A Fast Basketball Tracking Method Using Kalman Estimates In High Definition Videos

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ABSTRACT: For sports, application software on computer visions are used. These methods were used to identify, track and locate objects. Especially in sports, player and ball detection are major tasks required. The detection and tracking of basketball is done using several methods in literature. In this paper a kalman based basketball tracking method is used. The method finds efficient and immune to noise as observed from the experimental results. The implementation was done in Matlab.

Keywords: Ball Tracking, Basketball, Detection, Video, Kalman Filter, Games,

1. INTRODUCTION

Computer visions were used in recent time applications like sports, military, manufactory. Vision based object tracking in the real time environment is popular research topic and robust vision tracking are used in autonomous system, surveillance systems, vehicle navigation, and traffic monitoring [1,2,3]. Object detection method use color, feature points. Speeded Up Robust Feature (SURF) method and Scale Invariant transform Feature (SIFT) tracker has been used to detect multiple objects [4,5]. Color based methods are Mean-shift [6,7,8] and color distribution [9]. These methods require less processing time but compared to previous methods the accuracy is limited. Robustness and resistance are features detected in images with different lighting conditions and blurriness [10]. Computational time is to be measured. The object detection process is to be fast [11,12]. For success rate, accuracy, and repeatability, in this paper kalman filter based algorithm of fast and accurate visual object tracking is presented. The algorithm is designed to improve object-tracking

2. LITERATURE SURVEY

3. Object Tracking

In basket ball tracking, the movement of the projection of ball in video frame plane is identified by object tracking. The different types are Region-based methods, Contour-based methods, Feature point-based methods and template-based methods. The application extends on movement checking, human workstation connection, robotized observation. The object tracking system face challenges, when the image is noisy, complex movement and faster movement. In basketball the same issues happen. So method to be adopted should handle this issue.

4. KALMAN FILTER BASED OBJECT TRACKING

Kalman filter has Gaussian distribution for linear estimates [13]. This recursive solution for linear filtering in discrete data provides estimation at past, present, and future time domains. It also estimates the state while the model and the nature of the system is not known precisely [14]. 1) The Kalman Filter in discrete time mode is shown in Figure 2 has prediction step and correction step. The filter estimates the state in the prediction step. The current state in the prediction step determines the next estimate. In prediction step, the next state is estimated in advance based on current state projection. The prior estimation is improved in correction step. Feedback of results is utilized in the process of estimation.

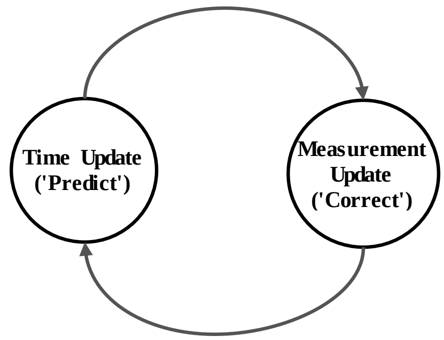

Figure 1: Basic operation of the Kalman filter

A. Prediction Step

The future state and prediction covariance expression is given in Eq. (1) and 2 [15]. The prediction of $(\bar{X}(k+1|k))$ is done using process model **F** and the current state $(\bar{X}(k|k))$. Similarly the calculation of the prediction covariance (P(k + 1|k)) done using process model F and the uncertainty of the process model (Q(k)).

$$(\bar{X}(k+1|k)) = F\,\bar{X}(k|k) \tag{1}$$

$$P(k+1|k) = FP(k|k)F^T + Q(k) \tag{2}$$

B. Correction Step

In correction step, or 'measurement update' step, the predicted state is corrected based on the difference between the real and the expected measurement result $\bar{Z}_{k+1}$ from the measurement model (H) given by Eq.3

$$\bar{Z}_{k+1} = H\,\bar{X}_{k+1} \tag{3}$$

The difference (v) between the real and the measurement model is calculated in Eq. (4). The Kalman gain, K, is then calculated to update the estimated state $\bar{X}_{k+1|k}$ to become $\bar{X}_{k+1|k+1}$. The complete calculation of this correction step is expressed in Eq. (5) to Eq. (7) [13].

