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Research on Abnormal Driver Behaviors Monitoring based on Bone Key Points

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Abstract. With the development of social economy, the number of road vehicles is increasing, and road traffic safety has become one of the major factors threatening people's life and property safety. Abnormal driving behavior of drivers represented by mobile phone operation is one of the important causes of road traffic safety accidents. Real-time monitoring of drivers' mobile phone use and implementing appropriate measures when abnormal behavior occurs are of great significance to protect the life and property safety of drivers and passengers. Due to the differences in the driver's own appearance, the various ways of operating the mobile phone, and the chaotic background in the car, the routine abnormal behavior monitoring is prone to wrong detection and missing detection. Based on the existing human pose estimation model, this paper proposes to classify the driver's mobile phone use by using the method of calculating the Angle between the arm and the bone key points: Did not use the mobile phone, answer the phone, edit the information, to prepare for the subsequent use of the model classification. Based on this model, it can be extended to monitor other abnormal behaviors of drivers. It has practical application value to promote civilized driving and improve vehicle safety.

Keywords: Human position estimation, Bone key points, Behavior detection.

1. Introduction

In recent years, with the continuous development of social productivity, vehicle manufacturing costs have been significantly reduced, and road travel vehicles have been increasing. According to the statistics of the Ministry of Public Security of the People's Republic of China [1], in 2023, the number of motor vehicles in China will reach 435 million, the number of motor vehicle drivers will reach 523 million, and the number of newly registered motor vehicles will reach 34.8 million. The popularity of vehicles not only facilitates people's travel, but also brings road traffic safety problems. The World Health Organization has declared that road accidents are the eighth leading cause of death globally and the number one cause of death among people aged 5-29 years [2]. According to statistics, from 1990 to 2019, a total of 1099 special traffic accidents occurred in China with more than 10 deaths at one time, and more than 17,000 people died in special traffic accidents [3]. The huge casualties and economic losses caused by road traffic accidents seriously threaten people's safety and the development of the country and society. Abnormal behaviors represented by drivers making phone calls, browsing mobile phone information and editing short messages during driving have a high degree of centrality and influence among the causes of major road traffic safety accidents [4]. Montuori et al. conducted a questionnaire survey on the use of mobile phones during driving in Naples, one of the most populous metropolitan areas in Italy [2]. The results showed that 69 percent of the 774 respondents had used a cell phone while driving at least once in their lives. 63.6 percent made phone calls and 75.2 percent only answered the phone. 49.1 percent read text messages and 33.3 percent edited them. Therefore, the use of appropriate ways to monitor the driver's use of mobile phones during driving is of great significance to reduce the risk of traffic accidents and ensure the safety of people's lives and property.

Due to the chaotic background in the cockpit, the driver's image obtained by the vehicle camera is easily affected by the occlusion. This paper proposes a method to classify the driver's use of mobile phones based on the bone key points. The video image is processed by the human pose estimation model to obtain the target bone key points, and the arm Angle value is calculated using its coordinate value to construct the classification standard of mobile phone use. In order to make preparations for the subsequent classification of the driver's mobile phone use, and then to monitor the driver's abnormal behavior.

Drivers' abnormal driving behaviors are mainly concentrated in fatigue driving and distracted driving [5], and distracted driving is taken as the research object in this paper. Distracted driving is one of the main causes of traffic accidents, which mainly includes operating mobile phones, eating, talking to passengers, smoking and using the car's operation panel. When the driver's attention is distracted by objects other than driving, the driver's response ability to driving decreases, resulting in a significant increase in the probability of traffic accidents [6]. The types of distraction represented by visual, cognitive and manual behaviors are closely related to the driving process. Currently, there are three common detection methods for distracted driving: measuring vehicle-related features, measuring human visual features, and bone-based action recognition [7].

(1) Measurement of vehicle-related characteristics: such as the use of pressure sensors, radar, etc., to detect foot pedal strength, hand steering wheel strength and direction, car speed and acceleration. Different parameters correspond to different driving states of drivers. The data of this method is simple and intuitive, and it can capture various indicators of vehicle driving. However, due to the huge differences in drivers' own behaviors, the practical value is low [8].

(2) Measurement of human visual characteristics: including visual target detection and visual target tracking, through the analysis of the driver's eye movement behavior, tracking the driver's visual target to determine whether the driver is distracted. However, this method is subject to external interference, and it is still limited by many problems in practical application, such as target shape transformation. The target moves quickly [8].

(3) Bone-based action recognition: aiming to use a small amount of aggregate information to represent human behavior in a limited way [7], is the focus of this study.

