A Driver Reaction Time Detection System Design

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Abstract

This paper proposes a design scheme of driver reaction time detection system, which collects electroencephalography (EEG) data and reaction time required by the driver to complete corresponding test actions by deploying sensors on the driving simulator. The scheme can be divided into control unit, data acquisition unit and interaction unit. The testee performs corresponding operations according to the instructions issued by the interaction unit, and the system sorts out and saves the collected data. This system is of great significance to study the reaction time of drivers in different states and scenarios.

Keywords: reaction time, driving safety, EGG, driving simulator

1. Introduction

With the rapid development of road traffic, not only has it brought a convenient way of travel, but also the importance of traffic safety has become increasingly prominent. The driver is an important part of the road system, and most of the safety accidents are closely related to the driver's behavior. Driver reaction time is an important indicator for studying driver behavior [1]. Since the reaction time of different drivers is not the same, using a fixed reaction time for research will cause certain errors. Collecting relevant data through hardware equipment and establishing an association model between it and reaction time can more accurately evaluate and predict driver behavior [2].

Driver reaction time refers to the time required for the driver to implement the corresponding decision after receiving the emergency stop signal. It is usually divided into perception time and execution time. At present, there are few devices for studying the driver's reaction time, and most of the data are collected independently.

Based on the above overview, this article proposes a driving assistance device for detecting driver reaction time. The equipment can be divided into three parts: control unit, acquisition unit and interaction unit. Through the EEG acquisition equipment and the hardware modules deployed on the driving simulator, the EEG signals of the driver and the time required to complete the corresponding actions are obtained. The system diagram is shown in Fig.1.

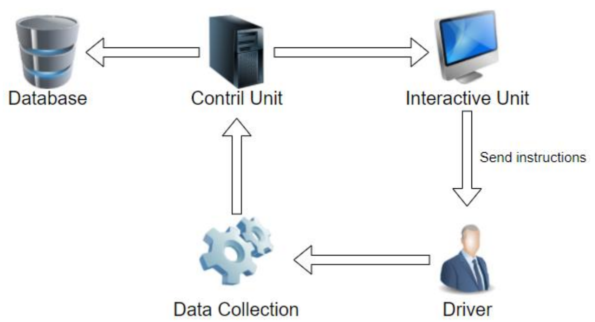

Fig.1 The system diagram

2. System Hardware Structure

In order to accurately obtain the driver's perception time, this design monitors the driver's EEG data. The hardware device deployed on the driving simulator can complete the execution time collection. Since the hardware needs to be deployed on the driving simulator, in order to facilitate installation, all functional modules use Bluetooth for communication. The system hardware structure diagram is shown as in Fig. 2.

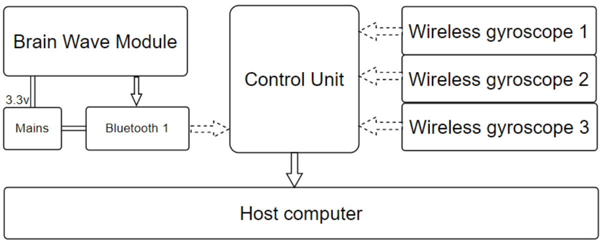

Fig.2. The system hardware structure diagram

2.1. EEG acquisition module

Perception time means that the driver does not act immediately after receiving the signal, but has a period of delay. This period of time is the driver's perception time. In order to accurately obtain the data at this stage, the system uses the TGAM brainwave module to identify and extract the driver's brainwave signal. The TGAM brainwave module is shown in Fig.3.

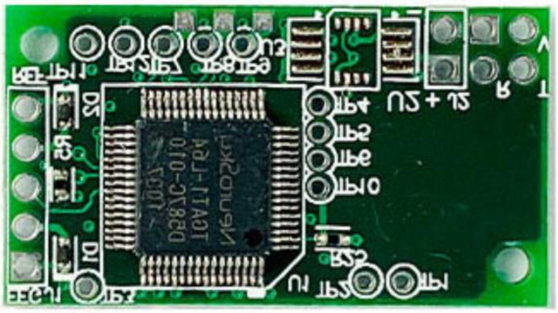

Fig.3. The TGAM brainwave module

The TGAM brainwave module can collect raw brainwave signals, including γ waves, β waves, and α waves. The high sampling rate of 512HZ ensures the timeliness of the collected data. The module collects EEG signals directly through dry electrodes, and sends the data to the control terminal through serial communication. The module has excellent anti-interference performance and has a hardware filter of 3-100HZ. Other hardware parameters are as follows:

- Operating voltage: 3 -3.6V
- Operating current: 15mA
- Electrostatic protection: 4KV contact discharge; 8KV air discharge

When the TGAM EEG module data acquisition module is used, in order to achieve the best effect, the input signal can be preprocessed. For example, to gain signal, consider the polarization voltage and physiological interference to the EEG signal coverage to reduce the previous value gain in the amplifier and increase the input impedance.

2.2. Motion detection module

The execution units detected by this system mainly include brakes, accelerators and steering wheels. Since the detection unit has a certain range of motion, this design will use a wireless nine-axis gyroscope sensor for data collection. The sensor is shown in Fig.4.

