A Fatigue Testing Method Based on Machine Vision

Tang Ya-yuan

Department of Computer and Communication Engineering,
Hunan University of Science and Engineering, Yongzhou, China

Abstract. Due to Chinese traffic safety situation which is becoming more and more serious, this paper presents a fatigue detection method based on machine vision to provide safety information for the driver in the process of driving. It uses difference, gray projection and the complexity and real-time image processing techniques to detect and analyze the state of eyes, calculate the blink frequency to determine whether the driver is fatigue or not. The results of the experiment show that the method has higher detection accuracy.

Keywords: Machine vision, Image processing, Fatigue driving, Eye detection.

1 Introduction

The early, objective evaluation of driving fatigue mainly uses medical equipment measuring driver EEG, ECG waveform to determine the driver's fatigue degree from the medical point of view. Although relatively accurate, but it is too complicated to be popularized. The traffic departments of all over the world have invested considerable resources to detect fatigue in recent twenty years. It generally achieved some certain effect, but it hasn't gained very good practical application. Detecting method and realization of the platform are the two main factors: the complexity of algorithm and measurement of exposure are the main bottleneck from fatigue detection method; They are mostly based on the PC machine and a few are based on DSP/ARM core processor from the implementation platform, but they play a restricting role in the fatigue detection system products because of the non real-time and higher costs. So it becomes the trend in the future that we do the research about driver fatigue detection system with miniaturization, strong real-time, non-contact and low cost through a combination of hardware and fatigue detection technology [1].

2 The Fatigue Detection Based on Machine Vision

The article uses PERCLOS value which is got mainly through monitoring human eye blink frequency [2] to determine whether the driver is fatigue or not, so the eye detection is to realize the core algorithm. Here we use the method of active infrared light source by controlling two groups sequential of infrared lamp whose wavelengths are 850nm and 940nm so that image frame frequency can be alternately flashing to obtain pupil obvious of difference image which isn't almost background interference. In addition, On the basis of the difference image, the eye detection was carried out to

T. Tan et al. (Eds.): IGTA 2013, CCIS 363, pp. 72–77, 2013.

reduce the complexity of the algorithm and also to improve the detection efficiency greatly. In the actual implementation and debugging process, we found that gray scale change around the eyes is quite fierce, so it can detect eyes by the complexity algorithm. But besides the eyes, the noses and even sometimes people's teeth will be detected, thus causing the error. In order to eliminate the interference, adding eyes coarse positioning algorithm. Coarse positioning algorithm firstly determines the face boundary, and then delineates the region of the eye according to the eyes and face of fixed geometric relationship. Thus the detecting the eyes can eliminate the interference of nose and teeth.

2.1 Face Region Location

Studies show that the reflectivity of 850nm infrared and 940nm infrared to retinal are respectively about 90% and 40%, and the reflectivity of the two wavelength infrared on the face of other position are equivalent. If we use the same light of the two wavelength infrared light irradiation, the reflected image of two wavelengths collected display only retinal gray difference and gray to other locations basically identical. If the two images are subtracted, most regional gray of the facial close to 0 and only retinal gray values is big, so you can easily find the location of the eyes from the face image, and thus can calculate the pupil area.

Although pupil is the most obvious organ in the differential image, the face is the subject of the image. The average of the face was significantly different from the background gray and the gray value of the face region is relatively uniform and high, so it can obtain the boundary value of the face through the gray projection algorithm. It also provides a good premise for the gray projection that face image is mostly positive image and infrared light source stability, as well as image affected little by illumination changes and is almost no background. So the process of the face region detection [3] and mark face are actually that we estimate face boundary for the gray scale difference image. Face location algorithm is to face regional calibration in a rectangular frame, defining the rectangular box upper, lower, left and right side of the four positions.

2.2 Pupil Detection

In the difference images, the gray value around the detection of the pupil changes most frequently, so the pupil detected can be achieved through the complexity of the algorithm. And on the basis of face region location, the eye area is delineated according to the inherent geometric relationship between the human eye and face to reduce the detection range. On the one hand, the detection speeds accelerates; on the other hand, the accuracy of the pupil detection can be improved with the exclusion of some interference.

The definition of the image blocks grayscale complexity [4]: if the image size is m rows and N columns, the grayscale image is G (x, y).