2. Human Posture Estimation

2.1. Two-dimensional Single Pose Estimation

Human pose estimation is also known as human key point detection. Its main purpose is to locate the human key point coordinates of each detection object from two-dimensional images to obtain the location of bone points. As one of the important branches in the field of computer vision [9], human body pose estimation has attracted more and more attention from researchers, and plays an important role in video surveillance, human-computer interaction and other fields [10]. Human pose estimation tasks can be divided into two categories: single-person pose estimation and multi-person pose estimation [11]. In this paper, two-dimensional single-person pose estimation is chosen as the research method. In order to accurately describe the human posture, the human posture estimation model uses human joints to describe the detected objects. Joints refer to specific points in the skeletal system that contain bones, such as the head, neck, shoulders, elbows, wrists, knees, and ankles [12]. In order to facilitate the subsequent calculation of the Angle between the arm, this study used a method based on two-dimensional coordinate regression to describe the location of the key points of the bone. The coordinate regression method takes the coordinates of key points as the model output, and uses deep learning model to establish nonlinear mapping from image to coordinates. This method eliminates the quantization error caused by the transformation of thermal map coordinates, and can directly obtain the coordinates of key points with low calculation cost, which has great optimization potential [13].

2.2. Estimation of Occluded Human Body Posture

In the real driving scene, the interference of the chaotic background in the cockpit, the occlusion of other passengers and the self-occlusion of the driver will affect the accuracy of the human pose estimation model. Therefore, how to improve the performance of the algorithm model under the occlusion condition is of great significance to improve the application value of the human posture model. Jia Xialing et al. proposed a robust Kalman filter (RKF) human body pose estimation method to identify and classify noise and improve the accuracy and robustness of human body pose estimation [14]. Chu Zhen et al. proposed a position-level occlusion perception human pose estimation method, which improved the accuracy of human pose estimation under occlusion by speculations, knowledge coding and use at the node level [15]. However, the method of randomly generating occlusion for human bodies in images could not effectively enhance the data of visible key points. However, Han Gangtao et al. proposed a combination of key point data enhancement and structure prior for occlusion human pose estimation, which can improve the effectiveness of the data enhancement method [16].

3. Calculate Arm Angle Based on Bone Key Points

3.1. Calculation of the Included Angle Value

The key points of the bones in the upper body of the human body can be obtained through the detection of the deep learning human pose estimation model [17]. In this study, six key points coordinates of the left and right shoulder, elbow and wrist are selected, as shown in Figure 1, that is, points 12, 1, 7, 9, 11 and 13 in the figure, and the Angle between the arms can be calculated.

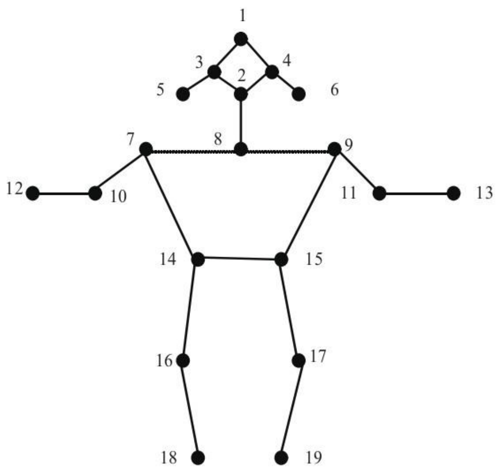

Figure 1. Schematic diagram of human body node [18]

Calculation description: AB, AC, and BC are the length between the key points, where A represents the shoulder key point, B represents the elbow key point, C represents the wrist key point, x and y represent the horizontal and vertical coordinates of the key point, representing the arm Angle.

Arm angle calculation diagram was shown in the Figure 2, and its calculation formulas:

