International Conference on Computational Science and Information Management (ICoCSIM)
Vol. 1 (2012) 51-54

A PERCLOS-based Driver Fatigue Detection

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Abstract

Drowsy driving is a major reason, though elusive, triggering traffic crashes according recently investigation result. Image processing is a kind of multi-dimension signal processing. With the development of semiconductor integrated circuit, image processing technology has been used in multifarious fields. In this paper, an approach based image processing, was proposed.to detect driver's status behind wheel. The target of the proposed approach is to avoid vehicle accident causing by driver fatigue and to improve vehicle safety. According the result of experimental work, the proposed approach is effective for increasing safe in drive.

*Keywords:*image processing; face detection; vehicle safety; fatigue detection; eye detection

1. Introduction

With the changing of life style, car is already a part of modern society. It is impossible mission for modern people to refuse to have business with vehicle. With the increasing popularity of automobiles, the traffic accidents have become severe social problems. Recent statistic shows that the number of fatalities due to road accidents in Malaysia increased 1.9% to 6,872 deaths in 2010 from 6,745 deaths in 2009 [1].It was demonstrated that driving performance deteriorates with increased drowsiness with resulting crashes constituting more than 20% of all vehicle accidents [2].Drowsy is synonymous with sleepy, which is the transition between awake state and sleep. In this situation, people's abilities to observe and analyses are strongly reduced. Driver fatigue is usually equated with driver drowsiness. The National Sleep Foundation's annual omnibus surveys consistently reveal that about 20% of Americans have, at some time, dozed off while driving [3].

In recently, numerous universities, research departments, and governments are paying more attention to increase traffic safety and to reduce traffic accidents which cause of driving performance deteriorates, particularly drowsy driving. There have three class technologies to improve driver's security. Firstly, bio-signal of human is used, for example EEG, EOG and heart rate. Secondly, the image and video processing is used to detect the status of facial motion such as eye and mouth. Lastly, putting sensors on standard vehicle component such as steering wheel, gas pedal, the data of driver's performance on the road are analyzed. In 1995, Fukuda, Akutsu and Aoki proposed a system that used the interval of steering adjustment to estimate the driver's drowsiness [4]. Tian er al.[5] presented a system to detect driver's eye status in which face detection in the YCbCr color space and finding eye area by projection function were mentioned. A method of driver drowsiness detection that use Eyelid related parameters to training Support Vector Machine was proposed by Shuyan Hu and Gangtie Zheng [6]. Electrooculogram(EOG), which is used in the literature to estimate drowsiness [7]. Jian-Da Wu, and Tuo-Rung Chenb [8] combined image processing and fuzzy logic to detect driver fatigue.

2. Drowsiness Detection System

Owing to the great improvement on semiconductor integrated circuit in recent years. The image and video capturing device become common goods. The calculational capability of processor is amazing speed. All of them provide a robust platform for researchers who focus on image and video processing and computer vision. Nowadays, the image analysis technologies have been greatly accepted and applied. In the proposed system, a non-intrusive fatigue detection method is sketched. A camera was used to capture consecutive facial image of driver. Face detection and eye detection will be accomplished in facial image, then according eye's status to do drowsiness analysis. The system flow chat is shown in figure 1. Each of the part will be described in the following sections.

