking. Object tracking is considered as one of the most important task in video surveillance system. Two key steps in these systems are: detection and frame by frame tracking of object. This paper proposes an illumination-sensitive background modelling approach to detect moving objects. The binary mask of moving objects can be generated by the proposed thresholding function. In the visual object tracking, the Kalman filter produce errors and decreasing estimation precision. In order to enhance the stability, Centroid Weighted Kalman Filter (CWKF) is proposed. The algorithm uses illumination sensitive background subtraction method to detect moving target region, and centroid weighted method to optimize the predictive state value, finally updates observation data according to the corrected state value. This tracking experiment shows that this algorithm can detect effectively moving objects and at the same time it can quickly and accurately track moving objects with good robustness.

Index Terms— Background subtraction, background model, moving object detection, Kalman filter and centroid.

1 Introduction

VIDEO surveillance is a process of analysing video sequences. These Video surveillance systems have significant implications in defence against criminality and terrorist threats in both public and private sectors. Moving object detection aims at extracting moving objects that are interesting out of a background which can be static or dynamic. Since subsequent processes are greatly dependent on the performance of this stage, it is important that the classified foreground pixels accurately correspond to the moving objects of interests.

In general, many background subtraction approaches cannot update the current status of the background image in scenes with sudden illumination change, especially when light is suddenly switched on or off. In this paper, an Illumination-Sensitive Background Modelling approach is used to detect moving objects. For the sudden illumination change, an illumination evaluation is used to determine two background models, including a light background model and a dark background model. Based on these background models, the binary mask of moving objects can be generated by the proposed thresholding function [2].

The goal of object tracking is to locate a moving object in consecutive video frames. Some of the difficulties encountered during object tracking are: the shape and size of the object, object occlusion, presents of noise, blur video, luminance and intensity changes, and object abrupt motion so on [3]. Generally, tracking of moving object has been done using Kalman filter. Here tracking of any object can be done by providing the frame number from which tracking has to be started. From the selected frame any object can be picked for tracking by setting the position of the mask and then the object can be tracked in subsequent frames.

The main objective of this paper is to extract human movements from the video sequence, using Centroid Weighted kalman filter. By using Centroid Weighted Kalman Filter, Centroid of each object is determined for detecting the occlusion and identifying each object separately. Mainly this paper involves two sections, (i) Object detection from video sequences done by using Illumination Sensitive Background subtraction method and (ii) Human movement Extraction using Centroid Weighted Kalman filter.

The remainder of this paper is organized as follows: Section II describes Object Detection, Section III describe Human Movement Extraction, Section IV describe Proposded algorithm for tracking using Centroid Weighted Kalman filter. Section V, presents the methodology and experimental results. Section VI conclude the thesis with the summary and suggestion given for further extension of this work.

2 Object Detection

Background subtraction is a process of extracting foreground objects in a particular scene. Background subtraction involves generating the background model from the video sequence to detect the foreground and object for many computer vision applications. In general, the background model can be generated by temporal average. But many background subtraction approaches cannot update the current status of the background image in scenes with sudden illumination change. This is especially true in regard to motion detection when light is suddenly switched on or off. So an illumination-sensitive background modelling approach is applied to analyse the illumination change and detect moving object.

Mainly illumination sensitive back ground modelling approach includes a Background model module, an Illumination Evaluation module, and an Object Detection module [2]. The Illumination Evaluation module determines two background models, including a light background model and a dark background model for sudden illumination change by using illumination evaluation. According to entropy theory, a dark image possesses a low entropy value due to insufficient luminance of the image content, whereas a light image possesses a high entropy value because of sufficient luminance of the image content. Based on this characteristic, ilumination evaluation module evaluates the change of illumination. Based on the background model and illumination evaluation, the binary mask of moving objects can be generated by the proposed thresholding function. It is done by object detection module.

3 Human Movement Extraction

Human motion analysis concerns the detection, tracking and recognition of people, and understanding human behaviours, from image sequences involving humans. In addition the motion region, includes not only body parts, but also may include moving cars, flying birds, animals, trees and other non-human body parts. Morphological methods are used for further processing. Firstly, most of the non-human body motion regions are filtered out while preserving the shape of human motion without injury, to get more accurate human motion region.

