Road Rage Recognition System Based on Face Detection Emotion

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Abstract. The drivers' anger caused by the influence of external environment leads to excessive aggressive driving behavior which brings great potential danger to traffic safety. This paper proposes a method using face recognition technology to design an emotional intelligence model of road rage with a high accuracy rate. Firstly, making a homemade emotion data set of road rage according to the definition of road rage and labeling the information of road rage in the data set. Secondly, using a sliding window combined with emotional intelligence scale to determine road rage emotion of drivers, so as to regulate driving behavior. Finally, the correctness and effectiveness of road anger emotional intelligence model were verified by the experimental scenes. It is of great practical significance to reduce the impact of road rage on road safety. Demos URL: https://b23.tv/CnMw6M.

Keywords: Face · Emotion · Road rage · Sliding window

1 Introduction

Emotional intelligence (EI), refers to the ability of individuals to monitor their own and others' moods and emotions, and to identify and use this information to guide their thoughts and behaviors [1]. Among the driving behaviors the driver's emotion is considered to be the most significant psychological factor that affects safe driving, the United States has been studied and concluded that nearly 94% of road safety traffic accidents are related to the driver's factors.

Road rage, as the name implies, is driving with anger and refers to aggressive or angry behavior by the driver of a car or other motor vehicle. On October 28, 2018, a bus crashed into the river at Wanzhou Yangtze River Second Bridge in Wanzhou District, Chongqing, killing 13 people and leaving two people missing [2]. The driver's road rage was the direct cause of the accident.

In today's rapid development of artificial intelligence, emotion recognition is an important method for machines to perceive humans and develop emotional intelligence, and the human face contains rich emotional information, so using an emotion recognition system based on face detection is the best choice for emotion recognition.

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2 Related Work

The first studies on driver road rage identification were based on subjective survey methods with questionnaires and interviews. In 1994, Deffenbacher, L et al. [3] proposed the Driving Anger Scale, a method to determine the presence or absence of road rage by assessing driver performance through pre-defined content. Moriyama et al. from Tokyo Institute of Technology in Japan [4] screened the image information of angry, happy and calm facial expressions of drivers by using the method of labeled long-term change, and finally extracted facial features of multiple parts of drivers by using the method of separated facial information space, and carried out emotional classification.

Lei Hu et al. of Wuhan University of Technology [5] used a modified driving anger scale to analyze the behavioral characteristics of drivers' angry driving and its impact on drivers' physiological psychology and on traffic safety. Tang Ning [6] from Shanghai Jiaotong University and others based on the mood model established by psychology for emotions, and combined with relevant design content, further user research and scenario analysis of road rage were conducted and a set of interactive experimental models were established. Kobayashi et al. from the University of Tokyo in Japan, [7] extracted expression features based on feature points in three regions of the face, such as eyes, eyebrows and mouth, and built a neural network model accordingly to recognize six emotions such as happiness, sadness, anger, fear, disgust and surprise with an accuracy of 70%.

Azman, A et al. from Multimedia University Malaysia [8] used support vector machine and Viola-JonesHaar feature algorithm for real time detection of driver's facial expressions and alerted once the driver was detected to be angry for 3 s continuously. Yu Shenhao et al. [9] from Shandong University conducted an emotion elicitation experiment, collecting images and pulse signals from subjects, fusing face images and pulse features, and constructing a road rage emotion recognition model using Convolutional Neural Network and Softmax classifier, with an average recognition rate of 88.25%. Paweł Tarnowski et al. from Warsaw Polytechnic University [10] calculated the features of 3D face models. K-NN classifier and MLP neural network were used to classify the features, and seven emotional states based on facial expressions were identified.

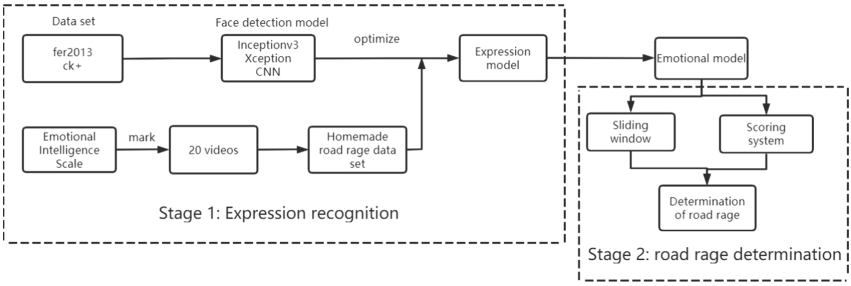

Fig. 1. Emotion recognition and road rage determination technology route

3 Methodology

This paper focuses on the problem of how to use face detection technology to identify emotions to achieve the road rage intelligence determination model, and the problem is broken down into two stages: recognition of driver expressions and determination of road rage status based on expression recognition results. As followed Fig. 1.

