International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Driver Fatigue detection By Kalman Filter And Mean Shift Using Two Cameras

Abhishek Bardwaj[a*] and Rishi Kumar[a]

[a]Amity School of Engineering and Technology, Amity University, Noida, India

Accepted 27 May 2013, Available online 1June 2013, **Vol.3, No.2 (June 2013)**

Abstract

Now a day the numbers of road accidents are increasing due to lessened acuity and diligence level of driver. How to avoid this has become a problem of serious concern. In order to detect and remove this cause of road accident development of driver fatigue detection methods have evolved as a good topic for researchers. Thus in last year's many such systems have been proposed which can detect the mind state of driver such as drowsiness or inattention, for generating some warning alarms to alert the driver. In this paper we have discussed the results of few methodologies of the Fatigue Detection system proposed by us that can improve the results of the earlier discussed methods used in designing many Fatigue detection systems.

Keywords: *Driver Fatigue Detection; Kalman Filter; Mean Shift*

1. Introduction

In the last 10 years the numbers of road accidents due to driver's fatigue are increasing constantly. For many countries all over the world it has become a serious topic of concern. It is the time to pay attention to driver safety problem and to investigate the mental state of driver relating to driver safety.

Most important reasons of traffic accidents are driver's state of mind and fatigue. Drivers with a diminished diligence level suffer from a marked decline in their abilities of perception, recognition, and vehicle control, which poses serious danger to their own life and the lives of other people.

According to (Abhishek Bhardwaj et al,2013), the study says that in France, 20.6 percent of accidents causing death are fatigue related. If with time solutions are provided and suggested this problem will increase with time.

In the recent years many systems and methods which can detect tiredness, drowsiness or inattention of the driver have been proposed by researchers and few of them have been implemented.

But, despite the successful proposal and designing of these systems, the existing systems are not successful in detecting the real state of mind of the driver. There are many reasons for the uneven results of the earlier proposed systems. It has become a challenging issue to detect the state of mind of the driver in the real environment and the realistic light condition.

The one of the main reason is the variety of eye moving speed of driver, external illumination interference and realistic lighting conditions. In the realistic light condition the motion of eye is highly nonlinear. So the detection of fatigue in realistic light or bright light using the system based on method which consider only linear movement of driver become a difficult task .

In this paper we have discussed a fatigue Detection System which can work and can give positive output in the realistic light condition also. This system can detect the movement of eye of the driver also.

In order to support the proposed system, we have first discussed the methodologies used in earlier proposed systems and then have provided the output of the each method discussed. The output provided itself shows the need of the proposed system.

The system proposed by other researchers have used the discussed method separately but our proposed system is the combination of these methods it means it takes the advantages of all the methods and provides the better results.

Further sections are organized as: description of the methodologies, Results of the discussed method, Proposed methods in section II, III and IV respectively. Finally the future work and a conclusion of the discussion are provided in last section.

2. Methodologies used in previous systems

There are various different techniques used for Eye

Abhishek Bhardwaj is M.Tech student and **Rishi Kumar** is working as Asst. Prof., *Corresponding author: Abhishek Bhardwaj

tracking these various techniques are classified into main three categories (Zutao ZHANG et al,2010). These techniques are being classified based on the way they contact to the user. These three categories are *Measuring Light Reflectance Technique, Electric Potential of the Skin* and *the third is Contact Lenses*. Thus the technique that developers use in designing their system belongs to one of these techniques but generally the developers use the techniques of first categories. Further discussing the first category there are four different eye tracking techniques which use the light reflected from the eye. These four techniques are

1. *Limbus tracking* in this technique the Limbus of eye is tracked. The Limbus is the boundary between the white sclera and dark iris.
2. *Pupil Tracking* in this technique the boundary between the pupil and the iris is usually used for tracking.
3. *Purkinje Images Tracking* in this technique the Pukinje images are used for tracking. These images are the different reflections from the boundaries of the lens and cornea.
4. Corneal Reflections Tracking

Generally the developers make use of the Pupil tracking technique in their systems. On further discussion, There are various filters used for detecting the location ad movement of the eye. These filters are discussed in brief in the subsections of this section.

A. Eye detection using kalman Filtering

The Kalman filtering based fatigue detection system make use of a special IR illuminator that illuminates the face of a person and use an IR-sensitive camera to acquire an image of the face. After locating the eyes in the initial frames, the Kalman filtering is activated to track bright pupils.

According to (Abhishek Bhardwaj et al,2013), the motion of a pupil at each instance can be described using its position and velocity. In order to understand this, let (s_t, r_t) parameters be the horizontal and vertical positions of the pupil measured in pixels and (u_t, v_t) be the horizontal and vertical components of the velocity of pupil measured in deg/s. thus, the state vector at time t can be represented as $X_t = (s_t\ r_t\ u_t\ v_t)_t$.