After morphological operations, some accurate edge regions will be obtained. By analyzing the characteristics of motion detection, the projection operator is combined with the shape of human motion. Based on these results, adopting the method of combining vertical with horizontal projection to detect the height and width of the motion region is adopted.[3]. The process flow chart for moving human Tracking is shown in figure 1, and is explained below.This algorithm involves two sections, (i) Object detection sing Illumination Sensitive Background subtraction method and (ii) Human movement Extraction using Centroid Weighted Kalman Filter.

4 Proposed Method

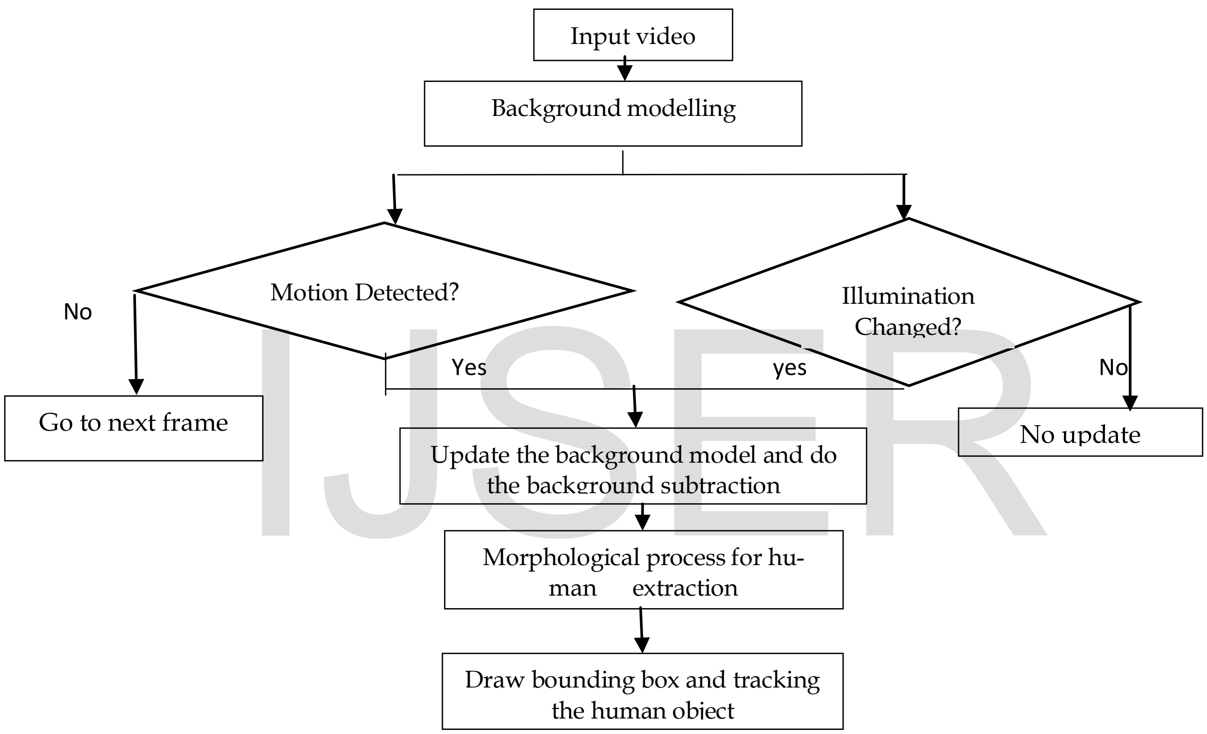

Fig.1. Process Flow Chart for Moving Human Tracking

4.1 Object Detection

The background model can be generated by the running average expressed as equation (1).

$$B_t(x,y) = B_{t-1}(x,y) + \alpha\left(I_t(x,y) - B_{t-1}(x,y)\right) \qquad (1)$$

where $B_t(x,y)$ is the current back groundmodel, $B_{t-1}(x,y)$is the previous background model $I_t(x,y)$is the current video frame, and α represents the adaptive parameter. Note that B_0 is set to I_0 for initialization.The entropy calculation is used to find the illumination changes. The illumination change can be measured as equation (2).

$$A_t = \begin{cases} 1, & if\ |E_t - E_{t-1}| > T. \\ 0, & other\ wise \end{cases} \qquad (2)$$

Where T represents the adjusted threshold which can be empirically set to 0.05. Note that A_t equals one to indicate the sudden illumination change. ,Then the background candidates can be updated by thfollowing function:

$$B_t = \begin{cases} B_{light}, & if\ m(B_{light}) < m(B_t) \\ B_{dark}, & if\ m(B_{dark}) > m(B_t) \end{cases} \qquad (3)$$

