Proceedings of CONF-FMCE 2025 Symposium: AI and Machine Learning Applications in Infrastructure Engineering
DOI: 10.54254/2755-2721/2025.MH25932

A Safety Alarm Device for Protecting Road Workers

Yuerong Wang

WLSA Shanghai Academy, Shanghai, China
1972624353@qq.com

Abstract. At present, the personal safety of road workers mainly relies on placing warning objects such as traffic safety cones and tripods on the road to remind rear drivers to avoid hitting the road workers. If drivers neglect to avoid, workers will be in a dangerous situation. In order to protect the personal safety of workers and policemen, this article uses ESP8266 chip and sensor to produce an intelligent safety alarm device. The device consists of a transmitter and a receiver. The transmitter is placed on a traffic safety cone or tripod, and the receiver is worn by the staff. When a car approaches or hits the cone, the transmitter emits an audible and visual alarm to warn the driver to stop, and at the same time sends a signal to the receiver, which emits an audible and visual alarm to warn the staff to escape in time and protect their personal safety.

Keywords: ESP8266, sensors, ultrasonic waves, traffic safety cones

1. Research background

When dealing with accidents or road construction on highways, warning objects such as traffic safety cones or tripods must be placed 50-150 meters away from the direction of incoming vehicles to remind them to change lanes, but this is a passive protection method. Statistics show that it is becoming progressively more difficult to work without accident or incident in work areas on the traveled portions of the roadways. Logically so; the continued increase in population, industrial growth,and development of residential areas, resulting in an unprecedented demand for utility service, are factors in the problem. Protection methods, sufficient in years past, are no longer adequate for current needs [1]. Since road personnel are focused on their work and may not immediately notice the danger when a warning object is hit, the safety of the personnel mainly depends on the driver behind the vehicle. When the driver is fatigued, careless, or loses control of the vehicle, it is very possible to cause a car collision accident, resulting in casualties. According to statistics, China has been ranked first in the world in terms of traffic accident deaths for over ten years, with 1% of these accidents being caused by road workers, despite the presence of traffic safety cones. Every year, nearly 500 casualties are caused by vehicles entering closed road areas across the nation.

Therefore, it is necessary to find a way that, when a vehicle collides with a warning object, the warning object can promptly notify the driver to brake and remind road workers to avoid danger in time, thereby turning passive measures into active ones and increasing the safety guarantee for road

DOI: 10.54254/2755-2721/2025.MH25932

workers. Implementing work zone intrusion alert technologies in a highway construction work zone could help improve the safety of roadway construction and maintenance workers [2].

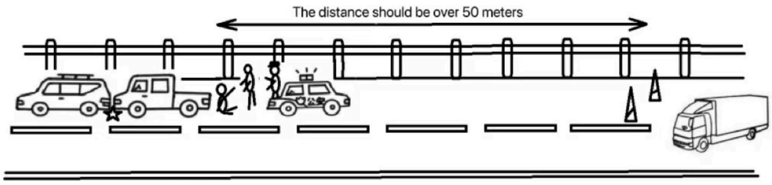

Figure 1. Dealing with traffic accidents in real life - passive protection

Table 1. Fatal occupational injuries at road construction sites and at all sites [3]

Year	2003	2004	2005	2006	2007	2008	2009	2010	2003-2010
Road construction	110	119	165	139	106	101	116	106	962
All sites	5,575	5,764	5,734	5,840	5,657	5,214	4,551	4,690	43,025
Road construction as a percentage of all fatal occupational injuries	2.0	2.1	2.9	2.4	1.9	1.9	2.5	2.3	2.2

2. Design of active protection device

The cone barricade was known as the best practice for temporary traffic control zone [4]. But this item lend the safety of workers to drivers. Employers must ensure adequate communication among all workers in a roadway working zone. Communication of any changes to scheduled tasks is critical, especially between mobile vehicle and equipment operators and workers on foot [5]. To meet the need, I made the protection device. It can immediately make an alarm and remind road workers to escape when they are hit, achieving active protection. Ultrasonic-assisted monitoring has been added to the transmitter to alert vehicles when they approach, thereby avoiding the risk of scratching.

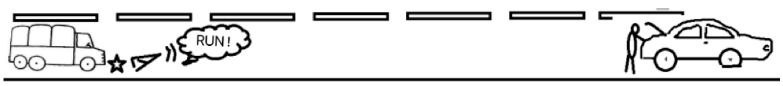

Figure 2. Design concept scenario - active protection

To achieve this idea, the ESP8266 chip is used to build a signal transmitter and receiver for communication. The transmitter chip, monitoring sensor, and alarm form the transmitter, and the receiver chip and alarm form the receiver.