Fig.4. Motion detection module

The sensor integrates a high-precision three-axis gyroscope, a three-axis accelerometer, a three-axis Euler angle, a three-axis magnetic field, and a high-performance microprocessor. Through dynamic calculation and Kalman dynamic filtering algorithm, the module can quickly solve the current real-time motion posture. In terms of anti-jamming interference, the door module is integrated with a posture solver, which can accurately calculate the posture in the dynamic process with high stability.

The data protocol of this module is shown in Table 1:

Table 1. Nine-axis wireless gyroscope data format

Num	Data	Meaning
1	0x55	frame header
2	0x53	logo angle package
3	RollL	X-axis angle low byte
4	RollH	X-axis angle high byte
5	PitchL	Y-axis angle low byte
6	PitchH	Y-axis angle high byte
7	YawL	Z-axis angle low byte
8	YawH	Z-axis angle high byte
9	TL	temperature low byte
10	TH	temperature high byte
11	Sum	checksum

Through the above data, the roll angle, pitch angle and yaw angle of the measured object can be calculated.

The calculation formula of the roll angle is as follows:

$$ROLL = ((ROLLH<<8)\ |ROLLL)/32768*180 \quad (1)$$

The pitch angle calculation formula is as follows:

$$PITCH = ((PITCHH<<8)\ |PITCHL)/32768*180 \quad (2)$$

The yaw angle calculation formula is as follows:

$$YAW = ((YAWH<<8)\ |YAWL)/32768*180 \quad (3)$$

2.3. The control unit

The microprocessor model selected in this design is STM32F103VET6. This chip is a 32-bit ARM microcontroller with Cortex-M3 as the core, and the frequency is up to 72MHz, which can meet the real-time requirements of the system. The chip has 3 12-bit ADCs, 3 SPI interfaces, an IIC interface, 5 serial ports, 48KB of SRAM and 256KB of FLASH, which is convenient for wireless communication. It has the following characteristics:

- Operating Voltage 2.0V ~ 3.6V.
- Operating temperature range: -40 ºC ~ 105 ºC.

3. System Software Design

This part mainly includes system software requirement analysis, feasibility analysis and overall design plan introduction.

3.1. Software requirements analysis

In this design, the upper computer software needs to obtain the data collected by the lower computer through the serial port, and decode and analyze it. The processed data can be displayed through the interface software, mainly including EEG signals and action trigger time records. At the same time, the upper computer plays the role of commander and issues test instructions to the driver and the control unit.

3.2. Software feasibility analysis

In order to realize the above-mentioned functions, this design intends to use the C# (C Sharpe) programming language to complete the realization of the upper computer in the Windows 10 environment. C# is an object-oriented developed by Microsoft Corporation, which runs a high-level programming language on the NET Framework. It has the characteristics of speed block, powerful function and data type safety. The development tool to be selected this time is Visual Studio 2019, which is a free version developed by Microsoft for individual users, and its functions are not much different from the professional version.

3.3. Software design plan

According to the demand, the upper computer of this design mainly realizes the functions of setting, data processing and interactive information sending. The system software design structure diagram is shown in Fig.5.

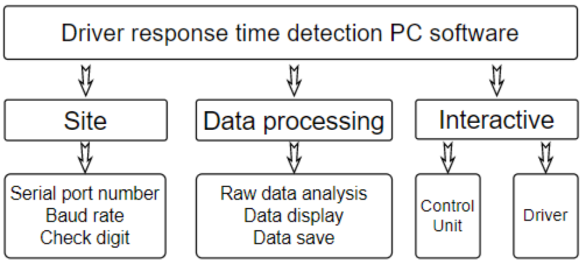

Fig.5. The system software design structure diagram

The setting unit mainly completes the setting and connection of the upper computer software to the communication serial port of the lower computer. The serial port number, baud rate, parity bit, data bit, and stop bit can be set through the software. After setting the parameters, choose to open the serial port to connect to the lower computer. All communication data are displayed in the data receiving and sending area, and two data formats, hexadecimal and decimal, can be selected. The software setting interface is shown in Fig.6.

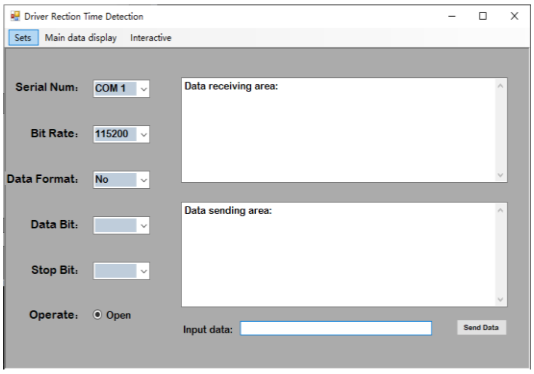

Fig.6. Setting interface

The data display interface is used to display real-time data, including EEG data and the data time collected by the action feedback. The data display interface is shown in Figure 7:

Fig.7. Data display interface

The interactive prompt is completed through the pop-up window of the host computer software, and different instructions, such as steering, braking, etc., are displayed through the pop-up text. When the pop-up window pops up, the software sends a timing instruction to the lower computer to start timing.

4. Conclusion

The driver's reaction time detection system accurately measures the driver's perception time and execution time. Researchers can obtain the reaction time of different populations, scenarios and conditions, which has a positive effect on follow-up research.

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Authors Introduction

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