Detecting driver drowsiness by combining Viola-Jones image processing method and image landmarks detection

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Abstract

Fatigue is one of the main causes of traffic crashes which leads to the death of many people on the roads every year. Several methods have been developed to detect the level of fatigue, one of which is intelligent fatigue detection based on driving history. This advantage leads to the detection of fatigue in the early stages and notifying before the crash. In this paper, a new method is applied to detect drowsiness from video frames using the YawDD database. The operation of the proposed system is based on the tracking of facial landmarks. The purpose of this paper is to detect drowsiness from facial expressions. By extracting and tracking key points, facial expressions such as normal or sleepy can be detected. First, the initial position of the face is determined and then the key points are extracted using Viola-Jones and SIFT algorithms, respectively. The results showed that the proposed method is capable of detecting the driver's drowsiness with good accuracy. The proposed method executed 47 frames per second in real-time with an accuracy of 94% and an error rate of 6%.

KEYWORDS

Car accidents, fatigue, Viola-Jones, drowsiness, facial tracking

1. Introduction

Drowsiness while driving is a problem in all countries, especially industrialized ones, leading to significant consequences, fatalities, and economic costs. The causes of driving drowsiness are complex and may be related to chronic insufficient sleep, driving at inappropriate times in the circadian cycle, untreated sleep disorders, medical and psychiatric conditions, and the use of medications and sedatives [1]. Identifying and addressing these individual issues has shown improvements in driving performance and reductions in accidents in many cases. Driver fatigue causes hundreds of road accidents annually, and these accidents are associated with nearly a 50 percent higher likelihood of death or injury [2]. The diagnosis of fatigue is very complex, and it can be said that image processing is one of the best methods for its detection. Therefore, the main objective of this study is to utilize image processing techniques to detect fatigue levels in a driving simulator.

Jasina et al. studied and analyzed several techniques to obtain the best technique with the highest accuracy for detecting driver drowsiness. They proposed a method by utilizing Python, dlib, and OpenCV to create a real-time framework that employed a computer camera to monitor and process the driver's eyes and yawning. A camera was used to focus on the driver's eyes and yawning [3]. Thiruvallar and Vimal examined two different algorithms based on Convolutional Neural Networks (CNN) for detecting drowsiness, and the results were compared accordingly. Thus, drowsiness detection based on the Viola-Jones and PERCLOS algorithms was tested using CNN, yielding satisfactory results. The Viola-Jones algorithm was superior to the other algorithm in terms of accuracy. However, both algorithms have their own specific importance in various aspects [4]. Given the significance of drowsiness and fatigue in safety discussions, many researchers have attempted to analyze the visual features of drivers using image processing to identify this phenomenon [5], [6].

2. Methodology

One of the methods for detecting drowsiness is the use of landmarks or key points on the face. By extracting and tracking these points, it is possible to identify the facial state of a person, such as normal or drowsy.

The proposed procedure is as follows: 1- After receiving the video frames, the face detection process in the first frame is initially performed using the Viola-Jones algorithm. 2- After face detection, key points are extracted from the facial area using the SIFT algorithm. 3- Considering that the detection and tracking of points in subsequent stages require the alignment of facial images and the transformation of images to a frontal view, the extracted key points are used for aligning the facial images. At this stage, the extracted key points are mapped to points using the Affine transformation so that if the person's head is angled, their image is transformed to a frontal view. 4- Another feature of the Viola-Jones algorithm is the extraction of regions related to the lips, mouth, and eyes. After detecting the area related to the person's mouth, to increase processing speed, only the key points related to the upper and lower lips are tracked. 5- To detect drowsiness, the Euclidean distance between the key points of the upper and lower lips is calculated. 6- If the calculated Euclidean distance in the previous step is less than the defined threshold, the driver's state is considered normal and the tracking of key points continues; otherwise, it indicates driver drowsiness and warning signals are activated.

3. Results and Discussion

Over time, the execution speed of the proposed algorithm (averaging 48 frames per second in the sample video) increased, indicating the real-time execution of the proposed method. Considering that in the subsequent frames the process of face detection and key point extraction has been removed and only the tracking of facial landmarks was performed, this led to an increase in processing speed (Fig 1).

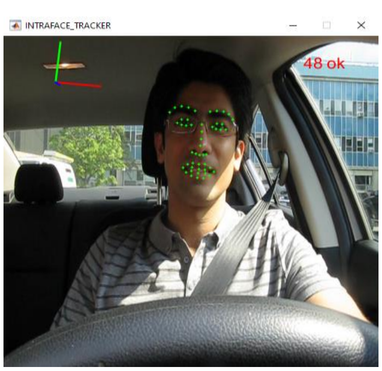

Fig. 1. Increasing the processing speed of the proposed algorithm

To demonstrate the accuracy of tracking and the performance of the tracking algorithm in consecutive frames, the mouth position was extracted using the Viola-Jones algorithm. The positions obtained by the Viola-Jones algorithm are considered as a reference. Subsequently, the trajectory obtained from tracking the mouth position in consecutive frames was compared with the actual output. As can be seen, the tracking algorithm can perform tracking operations with good accuracy (Fig2).

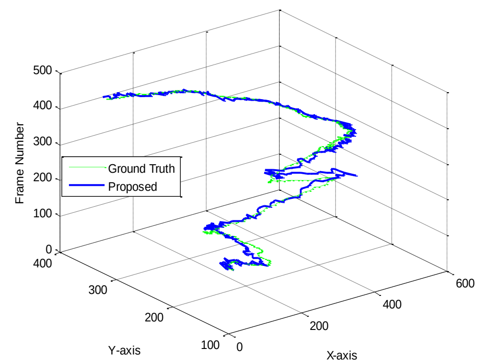

Fig. 2. The trajectory of the proposed algorithm is presented in comparison with the actual output

The results of comparing the proposed method of this research with the established methods for detecting drowsiness that have utilized the YawDD database are presented in Table 1.

Table 1. Result comparison

Algorithm	Detection accuracy	Error
Diagnosis of yawning through descriptive analysis of changes [7]	83	17
Monitoring of driver drowsiness under control of the Descent Method [8]	86	14
Detection of driver drowsiness using a hierarchical temporal deep learning network [9]	92	8
Detection of driver drowsiness by a set of convolutional neural [10] networks	92	8
The proposed method of this research	94	6

The errors that occur are due to the consideration of a manual threshold, "the distance between the upper and lower lips," during the detection of drowsiness. A person may open their mouth more than usual while speaking or may open their mouth less than usual while yawning, given that the distance between the lips is used to detect drowsiness and fatigue. The threshold considered for detecting drowsiness may encounter errors. It is suggested that the threshold be determined by an intelligent system to reduce the detection error of drowsiness.

Conclusion

Considering that the facial area in the image must first be identified to detect a person's drowsiness, the Viola-Jones algorithm is utilized for face detection in this study. Subsequently, facial landmarks will be extracted using the SIFT algorithm. To enhance processing speed, instead of tracking the entire face, tracking of extracted key points was employed. Finally, the Euclidean distance between the key points of the upper and lower lips was used to detect driver drowsiness. The total algorithms used in this research indicate that the proposed method is capable of accurately detecting driver drowsiness with a higher processing speed.

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