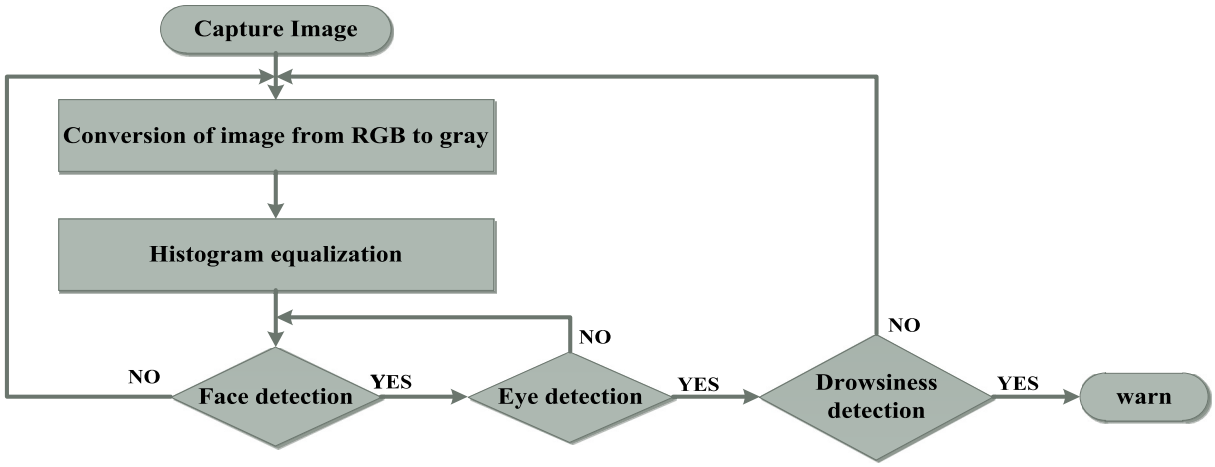

Figure 1 Flow chart of system

3. Image pre-processing

This part mainly introduces conversion of image and histogram equalization. Gray image just have one color channel. Normally a gray image can be divided into 256 level values. From 255 to 0, with the value decreasing, the color becomes dark gradually. When the pixel value is zero, this pixel is think black. On the contrary, 255 think as white. The follow formula explains how to get gray image from RGB color image.

$$Y = 0299*R + 0.587*G + 0.114*B \quad (1)$$

An image histogram is a kind of graphical representation of tonal distribution in a digital image. It plots the number of pixels or each tonal value. The purpose of histogram equalization is to improve the contrast in an image. To make it clearer, the lef pictures are original picture and its histogram, the right pictures are images after applying the histogram equalization [9].

Figure 2 The histogram equalization of image

Face detection

In this paper, the face detection was accomplished based on the Viola-Jones objection frame proposed by viola et al [10]. In this appeared-based method, the algorithm is insensitive to color. So the system can get good performance even with lot of skin-color like decorations surrounding. The Viola-Jones framework is based on the idea of a boosted cascade of weak classifiers. Each classifier uses a set of Harr-like (figure 3) features, acting as a filter chain. Only those image regions that manage to pass through all the stages of the detector are considered as containing the face. For each stage in the cascade, a separate sub classifier is trained to detect almost all target objects while rejecting a certain fraction of those non-object patterns that have been incorrectly accepted by previous stage classifiers [11]. The procedure of processing can be sketched in follow picture 4. More details about the framework, please review relative literatures.

