5G-V2X Based Traffic Safety Warning System through Mobile Sensor and Wireless Communication

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Abstract. This project designs a traffic safety early warning system based on 5G-V2X for the current situation of increasing traffic accidents in China, which concentrates on two modules of V2V (vehicle-to-vehicle), V2I (vehicle-to-road) for early warning system design, with OBU (vehicle communication unit) and RSU (roadside communication unit) based on 5G-V2X communication technology to establish vehicle-to-vehicle and vehicle-to-road interactive communication, and realize V2V collision warning and V2I traffic light emergency event warning at intersections through collision risk warning algorithm and intersection passage assistance algorithm, thus alerting drivers to avoid dangerous situations and reducing the incidence of traffic accidents.

Keywords: 5G-V2X, V2V collision warning, V2I traffic light emergency event warning.

1. Introduction
According to the National Bureau of Statistics, the number of traffic accidents in 2019 reached 247,646, of which 159,335, or 64.3%, occurred in automobile traffic accidents, and the direct property damage of automobile traffic accidents reached 111.41 million yuan. Traffic accidents caused by automobiles have resulted in severe property losses and personal safety, and thus how to improve the safety performance of automobiles so as to reduce casualties and property losses has become a growing concern for governments and society. Research shows that drivers can avoid at least 60% of rear-end collisions, 30% of head-on collisions, and 50% of road-related accidents as long as they are warned 0.5s before there is a danger of collision; with 1s warning time, 90% of accidents can be avoided.

To address the above-mentioned drawbacks of traffic safety warning system, this project adopts 5G-V2X communication technology, which allows vehicle-to-vehicle and vehicle-to-road to share each other's vehicle information in real time through two-way communication. After the vehicle realizes the 5G-V2X communication function, each vehicle driving on the road is equivalent to a mobile sensor, which can learn the traffic status information of the self vehicle and the surrounding environment in real time and accurately by receiving broadcast messages from the surrounding area. Even in the presence of large obstructions or blind spots, the real-time interaction of information enables the acquisition of the position, speed, heading angle and intersection traffic light information.
of surrounding vehicles, which can be processed by early warning algorithms to provide driving advice to drivers.

2. System design
The traffic safety warning system based on 5G-V2X mainly consists of three parts: information collection, data interaction and user terminal, and the overall block diagram of the system is shown in Figure 1.

The system uses GPS technology to collect vehicle location information and roadside units to collect traffic light event information, and uses 5G-V2X communication technology to realize real-time information interaction between vehicle units and roadside units, while the user terminal preprocesses the received data and uses it as input to the collision prevention and warning algorithm to determine whether there is a risk of collision, and if there is a possibility of collision, the driver will be prompted by the designed human-machine interface to make timely operation of the vehicle to avoid traffic accidents.

![Figure 1. Overall system design.](image1)

3. Hardware Composition and Design
The hardware part of the whole 5G-V2X early warning system is divided into main control module, 5G-V2X communication module, GPS module, interface module and power module. Figure 2 shows the hardware design block diagram of the system. While the modules are connected electrically, the main control module can control different modules by calling system resources, so that the modules can work in a better coordination.

![Figure 2. System hardware module design.](image2)
3.1. **GPS module design and source**

In order to ensure the reliability of the system, the positioning accuracy is required to reach sub-meter level and the hot start time is no more than 2 seconds. After screening, this paper adopts U-blox’ M8U chip as the GPS positioning module, which is the industry's first infinite heading projection (UDR) GNSS module that receives GPS, GLONASS, BeiDou, and Galileo satellite signals in parallel. It can perform continuous positioning in urban environments and still has effective positioning performance even in the case of complete signal loss, such as in garages and short tunnels.

3.2. **Huawei 5GMH5000 provides 5G network**

5G-5th generation mobile networks (5th generation mobile networks or 5th generation wireless systems, 5th-Generation) is the latest generation of cellular mobile communications technology, and is the next generation of cellular mobile communications technology after 4G (5G-A, WiMax), 3G (UMTS, 5G) and 2G (GSM). The performance objectives of 5G are high data rates, reduced latency, energy savings, reduced costs, increased system capacity and large-scale device connectivity, which can well meet the information transmission rate requirements of the system in this paper. Huawei's MH5000 is the first single-core multimode 5G industrial module that realizes full compatibility with 2G/3G/4G/5G networks and supports 5G SA/NSA dual-mode with uplink rates up to 230Mbps and downlink rates up to 2Gbps.

3.3. **5G-V2X communication module design**

![Figure 3. 5G-V2X communication method design.](image)

Considering the reliability and stability of vehicle communication, this project adopts the TCP/IP server-client communication method, and the cloud, i.e. Ali cloud server, plays the role of information forwarding. 5G-V2X network connected car terminal sends the vehicle information obtained by GPS module to the cloud, and the cloud receives the information and forwards it to neighboring cars. In addition, for V2I (vehicle to infrastructure), we chose to implement a typical implementation scenario of traffic light emergency warning, where the RSU sends information about the status of the traffic light to the cloud, and the car receives this information and graphically displays the dynamic information of the traffic light on the terminal and provides driving advice to the driver via voice.

4. **System software design**

Figure 4 shows the overall block diagram of the software design. The middle layer application firstly preprocesses the data in NAME format of its own vehicle information (including position and motion status information) acquired by GPS, and the valid GPS data of the self vehicle at the same moment is
retained and the invalid data is discarded. Then broadcast it through TCP/IP communication module with a certain period and send it out. At the same time, valid GPS messages sent by other vehicles are received. The upper layer application and the middle layer program receive the data of GPS in NMEA format through communication.

![Figure 4](image)

**Figure 4.** General block diagram of software design.

### 4.1. Software design of information acquisition module

The module mainly implements the data acquisition of GPS positioning module and parses the data according to the standard protocol. The GPS positioning chip is connected to the motherboard through the serial port, and the satellite positioning data is updated every fixed time, and the serial port transmits the updated data to the UART serial buffer, so that the user can read the required GPS format data from the serial port according to his needs.

### 4.2. 5G-V2X communication module software design

A TCP client is established at the vehicle terminal and roadside unit, and a TCP server is established at the cloud. The self-vehicle transmits its own GPS information to the server through the client, and then the server forwards it to the TCP client of other vehicles, thus realizing the sharing of V2V vehicle information. The roadside unit also transmits roadside information such as traffic light status information to the server through the client, and then the server transmits it to the vehicle terminal client, thus realizing V2I communication. As shown in Figure 5.

![Figure 5](image)

**Figure 5.** V2V and V2I communication.

### 4.3. User terminal module design

The main functions realized by the user terminal module:
5. **System testing**

The physical diagram of the 5G-V2X-based traffic safety warning system is shown below:

![Figure 6. 5G-V2X based traffic safety warning system.](image)

5.1. **V2V communication test and V2I communication test**

Start the vehicle terminal program of both computers and observe the console output, you can see that the two vehicles have completed the GPS vehicle data exchange and basically exchange the location information at the same time. Also start the vehicle-mounted terminal and roadside unit, observe the GUI interface, and see that the vehicle-mounted terminal has finished receiving information from the RSU side and projecting it, and has made voice announcement to assist driving.

![Figure 7. V2V communication test.](image)
5.2. Demonstration of vehicle collision warning effect

The vehicle collision data under four kinds of warning conditions are tested separately, and the test effect is shown in Figure 8. When the actual car and car collision model meets the four collision model conditions, the vehicle terminal will display the corresponding warning animation and prompt the driver's attention through voice, and the driver will change the driving mode according to the prompt and thus achieve the purpose of avoiding safety risks.

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