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Multifunctional Intelligent Security Integrated System of Highway Level Crossing

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Abstract: In consideration of the safety of drivers, we designed a multifunctional intelligent security guarantee integrated system for highway level crossing. Different from the existing intersection signs on the market, intelligent highway-level intersection indicators are based on the use of deep learning and computer vision technology to build a convolutional neural network model that can accurately recognize traffic accident images and traffic jams in a short period of time as well as obtain real-time road and highway meteorological environment information.

Keywords: Traffic safety; Guarantee system; Deep learning; Signal control

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1. Introduction

With the increasing number of urban vehicles, how to carry out rescue work in traffic accidents and avoid traffic congestion has become an important issue that has to be addressed by the smart highway traffic management. With the existing technology, the commonly used traffic accident identification methods include the global positioning system (GPS) data analysis method and image recognition method. The GPS data analysis method can be used to analyze the driving speed and direction of vehicles with GPS data and determine the occurrence of traffic accidents by identifying data anomaly points. The limitation of this method is that it cannot guarantee the accuracy and completeness of the GPS data collected by mobile terminals. In addition, many traffic accidents occur at a low speed or very-low speed driving state, so it is difficult to distinguish abnormal events from normal events by relying on speed alone. The image recognition method, on the other hand, uses the pictures taken by an on-board camera to determine the occurrence of accidents based on image recognition technology. The limitation of this method lies in the diversity of traffic accidents and the complexity of the image recognition algorithm itself. Ensuring comprehensive coverage and timely identification of accidents entail high calculation and communication costs and consideration of accuracy.

2. Study overview

Deep learning and computer vision can quickly build a convolutional neural network recognition and discrimination network model that can obtain real-time road information and road meteorological environment information accurately through images of traffic accidents and traffic jams. It also provides real-time road condition information of intelligent signs, including warning signals with LED intelligent signs, reminding drivers to pay attention to dangerous situations ahead [1]. At the same time, the data obtained by the photosensors are processed to determine whether it is necessary to open the light-emitting

band for auxiliary lighting. An intelligent highway monitoring system integrating road operation condition monitoring, highway emergency event monitoring, and highway meteorological environment monitoring is proposed. This provides a blueprint for evaluating traffic accidents and traffic congestion as well as a large amount of effective data for subsequent research.

3. System composition

The highway level crossing multifunctional intelligent security integrated system comprises a light-emitting diode (LED) display, solar panels, the Raspberry Pi 4B motherboard, a microcontroller secondary control board, a shell, and an external perception part that is equipped with a humidity sensor, a carbon dioxide sensor, a temperature sensor, and an ambient light sensor of five parts. Through the Raspberry Pi 4B motherboard, the corresponding algorithm programming is adopted to monitor the traffic situation at highway level crossings, with text reminders derived from safety accident judgment transmission signals (**Figure 1**).

