Research on Traffic Signal Characteristic Detection Device of Railway Railside System

Bei Wang
Lanzhou Jiaotong University school of Railway Technology, China

Abstract. The research direction of this paper is to study the railway railside traffic signal feature detection device. This device is a multi-sensor cooperative device using MPU6050 accelerometer, NRF24L01 wireless data transmission sensor and HC-SR04 ultrasonic ranging sensor on the Arduino tool platform. The feature quantity that can be detected by the device includes the vibration acceleration of the railway track and the real-time distance between the train and the device, and judges according to whether the measured parameter is in a normal range, and alarms when the train running state is abnormal.

1. Introduction
With the continuous development of the railway construction industry in our country, the running speed of the train is constantly increasing, and the monitoring and determination of the running state of the train becomes increasingly important. The monitoring of traffic signal feature quantity of Railway railside system is one of the important criteria for assessing the safety of train operation status. The importance of research on traffic signal characteristic quantity detection device of train trackside system is further highlighted.

2. Overall design
According to the current physical quantity of subway and light rail traffic signals and the achievements of the network literature, the core of vehicle-to-ground communication detection is positioned to the trackside and the standard and technical parameters of the vehicle signal. The railway railside system traffic signal characteristic parameters mainly include the acceleration of the track vibration when the train passes, the running position of the train, the running speed of the train, and the safe state of the train operation. The feature quantities that I mainly prepare to detect include the acceleration of the track vibration when the train passes to sort out the safe operation of the train by the field detection statistics, and then judge whether the measured parameter is within this range to judge the safe state of the train operation. Measuring the running position of the train can prompt whether the trains at each station are about to enter the station, and the staff can prepare in advance for the train to enter the station. Therefore, the importance of the monitoring of the running position of the train is self-evident. According to the current physical quantity of subway and light rail traffic signals and the achievements of the network literature, the core of vehicle-to-ground communication detection is positioned to the trackside and the standard and technical parameters of the vehicle signal. Because the working environment of the traffic signal characteristic detection device of the train trackside system is relatively poor, and the influence of many interference factors such as noise and road conditions,
many experiments are needed to avoid the interference of these factors to form a stable and high-precision detection device.

3. Selection and design of acceleration module

Acceleration is a very important feature quantity in the feature quantity to be detected by the rail track. Therefore, the acceleration sensor is also a key electronic component of the railway trackside traffic signal feature quantity detecting device designed this time. The acceleration sensor of this system uses the MPU6050 acceleration sensor.

MPU6050 small size PU6050 can measure the linear acceleration of three axes and the angular velocity of three sides. It has simple structure, small size and strong ability to adapt to harsh working environment. Therefore, it is widely used in various circuit design in China. For example, the anti-fall alarm device of the elderly, the speed measuring device of the train, and the like are applied to the module.

The MPU6050 accelerometer is divided into six axes and nine axes. Since the required feature quantity is only linear acceleration, the system uses a six-axis MPU6050 acceleration sensor. The working principle of the module is to directly measure the acceleration according to the piezoelectric principle. The internal data processing is performed first through the filtering algorithm built in the sensor, and then the corresponding external data processing is performed to directly obtain the measured acceleration value. The pins of MPU6050 and Arduino are shown in Figure 1.

![Arduino and MPU6050 pin wiring diagram](image)

The coordinate system definition of the MPU6050 module is shown in Figure 2.

![MPU6050 coordinate system](image)
The linear acceleration detection of the three axial aspects of the MPU6050 is recorded as positive along the positive direction of the axis and negative in the negative direction along the coordinate axis. After the module directly measures the acceleration, the measured acceleration point parameter values are converted into the shaped data by its internal filtering and data processing.

4. Wireless data transmission module selection
Since the project we are going to do is to monitor the characteristic quantity of traffic signals on the railroad track, we are facing a relatively poor working environment. We need to install the railroad track traffic signal feature detection device we designed next to the railway track. After the train on the track, we can't put the computer on the side of the railway track, so we need to choose a wireless communication module to ensure that the computer we receive data can receive data safely. After careful and careful thinking, considering the problems of signal transmission efficiency, module size, capital, etc., we finally decided to choose the NRF24L01 wireless data transmission module as the wireless data of the railway railside traffic signal feature detection device we designed. The internal structure of the transmission module NRF24L01 is shown in Figure 3.