The system can therefore be modeled as

$$X_{(t+1)} = \$\ X_t + w_t, \qquad (1)$$

Where, w_t represents system perturbation.
They further assumed that a fast feature extractor estimates

$Y_t = (\hat{}s_t, \hat{}r_t)$ as the pupil position at time t. Therefore, the measurement model in the form needed by the Kalman filter is

$$Y_t = A\,X_t + z_t \qquad (2)$$

Where, z_t represents measurement uncertainty. Specifically, the position of current frame *t* is estimated based on a simple local threshold in the neighborhood of the predicted position, assuming the existence of the bright pupil effect. Given the state model in equation (1) and the measurement model in equation (2) as well $\sum$ as some initial conditions, the state vector $X_{(t+1)}$, along with its covariance matrix $\sum_{t+1}$, can be updated using the system model and the measurement model. This was the brief description of the Kalman Filtering technique in eye tracking.

B. Mean shift tracking

The mean shift tracking algorithm is based on the appearance of the inputs submitted to it, it find the target candidate that is the most similar to a given model in terms of intensity distribution, with the similarity of the two distributions being expressed by a metric based on the Bhattacharyya Coefficient[7]. This process of deciding the target candidate from provided inputs is achieved by mean shift iteration.

The derivation of the Bhattacharyya coefficient is done by estimation of the target density *q* and the candidate density *p*, for which the histogram formulation is employed.

For better understanding let us say at location *y*, the sample estimate of the Bhattacharyya Coefficient for target density *q* and target candidate density *p*(*y*) is given by

$$\hat{}d(y) = d\,[\hat{}p(y), \hat{}q] = \sum^{m}_{u-1} \sqrt{\hat{}p_u\,\hat{}q_u} \qquad (3)$$

Where, *m* is the where *m* is the quantization level for histograms *p* and *q*. The distance between two distributions can be defined a

$$dist(y) = 1 - \sqrt{\rho[\hat{}p(y), \hat{}q]}. \qquad (4)$$

To reliably characterize the intensity distribution of eyes and non eyes, the intensity distribution is characterized by two images: even and odd fields, resulted from de-interlacing the original input images. They are under different illuminations, with one producing dark pupils and the other bright pupils.

During eye tracking, the target eye model must be updated whenever the bright pupil tracker tracks the eyes successfully in order to reduce the error propagation, resulted from the mean shift drifting. This was the brief discussion of one of the filters; in the next section we are going to discuss a technique designed using these two filters as well we will provide some drawbacks of this system too in support of our proposed system.

C. Combination of kalman Filtering and mean shift based fatigue detection system

In this section we are going to discuss a system proposed by Qiang Ji et al, they propose a system which is the combination of a Kalman filtering tracking algorithm and the bright pupil effect due to an active IR illumination and the mean shift eye tracker. They propose this technique because kalman filter cannot work in nonlinear scenario that is it cannot detect the movement of eye of the user.

This eye-tracking method consists of two major modules. The first tracking module is a Kalman filter-based bright pupil tracking, augmented with a support vector machine (SVM) classifier for pupil verification. If the first eye tracking module fails, then the functionality moves to second module based on the mean shift tracking to continue eye tracking. And two modules alternate during tracking to complement each other. To support the functionality described here a flow chart of Kalman Filtering Based fatigue has been provided in figure1and the concepts behind Kalman based eye tracking and the mean shift eye tracking have been described in the previous sections.

3. Shortcomings of previous methodologies

I tested all these methods and found out that each of the above mentioned method have shortcomings of their own. If we are using just kalman filter then it fails in the case when the user is moving his head very fast and if once its focus moves then it sometimes fails to regain its focus back in the given period of time.

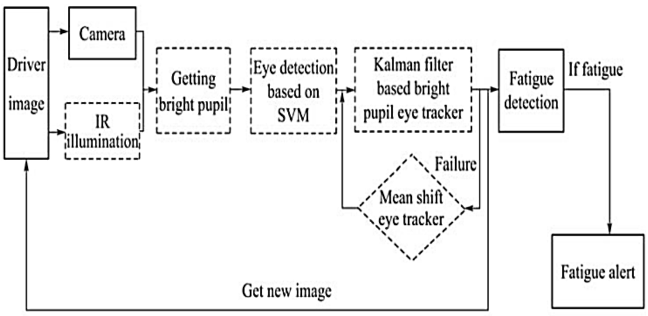

Fig1. Flow chart of the Kalman Filtering Based Fatigue detection system

In case of mean shift the problem of losing the focus is covered but the system is very slow as in this technique the image taken is been compared with all the images in the database of images and then the result is given and so this method is not feasible to be implemented in real-time scenarios.

If both these techniques are combined then the system becomes far more reliable and sufficient. In (Zutao ZHANG et al,2010) the author proposed a system which is based on combination of both these methodologies as explained in figure 1.

In this technique the author used infrared camera and based its result on bright pupil effect but this system fails in case of conditions of bright light and kalman filter fails to detect eyes in case of light coming from front or in case of bright light either due to sun or other light sources.