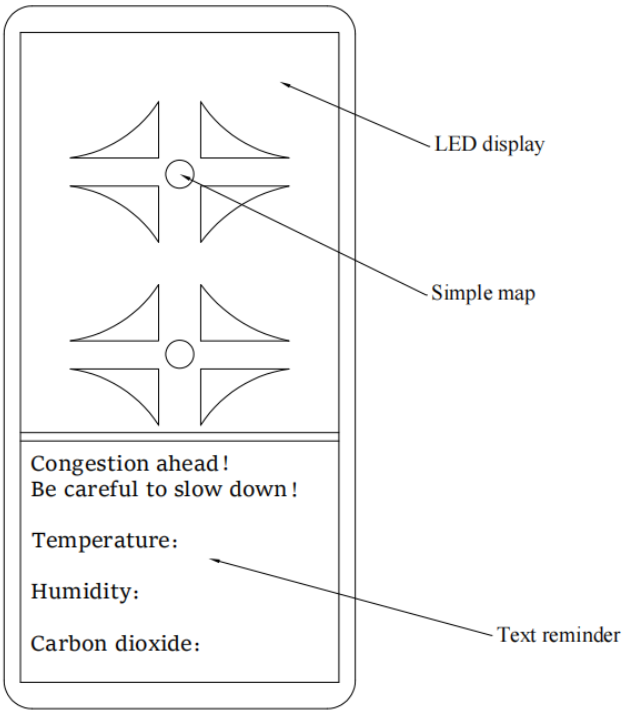

Figure 1. Schematic diagram of the main screen

Deep learning is used to identify the convolutional neural network of traffic accidents and traffic congestion. Through multiple training, the accuracy is high, and the output results of the two models that run at the same time are solved. The identification and discrimination of safety accidents are performed by a convolutional neural network. It is one of the best algorithms to complete the image recognition task. The purpose of designing a convolutional neural network is to imitate human learning and distinguish the samples by training and testing the input samples from simple to deep. Neural networks can reduce image classification errors and generate high recognition rates. In addition, compared with the traditional method, the advantage of convolutional neural network is that it can automatically extract the target features, identify the feature rules in the sample set, and solve the low efficiency and low classification accuracy problem [2]. Following data acquisition, a wireless transmission module is used to realize stable transmission to the data processing center and LED display screen after data encryption in various weather conditions. The wireless transmission module directly transmits information through the network; hence, its transmission speed is

relatively fast, and the information is in an encrypted information system to ensure information security. The control module includes the Raspberry Pi 4B motherboard and a secondary control board, Arduino UNO, which is used to receive data measured by the humidity sensor, carbon dioxide sensor, temperature sensor, and ambient light sensor. The secondary control board controls the LED display screen, while the Raspberry Pi 4B motherboard uses deep learning-based image recognition technology to identify traffic congestion and traffic accident scenes through machine vision (**Figure 2**).

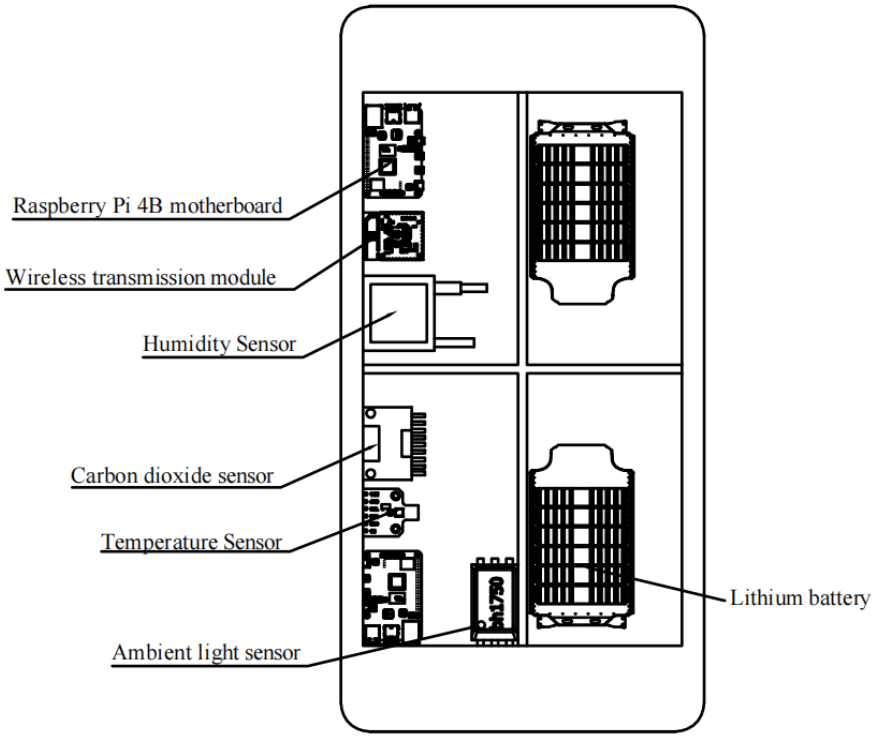

Figure 2. Schematic diagram of the control module

In order to better remind the driver of the road ahead, the LED display uses simple maps, text reminders, or voice broadcasts. In order to address traffic issues at night, photovoltaic power generation is used to power the LED display screen. During the day, the solar panels supply energy to the road sign and charge the lithium battery [3]. When the Raspberry Pi 4B motherboard processes the data obtained by the photosensitive sensor, the light-emitting band opens for auxiliary lighting.

