A REAL TIME SYSTEM FOR TRAFFIC MONITORING BY USING KALMAN FILTER

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ABSTRACT

Real time video vehicles' tracking is very important in the intelligent traffic monitoring system. This is because of the monitoring system provide the useful information for the government to develop a high quality road system that can reduce and prevent accident or congestion. The challenging of development system is to detect the vehicle track and monitor the vehicle movement in real time condition. Therefore, Kalman filter is used for detecting vehicle in a different lighting condition (with and without shadow) and wireless sensor network (WSN) for transmitting real time video to the computer as an input. Then, real time video is a process via MATLAB which Kalman filter is running for detecting moving vehicle. Based on the algorithm developed, this study conducted the test on the road inside university. The results show that the algorithm can detect a moving vehicle appropriately.

KEYWORDS: *Traffic monitoring; real time video; Kalman filter; wireless sensor network; vehicle tracking*

1.0 INTRODUCTION

Recently, Traffic Monitoring Systems (TMS) using real time visual tracking system has drawn increasing attention due to the tangible advances in the field of computer vision. In normal practice, a real time traffic data used for increasing traffic efficiency such as by providing real-time information on traffic condition around the city in order to know the incidents and the traffic congestion area. By knowing this information, users can re-routing the traffic through less congested area and the traffic lights timing cycles can be adjusted based on traffic flow in the monitoring area. Beside that, a real time traffic data also have been used as an input in simulation tools for traffic impact studies and urban planning (Aissaoui et al., 2014).

At present, available systems rely on specific sensor and device such as magnetic loop, pressure tubes, radar gun and microwave sensors which are very costly to be installed in the monitoring area (Zhang et al., 2011; Borkar & Malik, 2013). Thus, a real time system approach using a Kalman filter algorithm to detect moving object and wireless sensor network (WSN) for transmitting live streaming video from camera to computer is

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proposed. It involved several processes to detect moving objects such as digital image processing, video processing, pattern recognition, template matching and so many related fields of knowledge. All the processes are used for estimating the trajectory of an object in the image plane as it moves around a targeted area and the tracking problem can be seen as a state estimation one (Bar-Shalom & Fortmann, 1988; Khan et al., 2010; Lee & Chen, 2011).

Therefore, Kalman filter which uses the state model to predict the target state is selected method for solved the problem that exist since the Kalman filter is known as one of the effective state estimation methods (Fu & Han, 2012; Mo et al., 2016; Csank & Connolly, 2016. While, by using WSN technology, it enables the development of low cost, low power, multifunctional and wireless sensor structures that are small and able to communicate over short distance (Ng et al., 2009).

2.0 METHODOLOGY

2.1 Vehicle Detection Algorithm Based on Kalman Filter

The Kalman filter algorithm used for a dynamical model working by calculating the covariance and gain matrices of the filter. By using these matrices, the updated dynamical system state is recursively computed from the previous estimate and new input data signals which can estimate the past, present and future states. The main function of this filter is for minimizing the mean of the squared error. The Kalman filter is separated into two main groups of equation, time update equations and measurement update equations. For time update equations, it calculates the current state by projecting forward in time and error covariance estimates. Meanwhile, for measurement update equation, it deals with a new measurement into the a-priori estimate to gather an improved a posteriori estimate. The time update equation has operated as predictor equation, while the measurement update equation is operated as corrector equation. The basic Kalman filter cycle is shown in Figure 1 while the symbols and their respective definitions are given in Table 1.

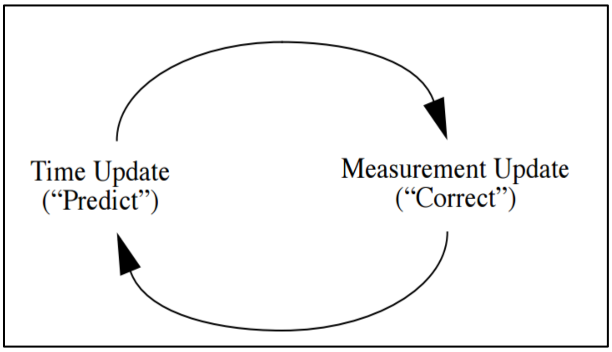

Figure 1. Kalman filter cycle (Kalman & Bucy, 1961; Welch & Bishop, 2006).