$$V_{k+1} = Z_{k+1} - \bar{Z}_{k+1} \tag{4}$$

$$K_{k+1} = P_{k+1|k} H^T (HP_{k+1|k} H^T + R_{k+1|k})^{-1} \tag{5}$$

$$\bar{X}_{k+1|k+1} = \bar{X}_{k+1|k} + K_{k+1|k} . V_{k+1} \tag{6}$$

$$P_{k+1|k+1} = (1 - K_{k+1} H) P^{-}_{k+1|k} \tag{7}$$

C. Kalman Filter for Object Tracking

The object tracking methods needs fast to analyze high definition videos. For basketball detection the efficiency on video processing and immunity towards noise is to be maintained. Video analysis is done through kalman filter based object detection, frame by frame tracking of the detected object and visualization.

Kalman filter predicts the next position of the object from the previous state information and the prediction is verified. Object was assumed to move with constant velocity, but the velocity varies between every attempt.

The model is given by,

$$X_{k+1} = X_k + \Delta X$$

$$Y_{k+1} = Y_k + \Delta Y \tag{8}$$

Δx, Δy are constants.

$$\begin{bmatrix} x_{k+1|k} \\ y_{k+1|k} \\ \Delta x_{k+1} \\ \Delta y_{k+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_{k|k} \\ y_{k|k} \\ \Delta x_k \\ \Delta y_k \end{bmatrix}$$

$$F = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{9}$$

The expected measurement result can be calculated as expressed in Eq. (10).

$$\bar{z}_{x(k+1)} = x_{k+1}$$

$$\bar{z}_{y(k+1)} = y_{k+1} \tag{10}$$

From Eq. (10), the measurement model can also be expressed from Eq. (3) to become Eq. (11).

$$\begin{bmatrix} \bar{z}_x \\ \bar{z}_y \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_{k+1|k} \\ y_{k+1|k} \\ \Delta x_{k+1} \\ \Delta y_{k+1} \end{bmatrix}$$

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \tag{11}$$

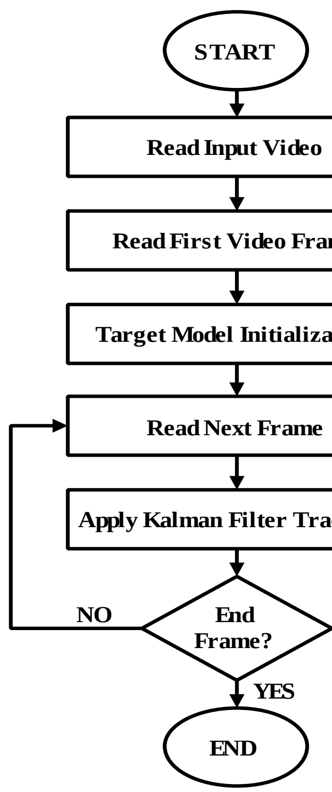

Figure 2: flow chart for kalman filter tracking

5. RESULT AND DISCUSSION

Matlab tool is used to implement, test and verify the experiments. Basketball game dataset is taken from internet. The object to be tracked is given as shown in fig 3. Object tracking is done using kalman filter. Fig 4 shows the ball tracked in video frames.