$$AC = \sqrt{(x_1 - x_3)^2 + (y_1 - y_3)^2} \tag{1}$$

$$AB = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \tag{2}$$

$$BC = \sqrt{(x_3 - x_2)^2 + (y_3 - y_2)^2} \tag{3}$$

$$\mathrm{a} = \arccos\frac{AC^2 - AB^2 - BC^2}{-2AB * BC} \tag{4}$$

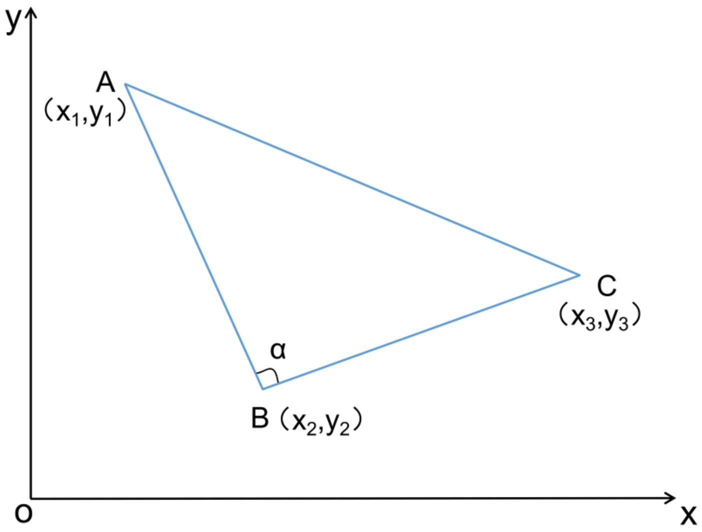

Figure 2. Arm angle calculation diagram (Photo credited: Original)

3.2. Cell Phone Usage Determination

The driver's mobile phone usage is divided into five categories: left hand answering the phone, right hand answering the phone, left hand editing information, right hand editing information, and no use of mobile phone. According to the formula, the Angle values of the left and right arms α1 and α2 are calculated, and the judgment limits are set as β and γ. By comparing the Angle values of the left and right arms with the judgment limits, the classification results are obtained: If the α value is less than the β value, the driver's mobile phone use is determined to answer the phone with the α value. If the α value is greater than the β value but less than the γ value, the driver's mobile phone use is determined to be the manual editing information of the α value pair; If the average α value is greater than γ value, it is determined that the driver's mobile phone use is not used. According to the above judgment methods, the driver's mobile phone usage can be roughly judged. The values of β and γ need to be trained using appropriate data set samples [19].

4. Discussion

To obtain the specific values of the classification limits β and γ, it is necessary to find a suitable image data set in the cockpit for training. Through training, the classification accuracy changes with the changes of the Angle values of β and γ can be drawn, and finally the optimal solutions of β and γ can be obtained. By comparing the label of the unclassified sample with the optimal solution, the unclassified sample can be further classified, so as to achieve the purpose of monitoring the driver's mobile phone use. The determination method proposed in this paper is only for the use of mobile phones in the driver's abnormal driving behavior. This analysis method can be used to select other key bone points of the driver, calculate the Angle value of the target body part, and further detect other abnormal driving behaviors of the driver. For example, the Angle between the upper body and the lower body is calculated to determine whether the driver bends down to pick up things, the Angle between the head and the shoulder is calculated to determine whether the driver turns back, and the Angle between the arm and the body is calculated to determine whether the driver drives with one hand. In order to improve the accuracy of classification, the object detection method can be used to detect the mobile phone itself on this basis, and the two judgment criteria of driver attitude and mobile phone object detection can be used [20]. On the basis of determining the driver's abnormal driving behavior, a reasonable warning and reminder system can be designed for the driver in the future, which is of great significance for promoting civilized driving, improving road traffic safety, and ensuring the safety of people's lives and property.

There are still some inadequacies and unconsidered problems in this research method. For example, for some normal driving behaviors of drivers that are very similar to abnormal driving behaviors, the method of calculating the Angle value using bone key points may have misjudgment and missing judgment. How to improve the correctness of this method and anti-interference strength is the key issue of future research. The interference factors of driver monitoring are not only the interference of occluding objects, but also the interference of light intensity change. In the case of weak light, whether the monitoring system can accurately identify and locate the key points of bone to ensure that the classification accuracy is not affected; As well as the interference of camera installation Angle, different shooting angles will make the classification boundary change, which requires the monitoring system to have a high anti-interference ability.

5. Conclusion

Based on the existing two-dimensional single-person pose estimation model, this study obtained the coordinate values of the key points of the skeleton, and proposed a method to monitor the driver's abnormal behavior represented by the use of mobile phones based on the key points of the skeleton. First, the appropriate key points of the skeleton were selected, and then the arm Angle value was obtained by mathematical calculation. For the subsequent use of the model to classify the driver's mobile phone use. This method can reduce the impact of the complex environment in the cockpit on the classification results, and can be popularized to monitor the driver's other abnormal driving behaviors. In the future, a reasonable driver reminder system can be designed to warn the driver who has abnormal driving behaviors, so as to improve the standardization of driver's driving behaviors. It is of great significance to study the intelligent safety monitoring system of the intelligent cockpit.

This study has not yet solved the problem of judgment interference caused by subtle movements, and the problems of light intensity change and camera installation Angle diversity are still not considered. In the future work, how to improve the accuracy and anti-interference ability of the model is the focus and difficulty of the research.

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