Real-Time Detection of Fatigue Driving Based on Face Recognition

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Abstract. At present, fatigue driving is the third most dangerous factor affecting traffic accidents. Therefore, how to accurately and quickly identify the driver's fatigue state is a common concern in the world. With the rapid development of machine vision and its application in the field of detection, a new solution to the problem of fatigue driving detection is proposed. Based on this, this paper proposes a fatigue driving detection technology based on face recognition. By means of computer image processing technology, the fatigue state of drivers is detected. The specific contents are as follows: based on dlib face recognition 68 feature points detection, the index of left and right eyes and mouth face marks are obtained respectively. The video stream is processed by OpenCV to detect the position information of human eyes and mouth. The eye opening or closing degree and mouth opening or closing degree are calculated to judge the blink frequency and yawn frequency, so as to determine whether the driver is tired.

Keywords: fatigue driving, face recognition, dlib, feature points detection.

1. Introduction

With the development of social economy, motor vehicles are increasing day by day, and the personal safety that comes with it has attracted more and more attention. Fatigue driving is an important cause of traffic accidents. With the rapid increase of automobiles in our country and the increasing work pressure of people, the frequency of fatigue driving is also increasing year by year. Therefore, it is of great significance to detect the driver's fatigue state and to provide early warning in abnormal state. The existing technical solutions can be divided into three categories: fatigue detection based on the driver's physiological signals, fatigue detection based on the driver's operating behavior and vehicle driving trajectory, and fatigue detection based on computer vision technology. Because the first two schemes have the shortcomings of inconvenient detection or lagging and non-real-time detection, they have not been put into practical application on a large scale. In recent years, with the rapid development of computer vision and artificial intelligence science, and the rapid progress of hardware technologies such as computing processors (CPU) and graphics processing units (GPU), driver fatigue detection based on video image processing technology has become more and more extensive attention and research. Because of all the visual characteristics, the change in the state of eye opening and closing is the most effective feature in the fatigue process, so computer vision often realizes the judgment of the fatigue state through the detection and subsequent analysis of the eye opening and closing state [1]. Common
open and closed eye detection methods are based on the gray-scale statistical features of eye images, some are based on eye contour features [2], some are based on eye template matching, and some are based on other image feature extraction [3]. Among them, PERCLOS [4] is an evaluation criterion, which means the ratio of the duration of human eye closure to a specific time. However, the existing methods have high requirements for image quality, which cannot meet the actual application requirements, or the calculation process is complicated, and cannot meet the real-time requirements, and none of them have the ability to conduct online learning for the specific conditions of different monitored objects.

The paper based on the existing face detection and feature points positioning technology, proposes a driver fatigue detection algorithm based on face recognition. The main idea of the algorithm is to recognize the identity of the detected object through face recognition technology. Then use the open or closed eye model of the object to perform real-time open or closed eye detection, and output the fatigue detection results.

2. Principle
According to the relevant literature, there are two types of fatigue in human facial expression: blinking (or eyes slightly closed, at this time the number of blinking increases and the blinking speed becomes slower) and yawning (the mouth is opened and maintained for a relatively long time).

**Blink detection.** The first is blink detection, which can locate the eye position directly through the landmarks. The experiments show that the series of points can be accurately located. In the 68 points landmarks, we can see that 37-42 is the left eye, 43-48 is the right eye, 49-68 is the mouth, as shown in the following figure 1:

![Figure 1. The position of 68 key points in human face.](image)

In paper, the concept of eye aspect ratio (ear) is proposed. Draw six points in the picture that contains the human eye, as shown in the picture. When a person blinks, the distance between these six points will change, so we can use some distance relations of these six points to judge whether there is blinking behavior.
Figure 2. The position of the six key points when the eyes are opened (upper left); the positions of the six key points when the eyes are closed (upper right); the curve of ear value change during the process of eyes opening to closing (bottom).