3.1 Labeling Data Set Using Emotional Intelligence Scale

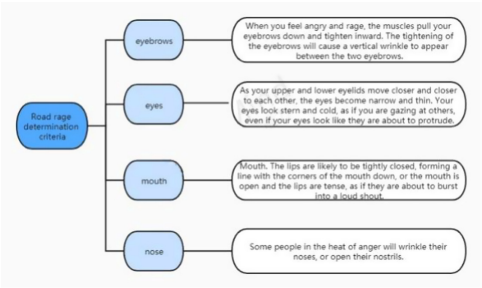

Fig. 2. Road rage determination criteria

The scale is based on the criteria for determining road rage mood, as shown in Fig. 2. The selected observers scored and labeled the measured data based on the characteristics of eyebrows, eyes, mouth and nose. Due to the lack of typical road rage datasets on the Internet, we selected 10 observers to annotate and analyze the driving videos (20 videos of 2 min each) and combined with the Emotional Intelligence Scale for the video set, divided into a training set and a test set for the related study.

3.2 Recognition from Expression to Emotion

Face expression recognition is already very mature [11]. So, this is not the focus of this paper's research. Based on the classical expression recognition algorithm, the homemade road rage data set is labeled by applying the emotional intelligence scale, and the expression model is trained and tested using the training and test sets, respectively, which construct the emotion recognition model. As the results can be presented: the bridge between expression and emotion is activated by expression pixels being labeled with emotion features, happy has strong correlation with eye and mouth related pixels, and angry has strong correlation with eyebrow, nose and mouth part pixels, so the effective recognition from expression detection to emotion can be achieved by extracting the feature points and combining with the emotion intelligence scale.

3.3 Sliding Window Technology Application

The program establishes a sliding window data structure of size 16. When the emotion recognition model detects an angry emotion, it deposits 1 in the array structure, and vice versa, it deposits 0. If a sequence of images has more than 3 consecutive images confirmed by the model as angry emotion, or the proportion of angry emotion images is more than 40% of the total images, the sequence is judged as an angry emotion sequence, and vice versa, it is judged as a non-angry emotion sequence. All the parameter settings here are the results of optimization after testing on training sets.

Figure 3 shows that there is partial data overlap in two adjacent image sequences, which can enhance the robustness of the driver road rage recognition method and make the determination more reasonable and accurate.

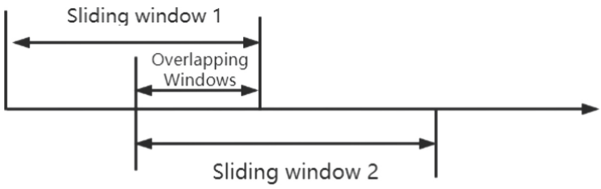

Fig. 3. Sliding window

3.4 Emotional Weighting Method to Determine Road Rage (Scoring Method)

According to the definition of emotions in psychology, human emotions can be divided into seven basic emotions: Angry, Disgust, Fear, Happy, Sad, Surprise and Neutral. And on the basis of the emotion recognition model, different emotions are given different weights. Finally, the road rage determination model is trained and optimized with the sliding window algorithm to achieve road rage determination.

4 System Design

4.1 Scenario Description

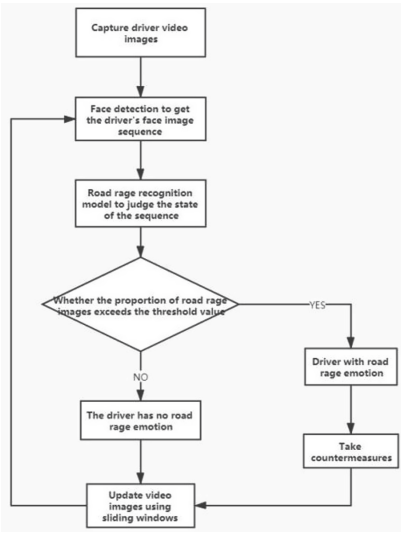

Fig. 4. The system design flow of this paper

Input: The driver acquires facial video images through the camera for data acquisition, as input to the facial expression recognition model, to driver emotion recognition, combined with emotion labeling using sliding window algorithm and emotional feature weight analysis method for road rage determination.