The time update is represented by Equation (1) and Equation (2):

$$\hat{x}_{\bar{k}} = A\hat{x}_{k-1} + Bu_{k-1} \tag{1}$$

$$P_{\bar{k}} = AP_{k-1}A^T + Q \quad (2)$$

While, the measurement update equations are defined as Equations (3) to (5):

$$K_k = P_{\bar{k}}H^T(HP_{\bar{k}}H^T + R)^{-1} \quad (3)$$

$$\hat{x}_k = \hat{x}_{\bar{k}} + K_k(z_k - H\hat{x}_{\bar{k}}) \quad (4)$$

$$P_k = (I - K_kH)P_{\bar{k}} \quad (5)$$

Table 1. Kalman Filter Notation

Symbols	Definition
A	State transition matrix.
B	Control matrix. This used to define linear equations for any control factors.
u_k	Control vector. This indicates the magnitude of any control system or user's control on the situation.
P_k	Newest estimate of the average error for each part of the state.
$\hat{x}_k$	Newest estimate of the current "true" state.
z_k	Measurement vector. This contains the real-world measurement we received in this time step.
H	Observation matrix. Multiply a state vector by H to translate it to a measurement vector.
R	Estimated measurement error covariance. Finding precise values for Q and R are beyond the scope of this guide.
Q	Estimated process error covariance. Finding precise values for Q and R are beyond the scope of this guide.
K_k	Kalman gain
I	Identity matrix

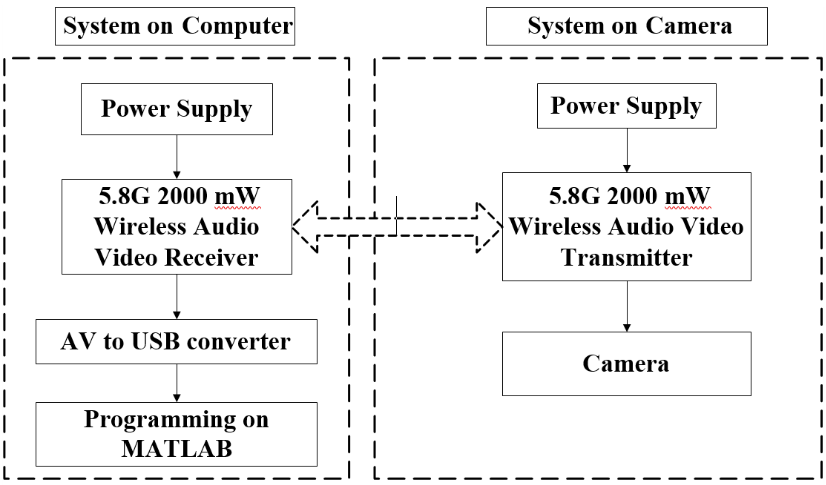

Figure 2. WSN structure

2.2 Real Time Visual Tracking System

Wireless Sensor Networks (WSN) make a human easy to collect, interpret and act on real time data gains which is can be used to monitor physical or environmental conditions. The components of WSN are smart sensors, which are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. These sensor nodes can exchange information between an application platform and one or more sensor nodes by sense, measure, and gather information from the environment (Sasikumar et al., 2009). In this research, the sensor that used is a camera, which connects with 5.8 G 2000 mW wireless audio video transmitter. The transmitter will transmit the real time video to 5.8 G 2000 mW wireless audio video receiver, which connects to the computer. On a computer, the Kalman filter algorithms that build in MATLAB program will process the video in order to detect moving vehicles. The complete system is shown in Figure 2.

2.3 Field of Experiment

The real time videos have been captured on the road inside the Engineering Campus, Universiti Sains Malaysia which the road trend is less congested as shown in Figure 3. The reason of selecting the road inside university is for testing the algorithm whether it can detect moving objects properly or not. Hence, in future, the algorithm will be tested in the highway, which the road is more congested. Furthermore, the algorithm also will improve to detect multiple objects since the algorithm that testing here is only can detect single object.

Figure 3. Testing Field **(**Engineering Campus, Universiti Sains Malaysia)

3.0 RESULTS AND DISCUSSION

The algorithm of the Kalman filter is running via MATLAB programming on a computer which integrated with 5.8G 2000 mW wireless audio video receiver and the input of real time video is gathered from the 5.8G 2000 mW wireless audio video transmitter that connect to the camera. The results of running the program are shown in Figure 4 and 5 respectively. As shown in Figure 4, the panorama condition is clearer than in Figure 5 since in Figure 5 there is the shadow of the tree. However, in both sequence images, the algorithm can detect moving object as desired instead in Figure 5, there are delay of prediction (blue and red box not overlapping).