Define ear function:

$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_3 - p_4\|}$$  \hspace{1cm} (1)

The value of ear is calculated by formula (1), and then a threshold is set to judge whether the eye is opened or closed. The longest time of closing eyes (which can be replaced by the number of frames) is calculated. The number of times of closing eyes is the number of times of closing eyes and opening eyes. By setting the threshold value of the times of closing eyes and closing time per unit time, we can judge whether a person is tired or not.

Yawn detection. Next is the yawn detection, the mouth mainly takes the six reference points in the following figure:

Figure 3. 20 key points of mouth.

Similar to the eyes, the Euclidean distance of the mouth was calculated:

$$\text{MAR} = \frac{\|p_{51} - p_{59}\| + \|p_{53} - p_{55}\|}{2\|p_{49} - p_{55}\|}$$  \hspace{1cm} (2)

Yawning can be used to calculate the opening degree of the mouth by calculating the ordinates of 51, 59, 53, 57, and the abscissa of 49 and 55. In addition, the threshold value should be reasonable and can be distinguished from normal speech or humming through a large number of experiments.

The specific steps of blink detection and yawn detection are as follows:

Step1: Each frame image is extracted to detect the face and locate the eyes and mouth;

Step2: After the eyes were accurately located, the ear value of eyes was obtained. If the ear value is less than the set eye threshold, blink plus 1. If the ear value is less than the set eye threshold value for three consecutive times, it indicates that an eye blinking activity has been performed; otherwise, it returns to step1 to detect the next frame.
Step3: After the mouth is accurately located, the mouth Mar value is obtained. If the Mar value is greater than the set mouth threshold value, yawn will be added by 1. If it is greater than the set mouth threshold value for three consecutive times, it means that a yawn activity has been carried out. Otherwise, step1 is returned to detect the next frame.

Step4: After analyzing all the images within the set time, the total times of blinking and yawning are calculated. If the threshold is exceeded, fatigue warning will be sent out.

3. Experiment
The experiment is divided into three steps.

1). Obtain facial feature points (such as eyes, nose, mouth, contour) through image feature points detection.

This step can be solved using the famous dlib (King, 2018), and there is a trained model with better effect: shape_predictor_68_face_landmarks.dat. Using it, you can get 68 key points of the face.

2). Detect the position of facial feature points in the image.

Face feature points detection uses dlib. Dlib has two key functions: dlib.get_frontal_face_detector and dlib.shape predictor (predictor path). The former is a built-in face detection algorithm, which uses hog pyramid to detect the boundaries of face regions. The latter is used to detect the feature points in an area and output the coordinates of these feature points. It needs a pre trained model (input through file path) to work normally. Use the pre trained model shape_predictor_68_face_landmarks.dat The coordinates of 68 feature points can be obtained. After connecting them, the effect as shown in the figure can be obtained (red is the result of hog pyramid detection, and blue is shape_ Only the feature points of the same organ are connected. As shown in the figure below.

![Figure 4. 68 key points of the real face.](image-url)
Figure 5. Using Dlib to detect the face (red frame) and connect the five senses in the same position (blue line).

3). Set the appropriate threshold according to the actual situation. Count whether the number of blinking and yawning in a period of time exceeds the set threshold. If both times are greater than the set threshold, fatigue warning will be issued. As shown in the figure below:

Figure 6. Real-time display of EAR value of eye closure (top); real-time display of MAR value of mouth closure (bottom).
4. Summary
In this paper, the driver's mental state can be obtained more efficiently and conveniently, and a real-time fatigue monitoring system with simple hardware structure and low development cost is proposed. The system is implemented in Python language. After optimizing opencv, the 68 points mark model of face in dlib library is used to locate facial and eye feature points. Ear parameters corresponding to eye feature states are calculated by ear algorithm, which is used as the basis for fatigue state detection. Finally, the system is equipped on the motor vehicle to carry out the simulation test. The system has high detection accuracy and good real-time performance.

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