The transmitter is placed on the traffic safety cone. When the cone is knocked down, the tilt sensor captures the signal and triggers an alarm. The transmitter emits an audible and visual alarm to alert the driver to brake; The receiver makes sound and light alarms to alert road workers to escape in time.

3. Build hardware

Using the ESP8266 chip as the control system chip, the transmitter is equipped with tilt sensors and ultrasonic sensors. Both the transmitter and receiver are equipped with alarm lights and alarm buzzers. The ESP8266 chip offers a high cost-performance ratio, features WiFi communication functionality, can receive mobile hotspot signals during testing, has a fast response speed, sufficient

DOI: 10.54254/2755-2721/2025.MH25932

ports, and is easy to compile. Using the HC-SR04 ultrasonic module with high cost-effectiveness, there are two ultrasonic components on the ultrasonic sensor, one for transmission and one for reception. Controlled through pins Trig and Echo.

When the trigger pin inputs a high level of more than 10 microseconds, the ultrasonic sensor immediately emits ultrasonic waves. After the ultrasonic wave is emitted, the "response" pin remains at a high level until it receives the transmitted ultrasonic wave. After receiving the reflected ultrasonic wave, it returns to a low level. Based on the duration of the high-potential pulse of the "response" pin, the distance of the measured object can be calculated using the formula: distance=high-level time * sound speed/2.

When the tilt sensor is tilted, the switch is turned on and outputs a low level. When standing upright, the switch is disconnected and outputs a high level.

The physical diagram of the constructed circuit is shown below, with plastic casing and straps added during actual use.

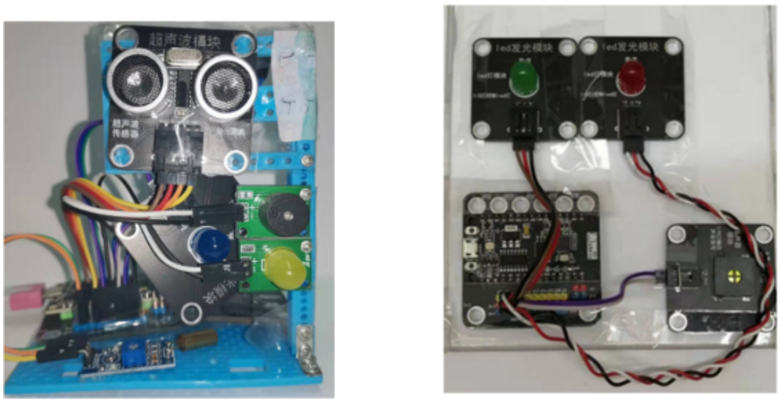

Figure 3. Physical diagram of transmitter and receiver circuits

4. Programming

Mixly software is chosen to use, which supports graphical programming in languages such as Arduino and Python. It is easy to operate, and it supports comparison display between graphical and code interfaces.

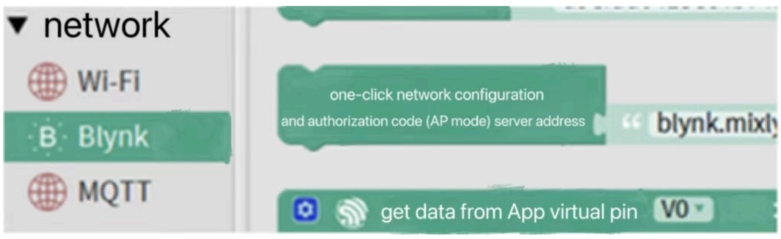

Figure 4. Blynk IoT function block call interface

To establish communication between ESP8266 chips, it is necessary to access the "Blynk IoT" module under the network function of Mixly.

Firstly, the ESP8266 chip must be interconnected, and then it must be able to check for alarm signals at regular intervals. The shorter the timing interval, the better. Considering the response speed and safety of ESP8266, a 0.1-second cycle check should be conducted. When an impact occurs, an alarm should be triggered within 0.1 seconds. A vehicle traveling at a speed of 80 kilometers per hour has a distance of about 2.22 meters and will not affect overall safety.

