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EEG based Reliable Riding Comfort Monitoring System for Automated Vehicle

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1. Introduction

Progress of the automated vehicles technology has promoted the commercialization and increased more attention from both academia and industrial fields. In fact, currently most of countries have the planned introduction of the intelligent transportation systems. Thus, it is obvious that the highly automated vehicles are going to be driving around our public roads in few years [1]. However, previous works are mostly focused on the accurate and precise driving technologies, for example, lane keeping, collision avoidance, coordination control or auto parking and so on. However, to realize the automated vehicle, it is needed to understand human emotions with the comprehensive driving situations [2,3]. Because, eventually, the automated vehicle is mostly used by people. This is very challenging part, because it is hard to quantify it. Researchers obtain electroencephalography (EEG) signals during automated driving recently (see Fig. 1) [4]. The EEG information is strongly related with the driving situations (e.g. acceleration, velocity steering, road condition, distance between other vehicles, etc.) of the human subject [5]. This paper, therefore, propose the reliable intelligent riding comfort monitoring system using the recurrent neural networks (RNNs) which is able to reflect all the driving conditions and situations with the human EEG and emotional signal information as input data.

2. Recent Study

Recently, improving driving comfort strategy is issue on the automated vehicle field since it is directly connected to the driving quality [6]. Many works tried to make a progress by controlling the acceleration and velocity of the vehicle [7-10]. But the vehicle control inputs like acceleration, velocity and steering are required to be adapted in the context and the situation. For this reason, some studies gathered human driving behavior information with the situations [11, 12]. These kinds of information can be used as good references, but still there exist emotional differences between the automated vehicles and the others which are controlled by him or herself, even if those vehicles move exactly same. Thus, the human EEG signal or other emotional data are gathered during driving [13-16].

Fig.1 The example of the EEG signal acquisition in the automated vehicle

3. System Structure

The proposed system applied the RNNs to make a human emotional model with the driving simulation. The vehicle control inputs like acceleration, velocity and steering influence driving comfort with external inputs such as terrain roughness, distance between cars, steepness of slope and sharpness of curve. The driving comfort factors are emerged by the human EEG signal and facial expression (e.g. happiness, fear, surprise, contempt and so on). And those emotional output is enrolled as RNNs inputs with the control and external input. Based on the RNNs model, the optimized vehicle control input parameters are obtained.

4. Experiment Design

Fig. 3 shows our automated vehicle conceptual design which is controlled based on the human emotional feedbacks. All the external situations are obtained by the camera, the Lidar sensor and GNSS sensors. The controller can control throttle, break and steering of the vehicle with the human emotional data and the EEG signals. The RNNs is trained by the all situations, to present the optimized control parameters which can satisfy the human driving comfort threshold.

5. Conclusion

The proposed intelligent riding comfort monitoring system can potentially be applied for many types of the automated vehicles, for example automated wheelchair, to improve the perceived quality of automated driving. In fact, it is important to gather emotional information in many driving situations for this system. But actual experiment which is conducted on the public road is very risky, therefore realistic simulator is required. Moreover, as a future work, the emotional information monitoring with various climate will be considered.

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