Where B_{light} is the light background candidate, $B_{dark}$is the dark background candidate, $m(B_{light})$ is the mean luminance of B_{light} and, $m(B_{dark})$is the mean luminance of B_{dark} , and$m(B_t)$is the mean luminance of B_t. After generating the illumination-sensitive background model, absolute difference $\Delta_t\ (x,y)$can be calculated between the incoming video frame$I_t(x,y)$ and the background model$B_t(x,y)$ as equation (4).

$$\Delta_t\ (x,y) = |B_t(x,y) - I_t(x,y)| \qquad (4)$$

For each video frame $I_t(x,y)$, the binary mask of moving objects $D_t(x,y)$ can be generated as equation (5).

$$D_t(x,y) = \begin{cases} 1, & if\ \Delta_t\ (x,y) > V_t(x,y) \\ 0, & other\ wise \end{cases} \qquad (5)$$

Where $V_t(x,y)$ represents the threshold value, $D_t(x,y)$equals 1 to represent a motion pixel and equals 0 to represent a background pixel. Note $V_0(x,y)$that is empirically set to twenty for initialization[2].

4.2 Human Tracking Using Centroid Weighted Kalman Filter

The algorithm firstly uses background subtraction method to detect moving target region, and then uses the Kalman filter to predict target position, combining centroid weighted method to optimize the predictive state value and finally updates observation data according to the corrected state value.

Suppose the probability of the pixels of gray level u is $\hat{q}_u$ in the n^{th} frame, and $M^n{}_u$ is the centroid of the pixels within the tracking region, then the Eqn.6 and Eqn. 7ar e given by:

$$\hat{q}_u = \frac{n_u}{N} \qquad (6)$$

$$M_u^n = \frac{\sum_1^n S_{i6}\ \delta[b(s_i) - u]}{\sum_i^n \delta[b(s_i) - u]} \qquad (7)$$

where *u (u = 1, 2, ..., m)* is the value of the pixel, $\{s_i\}$ is the sample point in *d*-dimensional space R^d, and $\delta(.)$ is the unit impulse function. $\delta[b(S_i) - u]$ is used to determine whether the value of $b(s_i)$ is equal to *u*. In the equal case, its value is one, otherwise its value is zeros. n_u is the number of the pixels of gray level *u*, and *N* is the number of all pixels within the tracking region.If the centroid distributions of the pixels of the same gray level are seen as random variables, the mathematical expectation of the centroid position is given by Eqn. 8.

$$E(M_u^n) = \sum \hat{q}_u M_u^n \qquad (8)$$

If the probability of the pixels is bigger, the weighted value of the centroid position is also bigger. So the mathematical expectation of the centroid of all the pixels within the tracking region is closer to the centre position of the target and it reflects position condition of most pixels in the region. Therefore, the position of the target is expressed by the Eqn.9.

$$\hat{s} = \sum_{u=1}^{m} \hat{q}_u M_u^n \qquad (9)$$

Since most of edge pixels are background pixels and are also easily subject to be covered with noise interference, the middle pixels are relatively stable. Therefore, the distance from the pixel to the centre point is used as the basis of the distribution of weighted value. The weighted value of the pixel which is closer to the centre point is bigger, conversely it is smaller. The set of weighted value increases the robustness of estimations.The algorithm implemented in Centroid Weighted Kalman Filter for tracking objects from the video frames is shown in Fig.2. After the centroid weighted method, the expected mean $\ddot{S}_{t+1|t}$ is closer to the true trajectory. Therefore, doing linear processing to the updated expected mean $\ddot{S}_{t+1|t}$ for obtaining the measure of $\ddot{S}_{t+1|t+1}$ that is as the reference will be more accurate [4].