DOI: 10.54254/2755-2721/2025.MH25932

Due to multiple drops to the ground during use, it is necessary to install inspection buttons to check if the chip or sensor components are damaged. If the system does not light up and alarm after pressing the inspection button, it indicates that the chip is damaged. If it can alarm but does not alarm when tilted, it means that the tilting sensor is broken. The same method can also be used to check ultrasonic sensors.

The "Bridge Virtual Pin" function can be used for one-to-many and many-to-one control connections. The control method is flexible and can be adapted to various scenarios.

After the transmitter is on, it connects to the Blynk server on the Internet through the mobile phone hotspot signal to establish communication between chips. After the chip output port is initialized to a low potential, it checks the signals from the tilt sensor and ultrasonic sensor for 0.1 seconds and issues prompts or alarms based on the signal situation.

5. Testing

5.1. Indoor testing

The transmitter is placed on the traffic safety cone. When the cone is hit, test whether the transmitter can emit an audible and visual alarm to warn the driver, and test whether the receiver can emit an audible and visual alarm to warn the road construction personnel. This test was conducted indoors, using a book to simulate a vehicle. When the book approached the transmitter and pushed it down 20 times, both the transmitter and receiver emitted audible and visual alarms during these 20 tests. This test proves the reliability of signal transmission and alarm issuance between the transmitter and receiver.

5.2. Outdoor testing

The transmitter is placed on the traffic safety cone. When the cone is hit, if the driver does not brake and continues to drive, we test the escape time of the staff. This time starts from the receiver's alarm and ends when the vehicle arrives at the staff's side. In theory, the signal transmission time is in the millisecond range and can be ignored. According to equation 1, escape time=distance between transmitter and receiver/speed of vehicle travel (T=S/V).

$$S = vt \tag{1}$$

where s refers to the displacement (meters, m), v_0 refers to the initial velocity (meters per second, m/s), t refers to the time (seconds, s)

This scenario test must be conducted outdoors for safety reasons and under controlled testing conditions; the experiment cannot be conducted on the road. Place the transmitter and receiver at a distance of 100 meters from both ends A and Z. Due to the danger of testing on the highway, the testing location was chosen on the sidewalk near the section where the light rail travels at a constant speed. After testing, the train's speed was approximately 80 kilometers per hour when traveling at a constant speed on this section.

During the test, two people stood at the A and Z ends of the transmitter and receiver positions, at a distance of 100 meters. When the subway reached the A end, they waved and overturned the transmitter to simulate a collision situation. The time started when the receiver activated the alarm and ended when the train reached the Z end. By taking the average of multiple tests, the relationship

DOI: 10.54254/2755-2721/2025.MH25932

between distance and the time it takes for road personnel to avoid danger was obtained. The average avoidance time for road personnel is 4.18 seconds.

Using the same method, a test was conducted on a sidewalk near a regular suburban road. During the test, the distance between transmitter and receiver A and Z was 50 meters, and the vehicle speed was approximately 50 kilometers per hour. Multiple tests were conducted on the transmitter and receiver, and the average evacuation time for road personnel was 3.30 seconds.

6. Conclusion

The test results indicate that the device is reliable and stable, with the transmitter emitting both audible and visual alarms when knocked down, and the receiver simultaneously emitting both audible and visual alarms. If the driver fails to brake in time, the road staff can evacuate in time based on the alarm of the receiver worn by the workers. The results of simulations and testing have proven that the equipment alarm is timely, which can save road workers in time. This device has practical functions and can be used.

References

[1] Smith, G. L. (1958). Work Area Protection. Sewage and Industrial Wastes, 30(12), 1518–1521. http: //www.jstor.org/stable/25033776

[2] Nnaji, C., Gambatese, J., & Lee, H. W. (2018). Work Zone Intrusion: Technology to Reduce Injuries & Fatalities. Professional Safety, 63(4), 36–41. https: //www.jstor.org/stable/48689296

[3] Pegula, S. M. (2013). An analysis of fatal occupational injuries at road construction sites, 2003–2010. Monthly Labor Review. http: //www.jstor.org/stable/monthlylaborrev.2013.11.003

[4] Wolff, G., & Terry, T. M. (2006). Temporary Traffic Control Zone Incident Reduction. Professional Safety, 51(2), 62–65. http: //www.jstor.org/stable/45455428

[5] Improving Work Zone Safety: Recommendations Based on a NIOSH Fatality Investigation. (2008). Professional Safety, 53(4), 46–48. http: //www.jstor.org/stable/45457093