4. Proposed system

The present systems work only on infrared illuminators and the infrared camera to trace the eye location and eye movement. But these systems fail in the presence of bright light because IR Camera cannot work on bright light. The standard Kalman filter works for systems which are based on bright eye effect and has tendency to follow linear eye motion and it loses focus in case of nonlinear eye movement. Mean shift based eye fatigue detection system when used separately is not dynamic in nature and do not give the required result as per the application. But when Kalman filter and mean shift eye tracking methods are used in combination and they overcome each other's disadvantages and are a big success as explained in (Q. Ji et al, 2004; H. Gu et al) as mean shift gives Kalman filter focus whenever it loses it and Kalman filter gives dynamic behavior to the system. But this system still can't be called perfect as it still did not overcome the bright light disadvantage of the Kalman filter and fails in the case of bright light. Our proposed system is a combination of Kalman Filter eye tracking, mean shift eye tracker, IR illuminator and in addition we have used a light camera to be used in case of bright light.

In this system two types of Cameras will be used, one IR camera and second light camera. This is an improvement over the system which proposed the combination of both kalman filter and mean shift filter. The flow chart of the proposed system is shown in the fig2.

If the kalman filter fails for more than 5 times in 2 seconds than the cameras will be switched and the control goes to the light camera where the same process will be repeated until there are light conditions that suits light camera but if in case of light camera kalman filter again fails for more than 5 times in 2 seconds then the control is transferred back to the infrared camera.

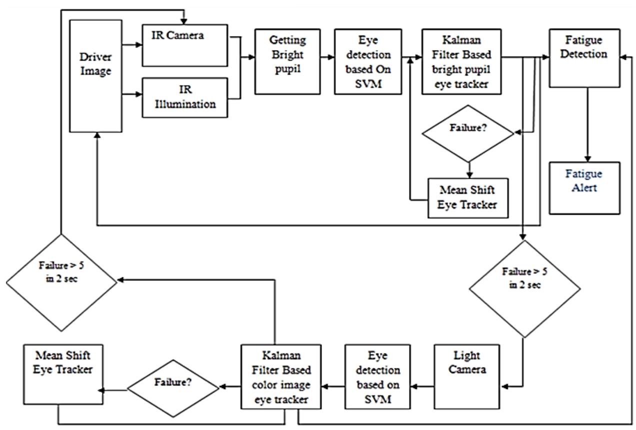

Fig 2. Flow chart of the proposed fatigue detection system

Conclusion and future work

In this paper we have briefly described present systems used for detecting eye fatigue and the methodologies used in these systems as well as we have included the results of these methodologies. Further we have discussed some drawbacks of these methodologies to support our proposed system.

Further research will be focused on implementing the proposed idea and coming with good results in detecting the driver fatigue using the proposed system.

References

Abhishek Bhardwaj, Pareesha Aggarwal, Rishi Kumar, Nidhi Chandra (2013), Image Filtering Techniques Used for Monitoring Driver Fatigue-A Survey at *IJSRP*

Zutao ZHANG, Jiashu ZHANG (2010),A new real- time ey tracking based on nonlinear unscented Kalman filter for monitoring driver fatigue at *J Control Theory Appl.*

W. Dong, X. Wu (2005),Driver fatigue detection based on the distance of eyelid at *Proceeding of IEEE International Workshop on VLSI Design and Video Technology*. New York: *IEEE* : 365 – 368.

Q. Ji, Z. Zhu, P. Lan (2004), Real time nonintrusive monitoring and prediction of driver fatigue at *IEEE Transactions on Vehicular Technology*, 53(4): 1052 – 1068.

W. Horng, C. Chen, Y. Chang, et al (2004),Driver fatigue detection based on eye tracking and dynamic template matching at *Proceeding of the IEEE International Conference on Networking, Sensing & Control*. New York: IEEE : 7 – 12.

S. J. Julier, J. K. Uhlmann(2004), Unscented filtering and nonlinear estimation at *Proceedings of the IEEE*, 92(3): 401 – 422.

H. Gu, Q. Ji, Z. Zhu (2002),Active facial tracking for fatigue detection at *Proceedings of the Sixth IEEE Workshop on Applications of Computer Vision. Piscataway:* IEEE : 137 – 142.

D. Comaniciu, V. Ramesh (2000),Mean shift and optimal prediction for efficient object tracking at *Proceedings of the International Conference of Image Processing. New York: IEEE*, : 70 – 73.

L. Hartley, T. Horberry, N. Mabbott, et al (2000), Review of fatigue detection and prediction technologies at *National Road Transport Commission Report* Melbourne: Murdoch University.

S. Singh, N. P. Papanikolopoulos (1999), Monitoring driver fatigue using facial analysis techniques at *Proceedings of International Conference on Intelligent Transportation Systems. Piscataway: IEEE* : 314 – 318.