So the formula（1）of the columns complexity of the image block is as follows:

$$Com(row) = \sum_{i=1}^{m} \sum_{j=1}^{n} \left| G(i, j+1) - G(i, j) \right| \quad (1)$$

By the formula, the rows complexity degrees of the image block is CUSUM of the grayscale gradient of the image blocks in each row, reflecting the complex degree of image gray value changes in the X direction. Similarly, the formula (2) of the columns complexity of the image block is as follows:

$$Com(row) = \sum_{i=1}^{n}\sum_{j=1}^{m}\left|G(i+1, j) - G(i, j)\right| \tag{2}$$

The columns complexity degrees of the image block is CUSUM of the grayscale gradient of the image blocks in each column, reflecting the complex degree of image gray value changes in the Y direction. This paper realizes the complexity algorithm of pupil detection which uses the sum of row complexity and column complexity, the formula (3) is as follows:

$$Com = \sum_{i=1}^{m}\sum_{j=1}^{n}\left|G(i, j+1) - G(i, j)\right| + \sum_{i=1}^{n}\sum_{j=1}^{m}\left|G(i+1, j) - G(i, j)\right| \tag{3}$$

2.3 The Realization of the PERCLOS Algorithm

The paper adopts PERCLOS [5] as a standard for fatigue evaluation and a prerequisite of the PERCLOS algorithm implementation is to obtain the area of the pupil. It contrasts the area of the pupil in each frame image by calculating with the area of the pupil of the human eye when the normally opened to judge the driver in the open or closed state and then obtain the blink frequency to judge fatigue.

PERCLOS is short for Percent Eye Closure, referring to the eyes closed time accounted for a specific time. It is presented firstly by the University of Pennsylvania intelligent traffic laboratory and NHTSA, whose main research contents are the relationship between the physiological characteristics of eyes and driver fatigue. In general, the closing time of the human eye is between 0.1and 0.35.But if the closing time is more than 0.55, the accidents are likely to happen.

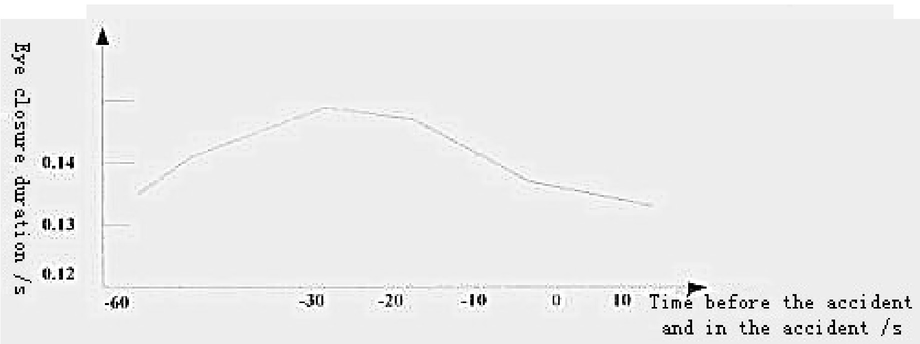


Fig. 1. Relationship diagram between eye closure duration and the accident

Figure 1 reflects the relationship between eye closure duration and the accident. As can be seen from the figure: Eye closure duration before the accident than in the accident, but it suddenly becomes shorter before the accident 10S.The driver's eyes closed time is longer ,fatigue is more serious. It determines the driver's fatigue degree by measuring eye closure duration.

The PERCLOS method has three kinds of standards: P70, P80 and EM. The fatigue degree of the driver is closely related with P80, so the article uses P80 as the fatigue criterion. P80 measurement principle diagram is shown in Figure 2. As can be seen from the graph: the length of specific period is from t4 to t1 and the time of eyes closed is more than 80% is from t3 to t2, So the calculation formula (4) of the PERCLOS value as follows:

$$f = \frac{t3 - t2}{t4 - t1} \tag{4}$$

Under normal circumstances, the closing time of human eyes is between 0.15 and 0.35.It is easy to have an accident when the time is more than 0.55. So the time selected is 0.65 in the paper. In this time, if the PERCLOS value is bigger than 0.4, i.e. closed frames total frames ratio is greater than 40%, the driver is in a state of fatigue to give real time alarm.