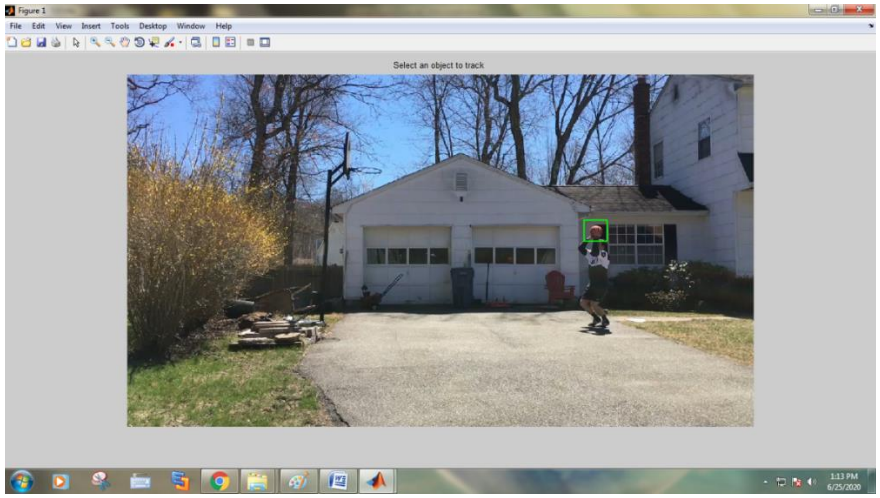

Figure 3: object to be tracked

Figure 4: ball tracked in different frames in a video

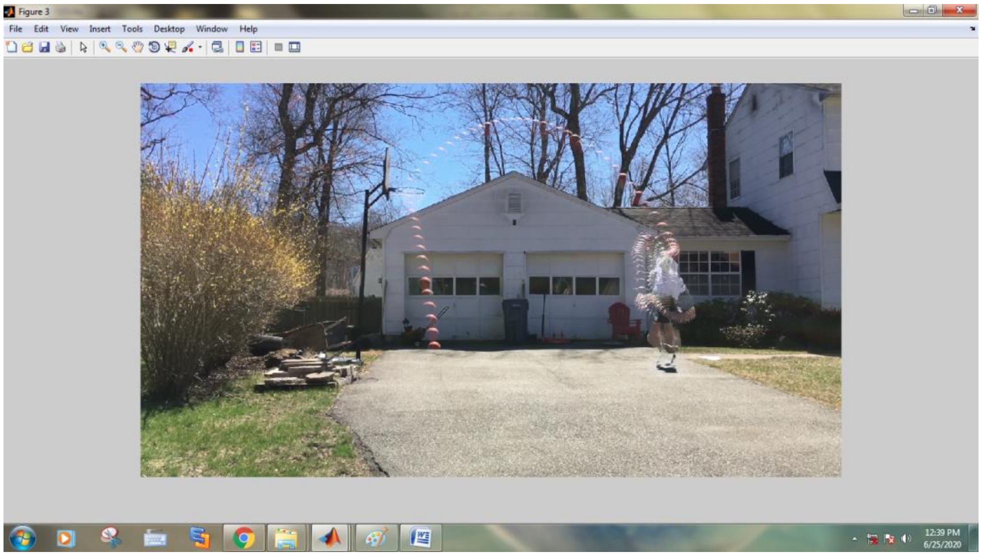

Figure 5: Object tracking and trajectory using kalman filtering

A trajectory (state) is the path that a moving object follows through space as a function of time .Fig 5 show the path of the ball movement.

Performance Analysis

The performance analysis of the proposed MTMS method is studied by the statistical measures by sensitivity, specificity and accuracy.

$$Sensitivity = \frac{TP}{TP + FN} \tag{12}$$

$$Specificity = \frac{TN}{FP + TN} \tag{13}$$

$$Accuracy = \frac{TP + TN}{Total\ \ Frames} \tag{14}$$

- True positive (TP): ball exists on the frame and correctly tracked as present.
- False positive (FP): ball does not exist on the frame image but pointed as present.
- True negative (TN): ball does not exist on the frame image and correctly viewed as not present.
- False negative (FN): ball exists on the image but noted as not present.

Table 1: Performance table

Parameters	Kalman filter tracking
Total Frame (TF)	80
True Positive (TP)	60
False Negative (FN)	15
False Positive (FP)	0
True Negative (TN)	5
Sensitivity (%)	80
Specificity (%)	100
Accuracy (%)	81.25

The table 1 presents the performance of algorithm for the video sequence.

CONCLUSION

In this paper, the problem of ball tracking through object detection is addressed. Even though several methods are used in literature, these methods find itself better towards detection of basketball on noise environment. The Kalman based object tracking method is found efficient from the results obtained. The results are obtained using MATLAB software.

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