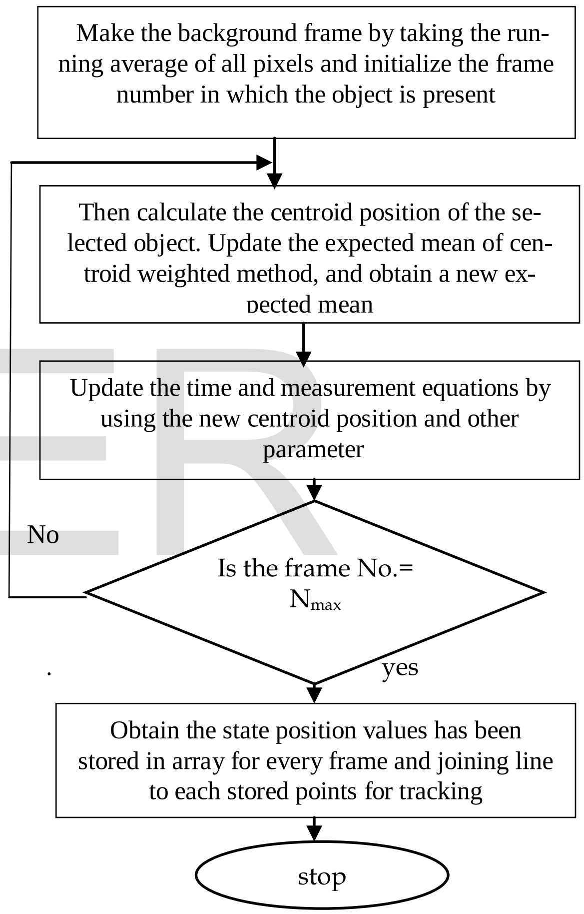

Fig.2. Tracking algorithm

5 EXERIMENTAL RESULT

In order to verify the algorithm's feasibility and effectiveness, this paper has executed a tracking experiment. In the experiment, the computer is configured to Pentium 4, 2.8G, memory 768 M running window 7operating system, and the size of 283-frame image sequences is 320X240. And set the system' state transition matrix and measurement matrix as.

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$$A=\begin{bmatrix}1 & 0 & dt & 0\\ 0 & 1 & 0 & dt\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix} \quad \text{and} \quad H=\begin{bmatrix}1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\end{bmatrix}$$

In the tracking process of moving object, a bounding box is used to track the positions using Centroid weighted Kalman filter. The object tracking process shows that this algorithm can be capable of accurate, tracking. Fig. 3.shows the implementation result of proposed method.

(a)

(b)

Fig.3. (a). Input Video, (b) Tracking output

In general, the accuracy of binary mask of detected object was usually done by calculating the '*Recall*' and '*Precision*' functions[1][2]. The percentage of true positives in the detected motion mask can be evaluated using the Recall function as follows:

$$Recall=\frac{t_p}{t_p+f_n} \qquad (10)$$

where t_p is the total number of true positive pixels in the motion mask, f_n is the total number of false negative pixels in the motion mask, and (t_p+f_n) indicate the total number of true positive pixels in the reference frame. On the other hand, *Precision* presents the effect of false positives in the detected motion mask. The *Precision* function can be expressed as:

$$Precision=\frac{t_p}{t_p+f_p} \qquad (11)$$

Where *fp* is the total number of false positive pixels in the motion mask and *(tp + fp)* indicates the total number of positive pixels the detected motion masHowever, a motion mask with all positives can generate the highest *Recall* value and a motion mask with only one true positive can generate the highest *Precision* value. Thus, simply using *Recall* and *Precision* alone cannot supply an objective measurement. To solve this problem, *Recall* and Precision can be mixed to form the hybrid metrics: F_1 and *Similarity* can be expressed as follows:

$$F_1=\frac{2(Recall)(Precision)}{Recall+Precision} \qquad (12)$$

$$Similarity=\frac{t_p}{t_p+f_p+f_n} \qquad (13)$$

All metric-attained values range from 0 to 1, with higher values representing better accuracy.

In order to find the efficiency of the proposed algorithm various video sequences were applied and evaluate the processing time of the motion detection is shown in table 1. Tracking time typically involves matching objects in consecutive frames using features such shape, size, etc.

TABLE 1
THE PROCESSING TIME OF TEST VIDEO SEQUENCES

Test video Sequence	Frame Numbers	Tracking Time (Seconds)
Video 1	25	0.252
Video 2	80	0.588
Video 3	283	1.943

6 CONCLUSION

This paper proposes an algorithm based on Illumination Sensitive Background Subtraction method and centroid weighted kalman filter for human movement detection and tracking. In the experimental simulation, the algorithm shows good and real time tracking stability. The algorithm uses two background models to detect the foreground with the help of Illumination evaluation. If the expected mean of tracking object is closer to the expected mean of object in the reference frame, then the updating in linear fashion and the result will be more accurate. The proposed approach also calculates the adaptive threshold values according to the change in illumination and to apply two criterions for tracking human body. The occlusion has also been dealt effectively by using Centroid calculation of moving object. Experimental results indicate that the proposed approach attains the most satisfactory outcome by the observation.

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Moreover, the proposed approach can be easily implemented in embedded systems with limited resources.

6 REFERENCES

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