Blue box represents the algorithm based on background subtraction for detecting object. However, by using background subtraction, it only finds a portion of the vehicle because the low contrast between the color of the vehicle and the color of the surrounding area. In other words, the detection process has a noise and not ideal. Therefore, the Kalman filter which represents by red box is used in order to improve the accuracy for detecting moving objects. When the vehicle is detected by Kalman filter, the process that happened has predicted the vehicle state of current video frame, and then uses the newly detected vehicle location to correct its state. This produces more appropriate results even though there is shadow on that image.

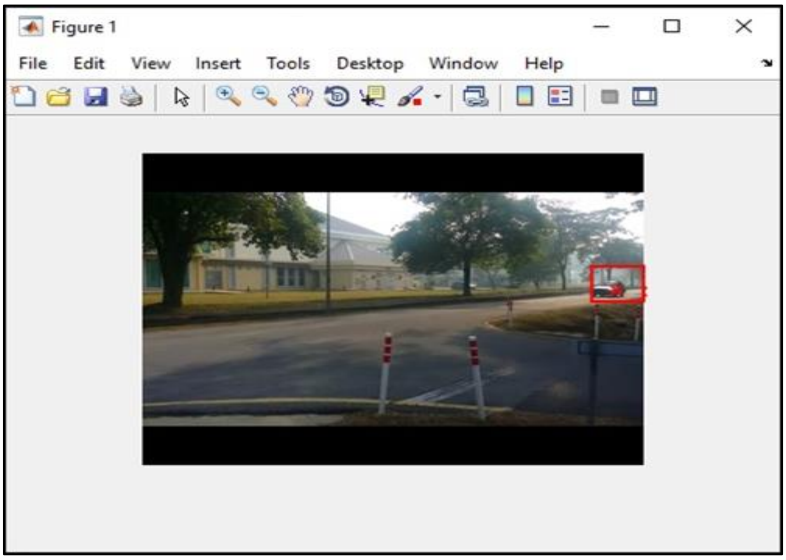

Figure 4. Detecting vehicles with perfect lighting

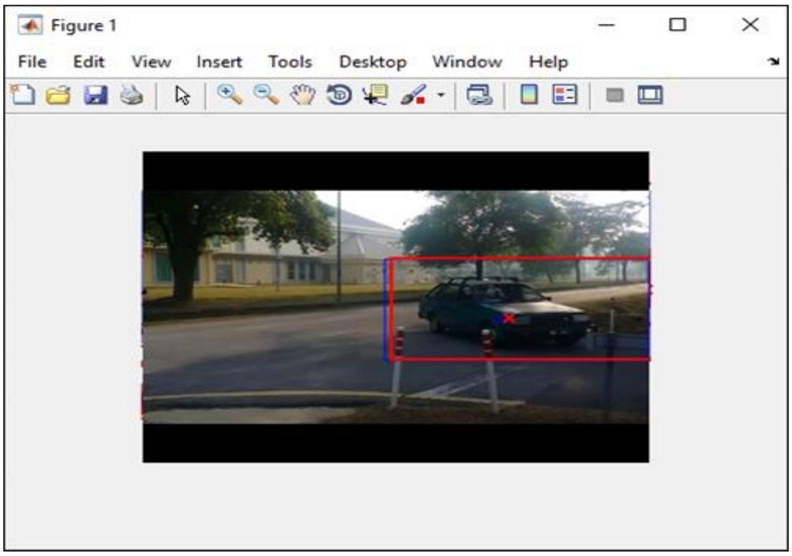

Figure 5: Detecting vehicles in shadow of tree

4.0 CONCLUSION

In this study, a real time system for detecting of the moving vehicle and tracking it has been presented. Due to the results, the algorithm that has been implemented for tracking a single vehicle which used road inside university has been successfully running using Kalman filter. The system works on videos with the various lighting condition. The input to run the algorithm captured from real time video transfer to computer using WSN. The program that developed is smoothly running on the computer and can detect the moving vehicle. In future, this research can be expanded by developing the algorithm which can detect multiple vehicles, verify each type of vehicles and count it so that it can be used effectively to developed intelligent traffic monitoring system.

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