Real Time Object Tracking Using Kalman Filter

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Abstract

Basically, object detection and object tracking are two important and challenging aspects in many computer vision applications like surveillance system, vehicle navigation, autonomous robot navigation, compression of video etc. Object detection is first low-level important task for any video surveillance application. Tracking is required in higher level applications. In this proposed work, detection of the moving object has been done using simple background subtraction and tracking of moving object has been done using Kalman filter. Various images are also obtained in the paper such as dilated image, difference image, gray images etc. Tracking algorithm have been implemented and tested on Matlab 2013a (64 bit) with operating system windows7.0

Keywords: Kalman filter, posteriori, covariance, estimate

I.   INTRODUCTION

Ease Object tracking is important task in computer vision. It has vast applications which include traffic monitoring, vehicle navigation, finance, medical and video encoding. Kalman filter is traditionally widely used in navigation for position and other parameter estimation. Exploring on concept of how Kalman filter works, it can be potentially explored for other domain such as signal analysis for detection. Kalman filter estimates reduce the error in process/estimate covariance. Kalman filter is used

for purpose of tracking filter because of less amount of information on moving object and its noise variances.

II.   KALMAN FILTER

It is an interactive mathematical process that uses a set of equations and consecutive data inputs. To quickly estimate the true value position, velocity etc. of the object being measured, when the measured value contains and unpredicted. A Kalman filter is an optimal recursive data processing algorithm. Assumes that variables being estimated are time dependent. Good results in practice due to optimality and structure. The convenient form for online real time processing. Easy to formulate and implement given a basic understanding.
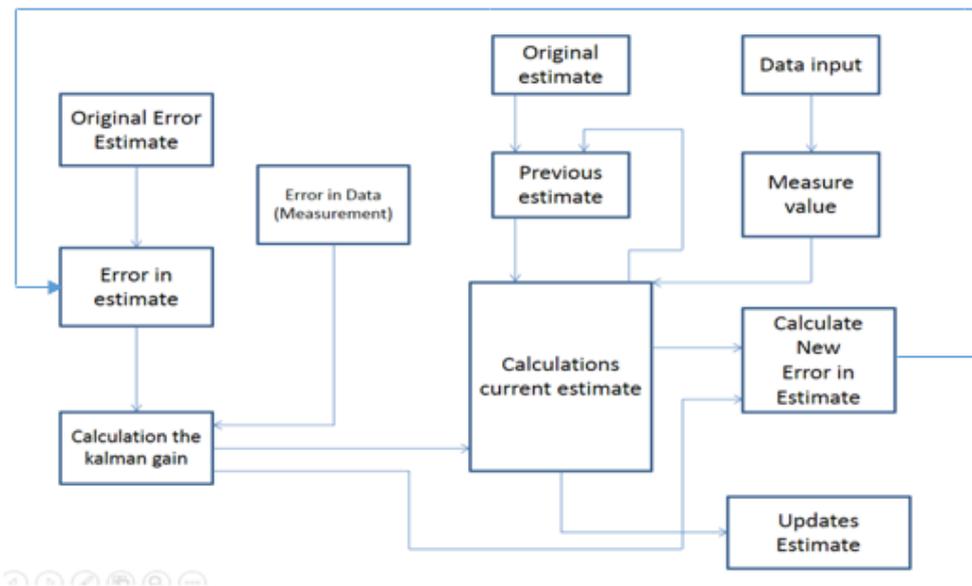

Fig. Block Diagram of Kalman Filter

A.   USAGE

 s = kalmanf(s)

 "s" is a "system" structure containing various fields used as input and output. The state estimate "x" and its covariance "P" are updated by the function. The other fields describe the mechanics of the system and are left unchanged. A calling routine may change these other fields as needed if state dynamics are time-dependent; otherwise, they should be left alone after initial values are set. The exceptions are the observation vector "z" and the input control (or forcing function) "u." If there is an input function, then "u" should be set to some non-zero value by the calling routine.

B. *SYSTEM DYNAMICS*

The system evolves according to the following difference equations, where quantities are further defined below:

$$x = Ax + Bu + w$$

meaning the state vector x evolves during one time step by premultiplying by the "state transition matrix" A. There is optionally (if nonzero) an input vector u which affects the state linearly, and this linear effect on the state is represented by premultiplying by the "input matrix" B. There is also gaussian process noise w.

$$z = Hx + v$$

meaning the observation vector z is a linear function of the state vector, and this linear relationship is represented by premultiplication by "observation matrix" H. There is also gaussian measurement noise v.

Where ;

w ~ N(0,Q) meaning w is gaussian noise with covariance Q

v ~ N(0,R) meaning v is gaussian noise with covariance R

C. *VECTOR VARIABLES*

- s.x = State vector estimate. In the input structure, this is the "a   priori" state estimate (prior to the addition of the information from the new observation). In the output structure; this is the "a posteriori" state estimate (after the new measurement information is included).