Output: Beep, music, or car seat vibration, etc.

Pre-processing: A total of 68 feature points are detected during face feature extraction and labeled in the graph. In addition, key parts such as eyebrows, eyes, nose, mouth, etc. are also extracted and labeled with scale criteria, which are finally input into our model to complete the emotion prediction. The system design flow of this paper is shown in Fig. 4.

4.2 Implementation of the Sliding Window Mechanism

When road rage emotion recognition is performed with this method on the face expression sequence in Fig. 5, the result vector obtained is [0,0,1,0,1,1,0,1,1,0,1,1, 0,1,1,1]. Where, 1 means that the model judges the image as a non-angry expression state and 0 means that the model judges the image as an angry expression state. In the image sequence shown in Fig. 5, the total number of images is 16 and the number of angry images is 10, accounting for 62.5%. Among them, the 14th to 16th facial expression of three consecutive pictures were judged as angry expression state. The above two conditions are satisfied at the same time, so the expression sequence is judged to be a road rage state sequence diagram.

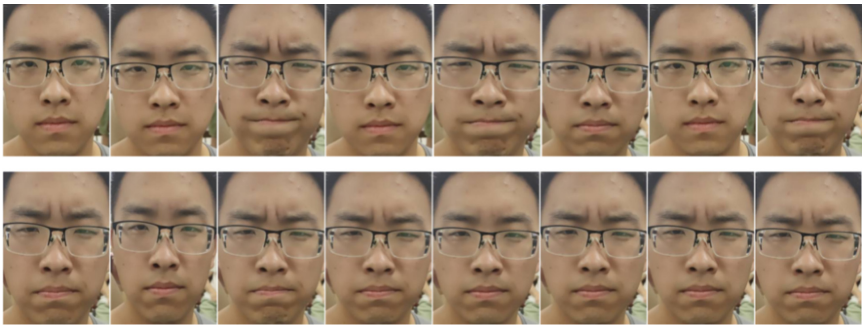

Fig. 5. Road rage state sequence diagram

4.3 Emotional Weighting Analysis Method Implementation

Each emotion identified is scored according to the scale, for example, angry emotion 10, surprised emotion 6, sad emotion 5, happy emotion 0, neutral emotion 1, etc. A sliding window is also created to convert each recognized emotion into a numerical value to be stored in an array. Calculates the sum of the values in the current array,if it reaches the threshold value, it is judged to be road rage. This method enhances the robustness of the determination, and the determination is reasonable and more reliable. The recognition effect is shown in Fig. 6.

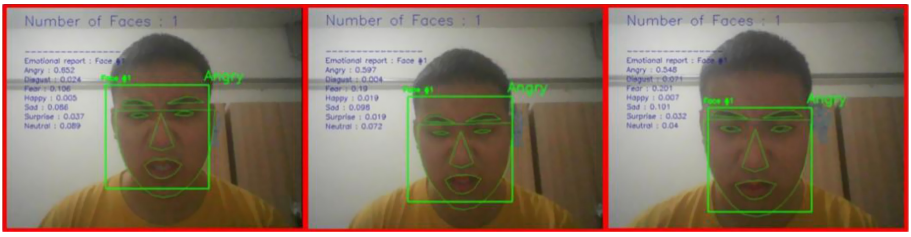

Fig .6. Effect picture of road rage judgment.

In order to implement the model effects presentation, this paper chose to create a web application. The purpose of this platform is to provide an intuitive and easily accessible way to get a feel for the specific application of the road rage intelligence model.

5 Evaluation

5.1 Experimental Design

For how to translate the identified emotions into criteria for determining road rage by the emotional intelligence model, this study proposes three determination schemes, which are direct determination of anger, sliding window mechanism, and combination of sliding window and scoring system.

Firstly, 10 students made an artificial determination of the number of occurrences of road rage in 20 videos. The average value obtained was used as the standard value for the number of occurrences of road rage in each video.