Some of the devices comply with the national requirements for environmental protection, using LED lamps as a luminous module and solar panels to assist in power generation [4]. This helps achieve the same luminous effect with less electricity and reduce the consumption of electricity and pollution of light source.

4. Structural composition

The basic mechanical structure of the multifunctional intelligent security guarantee integrated system includes the main structure and the lifting structure [5], in which the main structure is fixed and connected to the lifting structure.

4.1. Main structure

The main structure includes a moving plate, a fixed plate, universal wheels, adjusting rods, and a spring. Universal wheels are arranged below the moving plate [6], an adjusting rod is interspersed with the outer wall of the moving plate, and a fixed spring is arranged above the moving plate (**Figure 3**).

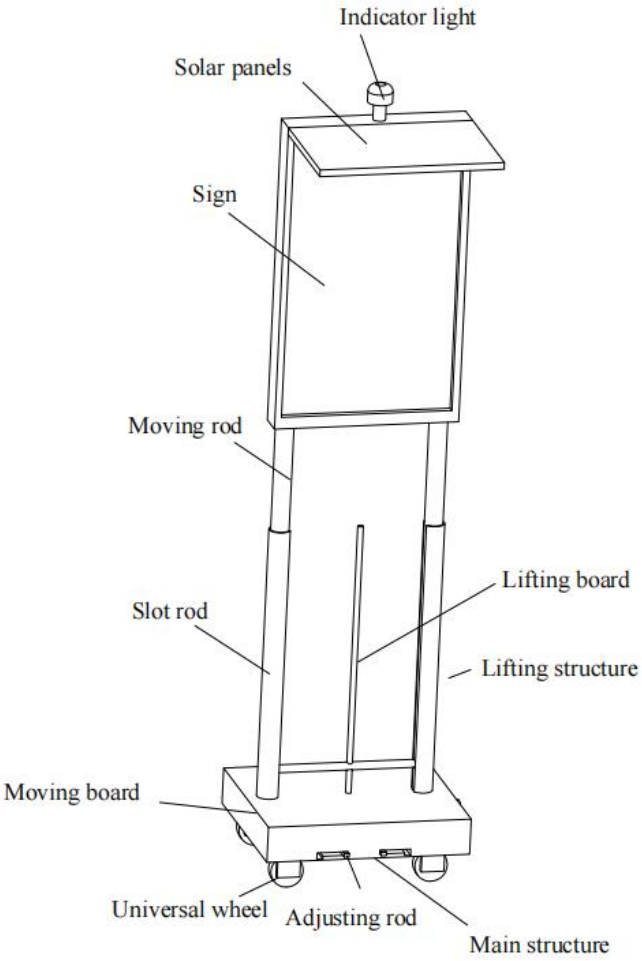

Figure 3. Schematic diagram of the main structure

4.2. Lifting structure

The lifting structure includes rotating lever, gears, bearing, lifting rod, slot rod, moving rod, indicator, indicator light and solar panels; the two gears are fixed on the top of the lifting rods; a moving rod is interspersed above the rotating lever, a connection board is fixed above the moving rod, an indicator light is fixed above the connection board, and the front of the board is connected to a solar panel [7]. Four fixed plates are used to fix the mobile signs to the ground, thus effectively preventing the wind blowing down the signs (**Figure 4**).