5. Ultrasonic distance measuring module design
Taking into account the consideration of various factors, I finally chose the HC-SR04 ultrasonic ranging module, which has non-contact distance sensing function, and the ranging accuracy can be up to 3mm. The module contains an ultrasonic generator, a receiver, and a control circuit.

The ultrasonic transmitter starts timing immediately after the ultrasonic wave is emitted. When the ultrasonic wave encounters the target object to be measured in the air, it will be emitted. The ultrasonic wave will be transmitted back to the ultrasonic receiver in the original path, and the ultrasonic receiver receives the reflection. After the ultrasonic wave came back, the timer immediately stopped timing. The speed at which ultrasonic waves are transmitted in the air can be determined based on local temperature, altitude, and wind, and the measured distance is calculated based on the speed of sound and time.

\[ H = S \cos \theta \]  
\[ \theta = \arctg \left( \frac{L}{H} \right) \]  

In the equation: \( L \) is half the distance between the ultrasonic transmitting point and the receiving point.

The distance traveled by ultrasonic waves is known as:
2S = vt

In the equation: v is the speed of sound. t is the time required for the ultrasonic round trip. Substituting equation (2) and equation (3) into equation (1) yields:

\[ H = \frac{1}{2}vt \cos(\arctan L/H) \] (4)

When the measured distance H is much larger than L, then equation (4) becomes:

\[ H = \frac{1}{2}vt \] (5)

It can be seen from the equation that H can be obtained by knowing t.

6. Overall software flow chart

The overall software flow chart mainly includes acceleration detection program, wireless data transmission and reception program, ultrasonic ranging program, LED and other alarm programs. The overall flow chart is shown in Figure 4.

![Overall flow chart](image-url)

**Figure 4.** Overall flow chart

The first is to power on, open the computer and burn the ur into the uno development board to connect to the computer, directly power the arduino development board through the computer, then initialize the arduino microcontroller, set the status of each pin, and take out two separate Responsible for receiving and sending two arduino development boards, calling up two programs that send data and receive data at both ends, respectively corresponding to the arduino development board that sends the program into the gold responsible for sending, and the receiving program is burned into the arduino responsible for receiving data. Development board. After burning the program into the arduino development board, connect the electronic components, open the serial port display interface of the two arduino development boards, swing the MPU6050 acceleration module, and prepare a book to move back and forth before the ultrasonic module. After that, we can observe the measured feature quantity parameter value on the serial port display interface of the sending board, and then receive the data on the receiving board through the two wireless data transceiver modules, and then we can display the serial port display interface on the receiving board. The measured feature quantity parameter values were observed.
7. Summary
This paper designs a railway rail transit signal feature quantity detection device based on Arduino development board, which can realize the detection of the track acceleration and the real-time distance between the train and the device. The main process of design is divided into hardware design and software design. The simple railway track traffic signal feature quantity detecting device designed this time can realize the detection of the acceleration and distance feature quantity parameter values, and the device can wirelessly transmit data and can work in a relatively poor environment, and the structure simple and compact, the cost is low, the sensitivity accuracy meets the basic requirements, and has certain promotion and use value.

References
[1] Nian Yongbo. On the impact of high-speed rail development on China's domestic economy [J]. Heilongjiang Science and Technology Information, 2014, (15): 237.
[2] Cai Ruiqi. The principle and application of Arduino [J]. Electronic Design Engineering, 2012, (16): 155-157.
[3] Wei Qiang, Wei Xiuzhen, Jia Limin. Application of FBG Sensor in Railway Monitoring [J]. China Railways, 2013, (09): 96-99.
[4] Liu Yue, Ning Bin. Discussion on Train Speed Measurement and Distance Measurement Method [J]. Railway Communication Signal, 2007, (12): 3-5.