The experiment was repeated three times independently for 20 videos using this scheme, and the data in the following table were obtained:

Table 1. Three times experiment independently for 20 videos.

Number of rounds	1	2	3	Average
1	11	10	11	11
2	12	11	10	11
3	13	12	13	13
4	12	12	11	12
5	12	13	12	12
6	6	5	5	5
7	14	14	14	14
8	22	23	21	22
9	8	8	7	8
10	16	17	18	16
11	5	6	6	6
12	2	1	2	2
13	7	8	8	8
14	17	17	18	17
15	11	11	11	11
16	15	16	14	15
17	8	9	10	9
18	8	8	8	8
19	9	10	9	9
20	11	10	11	11

5.2 Summary of the Comparison of the Three Schemes

The line and bar charts comparing the three scenarios with the standard values are shown in Fig. 7 and Fig. 8.

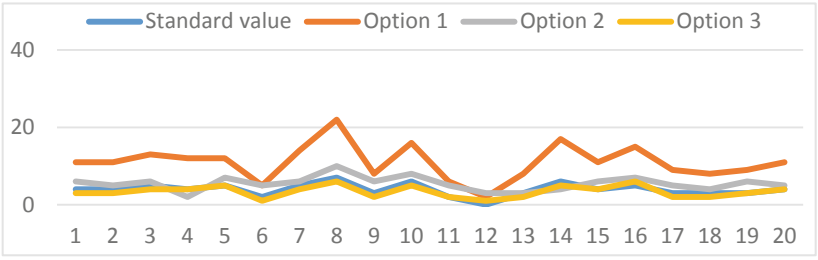

Fig. 7. Comparison line chart between the three schemes and standard values

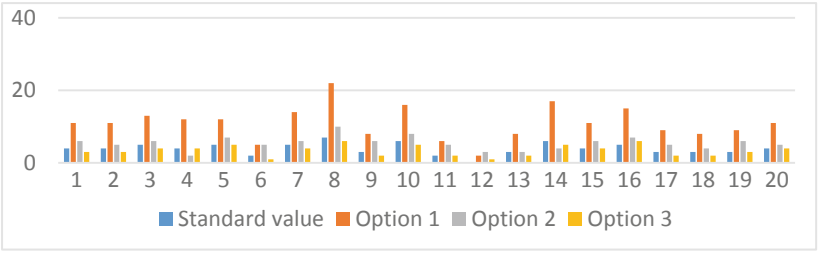

Fig. 8. A bar chart comparing the three schemes with the standard values

The line and bar charts clearly show that the determination results of scenario 3 (the model studied in this paper) fit the standard values very well and is the better scenario.

In addition, it is obvious from the data in the table that the data obtained in Option 1 are significantly higher compared to the standard data results. The solution's memorylessness of expressions makes it more sensitive to each frame. The data obtained in Option 2 is more consistent with the standard data comparison results, but it is influenced by the accuracy of the emotion recognition model, and a small amount of experimental data will lead to an excessive influence factor of chance and robustness. Option 3 combines the application scale on the basis of Option 2, and the comparison between the obtained data and the real data shows that the determination scheme is most consistent with the real value than the first two schemes. Option 3 has a greater impact on the recognition rate when the simulated driver's expression changes in a smaller magnitude or has too many masked parts of the face, which further enhances the robustness of the experimental determination and makes the experimental data more reliable.

6 Conclusion

To address the problem of lack of representative training data sets for the determination of road rage, this paper constructs an emotional intelligence scale based on psychological concepts, different weights are assigned to different identified emotions.

Exploring the determination of drivers' road rage based on a sliding window model, if there are more than three consecutive pictures of emotions recognized by face detection that are judged by the model as angry pictures, or if the proportion of angry pictures in the total window is more than 40%, then it is judged as road rage emotion, so that the experimental results are more robust. The problem of the size of the sliding window and the proportion of the window size occupied by the anger emotion is the key point to be explored and solved in the next experiment.

The model can be combined with intelligent driving assistance system, when the driver is identified as having road rage emotion, corresponding measures can be taken to make the driver's emotion reach a relatively safe and stable state, so as to reduce the impact of road rage emotion on traffic safety, which is of great practical significance to effectively protect the driver's life and property safety and maintain road safety.

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