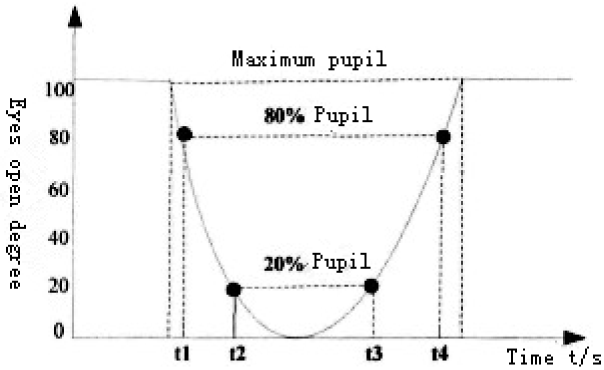
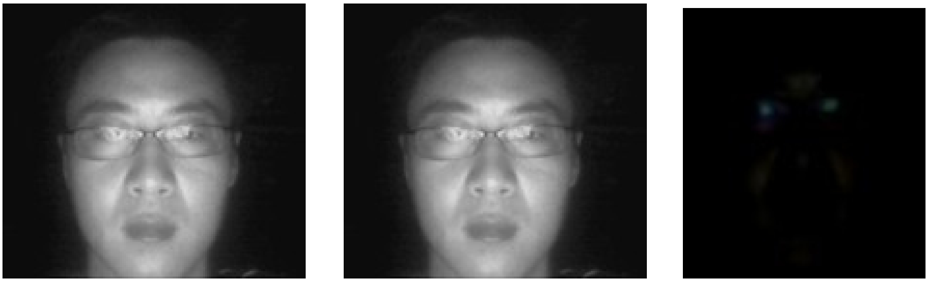


Fig. 2. P80 measurement schematics

3 The Experimental Results and Analysis

The paper uses Visual c++6.0 to carry out the simulated experiment on eyes location detection and object tracking process based on the fatigue detection algorithm.

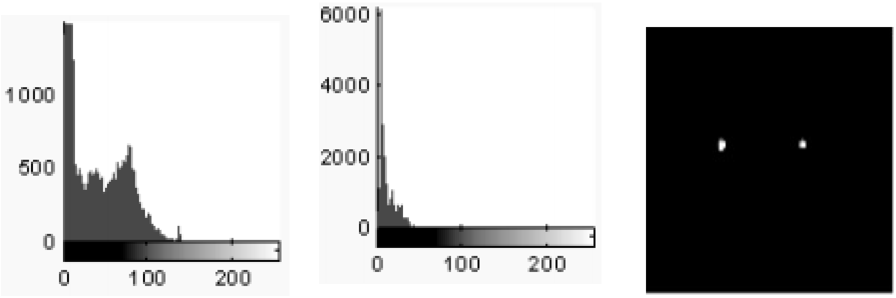
In Figure 3, there are pictures of 850nm wavelength of the reflected image and 950nm wavelength of the reflected image, as well as the difference diagram of the two images from left to right.



(a) 850nm wavelength of the reflected image (b) 950nm wavelength of the reflected image (c) difference image

Fig. 3. Double wavelength of the reflected image and difference image

In Figure 4, there are pictures of gray histogram before difference, gray histogram after difference and eyes location diagram after binarization from left to right.



(a) gray histogram before difference (b) gray histogram after difference (c)eyes location diagram

Fig. 4. Gray histogram and eyes location diagram

4 Conclusion

In comparison to the other fatigue detection algorithms, P80 detection algorithm ensures that the detection accuracy is above 90% under the simulated condition. As can be seen from the eye location results, the method on driver's eye state detection can be effectively separated from the eye and the rest of the facial image, avoiding the background interference, and can accurately locate the eye position and calculate its area, thereby improving the accuracy and reliability of PERCLOS. The algorithm has the advantage of high real-time and high accuracy. It has strong application value in vehicle driver fatigue testing field.

References

1. Xia, Q., Song, Y.W., Zhu, X.F.: Progress of driving fatigue monitoring methods based on PERCLOS. Techniques of Automation and Application (06) (2008)
2. Liu, X., Xu, F., Fujimura, K.: Real-time eye detection and tracking for driver observation under various light conditions. In: IEEE Intelligent Vehicle Symposium, Versailles, France, pp. 18–20 (2001)
3. Feng, G.C., Yuen, P.C.: Variance projection function and its application to eye detection for human face recognition. Pattern Recognition Letters 19(9), 899–906 (1998)
4. Kanade, T.: Picture Processing by computer complex and recognition of human Faces. Kyoto University, Kyoto (1973)
5. Li, Y., Wu, Y.: Research on Algorithm of Eye Tracking in Identification of Human Eye. In: Proceedings of the Third International Symposium on Test Automation & Instrumentation, vol. 2, pp. 300–302 (2010)