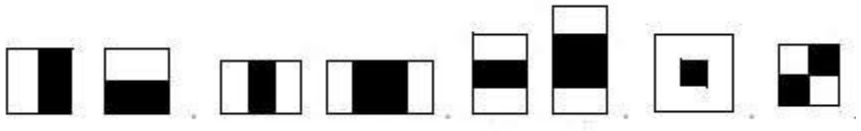

Fig 3 The feature prototype of simple haar-like

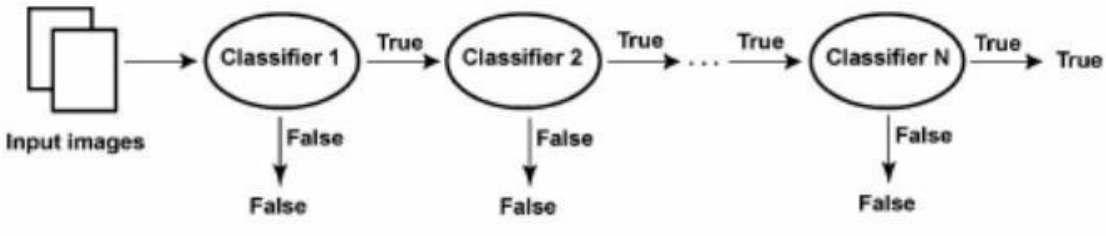

Figure 4 Cascade classifier

Eye detection

In this part, the work is how to find and track eye in the face area getting from previous stage. Localizing the eye position directly is a difficult task becausebackground has a large number of disturbances look-like eye.in shape. According the idea of face detection, a cascade of boosted classifiers based on Haar-like features is trained using free database and some picture collected in internet. In consider the speed of the algorithm, just right eye is detected and tracked. The face area was divided into upper face and lower face. According common sense, the eyes just exist in upper face. So the cascade classifier was used to select eye area in upper face area. When finding the eye area, the position information will be used to track eye location in next frame. If eye could not find in sub window of next frame, face detection will be triggered to find face area. The figure 5 shows the face and eye location.in video frame. The eye area will be become black-write image. According the value of pixel in black-write image, it is not difficult to get the status of eye.

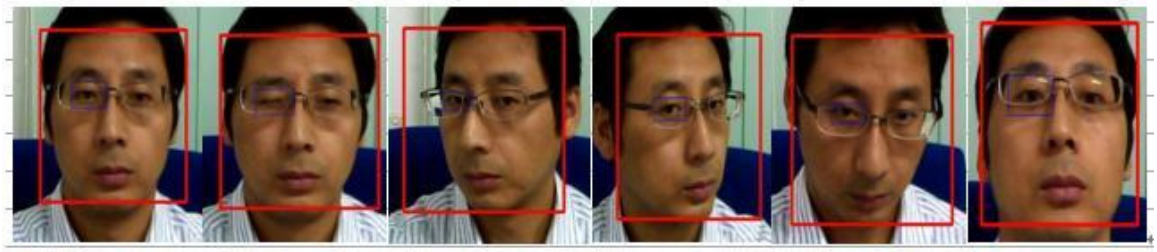

Fig 5 the result of face and eye detection

Drowsiness detection

Eye blinking message is considered to reflect an important characteristic of fatigue. There are many algorithm based on motivation of eye to research driver drowsiness in present. PERCLOS was found to be the most reliable and valid determination of a driver's alertness level [12]. PERCLOS is the percentage of eyelid closureover the pupil over time and reflects slow eyelid closures rather than blinks. In the family of PERCLOS, P80 is considered the best indicator of driver's fatigue according a serial of experiments. The measurement principle of PERCLOS is described in figure 6. The formula is used to measure the value of PERCLOS.

$$f = \frac{t_3 - t_2'}{t_4 - t_1} 100\% \qquad (2)$$

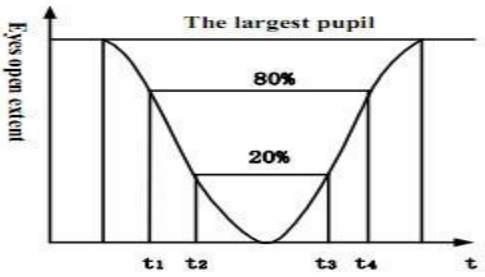

Figure 6 Principle of PERCLOS

4. Experiments

The system was primarily developed and tested on a personal computer. The personal computer has follow hardware and software resources.as table 1.Video was captured with Logitech C300 in RGB colour space under normal illumination. The tested video was record at 30fps, and its size is 640*480. According analysis of result, the experimental results show that the driver drowsiness detection system in real time with an accuracy of about 92%. If the system processes the image sequence from camera directly, it can run smoothly at 20fps.

Table 1 system information of personal computer

Hardware	Software
Intel Core2 6400 @2.13Ghz Processor	Microsoft Visual Studio 2010
Samsung DDR2 @667Mhz RAM	OpenCV 2.2

5. Conclusions

A vehicle driver drowsiness warning system using image processing and cascade classifier is proposed in this study. The key technology in part of drowsiness detection is the P80 of PERCLOS. It is convincing evaluating technique of motor driver fatigue. The experiment shows that the algorithm is rapid reliable and effective under normal illumination. However, one important issue that is not addressed in the paper, the lack of lighting at day and too dark at night for the system to properly detects the driver. So the future work will be focused on the development of more robust system for dark situation.

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