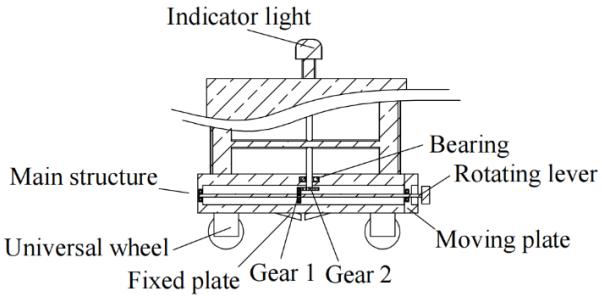

Figure 4. Schematic diagram of the lifting structure

4.3. Function implementation

The four adjusting rods are moved forward and backward to fit into the four grooves at the front and rear ends of the moving plate. Then, they are moved to the left and right sides. The four adjusting rods drive the four fixed plates to flip down. The four adjusting rods are attached to the fixed grooves above the four fixed plates. There are also anti-skid grooves on the left and right sides of the four fixed plates, which should be in contact with the ground. Subsequently, the moving plates are attached to the four fixed plates to secure the movable sign and prevent the movable sign from being shifted by the wind. The connecting groove rod is fixed above the moving board, and the four universal wheels are respectively fixed to the four corners below the moving board. With the four universal wheels, the moving board can be moved [8], thus saving time for workers and improving work efficiency. Below the moving plate, there are four grooves, and the four fixed plates are fixed to the inner walls of the four grooves. The two ends of the four springs are connected to the right side of the fixed plate and the four sides of the moving plate [9-12]. When withdrawing the four fixed plates, the four adjusting rods must be moved to the left and right sides; then, under the action of the four springs, the four fixed plates should be turned up and then taken back. The forward and backward movement of the four adjusting rods fixes the movable sign to prevent the movable indicator from shifting when the wind blows.

There are three bearings, which are embedded in the grooves on the right side and above the moving plate. The rotating lever is inserted into two bearings in the groove on the right side of the moving plate, while the bearings above the moving rod run through the groove below the outer surface of the moving plate and extend above the second gear. Rotating the rotating lever drives the first gear. This in turn drives the rotation of the lifting rod via the second gear. There are two groove rods. Threaded holes can be seen in the middle of the moving rod, and the upper part of the outer surface of the lifting rod is threaded. The threads are connected to the threaded holes in the middle of the moving rod. There are two groups of slot rods, there is a threaded hole in the middle of the lower part of the moving rod, and there is a thread on the outer surface of the lifting rod. Through the rotation of the lifting rod in the thread, the two groups of grooved rods move inward, and the moving rod can be adjusted according to the height of paving. The indicator plate is attached to the surface, while the back end of the solar panel is attached to the front end of the indicator [13].

The reflective film is pasted on the signboard, making it shine at night, so that it can be seen by motorists. In addition, solar-powered indicator light is an existing technology [14]. Indicator lights can be lit through the solar panel, so that drivers can see them from far.

5. Conclusion

The system shows the real-time traffic conditions at the level crossing, the road danger instructions ahead, and the real-time warning of traffic accidents, thus providing more guidance for drivers. Intelligent indicator signs make use of the light from LED intelligent signs, as well as the streetlights and reflective belts for auxiliary lighting. At night, their brightness can be adjusted depending on whether there are vehicles or not so as to effectively reduce energy consumption and improve resource utilization [15]. The moving plate can be moved with the four universal wheels to reach a specified location, and the four adjusting rods can be moved forward and backward to reach the four grooves at the front and rear ends of the moving plate. The four adjusting rods can then be moved to the left and right sides, driving the four fixing plates to flip down. The four adjusting rods can then be fixed to the fixed grooves above the four fixed plates, and the anti-skid grooves on the left and right sides of the four fixed plates should be in contact with the ground. The moving plates should then be fixed with the four fixed plates to fix the movable indicator sign and effectively prevent the wind blowing away or down the road signs. To some extent, there is significance in preventing traffic congestion and improving traffic flow.

Disclosure statement

The authors declare no conflict of interest.

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