- s.z = Observation vector

- s.u = Input control vector, optional (defaults to zero).

D. *MATRIX VARIABLES*

- s.A = State transition matrix (defaults to identity).

- s.P =Covariance of the state vector estimate. In the input structure, this is "a priori," and in the output it is "a posteriori.

- s.Q = Process noise covariance (defaults to zero).

- s.R = Measurement noise covariance (required).

- s.H = Observation matrix (defaults to identity).

E.   INITIALIZATION

If an initial state estimate is unavailable, it can be obtained from the first observation as follows, provided that there are the same number of observable variables as state variables. This "auto- initialization" is done automatically if s.x is absent or NaN.

$$x = inv(H)*z$$

$$P = inv(H)*R*inv(H')$$

III.   OBJECT TRACKING SYSTEM ALGORITHM

First, Initialize camera at Matlab so, image of desired object can be detected. Trigger the camera and camera start capturing frames. Command camera to capture background image. Select the boundary of desired object and locate the center of the object and also obtain rectangular region of tracking. Then, define all state definition fields: A,B,H,Q,R. Define initial state estimate: x,P. Obtain observation and control vectors: z,u. Call the filter to obtain updated state estimate: x,P. Calculate center of target and new vector for every frame of the target. This process is continued until exact center of tracking has been realized then, Kalman filter starts predicting and correcting new position. Hence, an estimated track of an object is achieved.

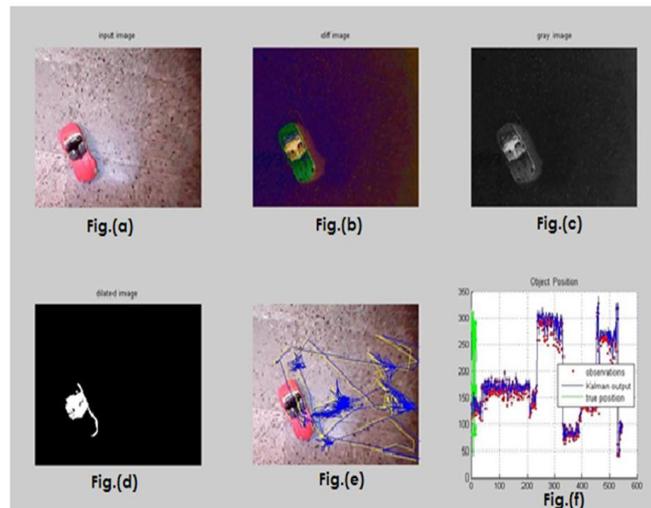## IV.   EXPERIMENTAL RESULT

Fig.(a) is a frame which shows object image captured from video sequences. Fig.(b) is a difference image obtained from subtraction of input and background image. Fig.(c) is a gray image of desired object. Fig.(d) shows diluted image. Fig.(e) is a frame shows object tracking and Fig.(f) shows observation, Kalman output, true position values of tracked object in a graph.
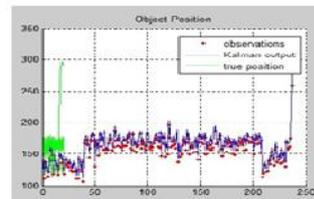
Object Image
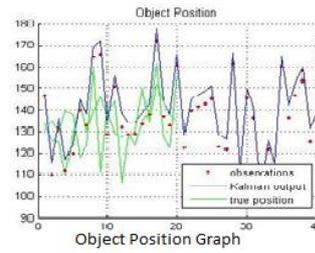
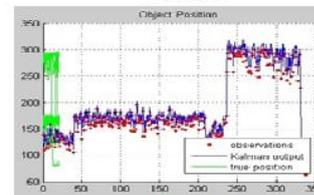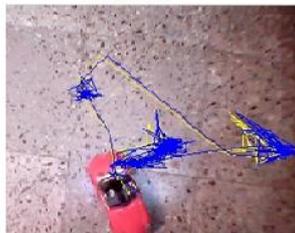
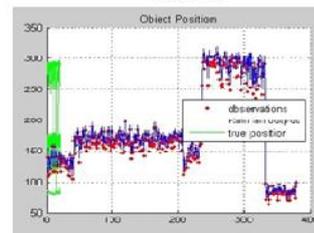Object Position Graph

Position: 1

Graph: 1

Position: 2

Graph: 2

Position: 3

Graph: 3

Above figures show object tracking at various positions and their respective graphs. Graphs show observation value, true value and Kalman output of object.

V. CONCLUSION

This approach can help to achieve real-time object tracking. The algorithm provided uses centroid of the object and best Kalman filter estimation for object track. In the program, a posteriori state estimate helps to achieve all parameter required for tracking.

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