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Safety management system of electric vehicle in residential area based on target detection technology

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Abstract: This paper presents a safety management system for electric vehicle in residential area based on computer vision. By connecting with the existing cameras in the community and using the target detection technology, the intelligent identification of whether there is an electric vehicle entering the elevator and whether there is a flame at the stopping point of electric vehicle without adding hardware equipment will be carried out in the first time and the alarm information and pictures will be sent to the mobile phone of the staff. In order to meet the design requirements, the image preprocessing is used to reduce the amount of data needed for target detection, and the lightweight target detection model is used to detect whether there is electric vehicle or flame in the preprocessed data. The detection results are transmitted to the back-end management module, and the back-end management module completes the logical realization of various functions of the system. According to the calculation results of the data analysis module, the operation logic of the elevator electric vehicle alarm, flame alarm, user login, camera management and other parts are carried out and various interfaces are connected with the human-computer interaction interface. Man-machine interaction module is divided into web terminal and mobile terminal, and mobile terminal supports Android system. Mainly responsible for more humanized display system to users, users more convenient use.

Key words: Electric vehicle management;Object detection;fire alarm

Introduction

The large-scale popularity of electric vehicles has brought great convenience for people to travel short distances, but it has also brought a lot of safety risks. Although there are rules that do not allow electric vehicles to be recharged upstairs, it is difficult to monitor. Aiming at the above problems, this design studies and realizes the intelligent upgrading scheme by using the existing cameras in the existing community. The management system of the electric vehicle in this community is of great value to prevent and deal with the fire caused by electric vehicle charging or spontaneous combustion in the urban community.

1.Overall design

The management system of EV in the community mainly consists of two functions: EV identification function in the elevator and fire warning of EV stop point. This system adopts the modular design idea, mainly divided into communication and data sampling module, data analysis module, data storage module, application service module, human-computer interaction module five parts. The communication module adopts TCP/IP technology. Different camera manufacturers and models adopt slightly different communication protocols, but all webcams support UDP protocol. If the camera model is known, the SDK provided by each manufacturer is used for communication. Directly capture camera data with a specified IP address, ensuring system compatibility with cameras without sacrificing certain transmission speed.

The acquired image is preprocessed to remove the unattended image, and then the electric vehicle detection or flame detection is carried out according to different camera positions.

The application service module mainly completes the logical implementation of various functions of the system, and is responsible for the operation logic of various parts such as elevator electric vehicle alarm, flame alarm, user login, camera management and various interface docking with human-computer interaction interface according to the calculation results of the data analysis module.

The data storage module is mainly responsible for building and optimizing the database, storing the corresponding data information in real time during operation, and protecting the data security. MySQL is mainly used to build the database, which ensures the rapid development and data stability.

Man-machine interaction module is divided into web terminal and mobile terminal, and mobile terminal supports Android system. At the same time, the human-machine interaction module is responsible for processing user requests, and fetching corresponding other interfaces and application service module interfaces.

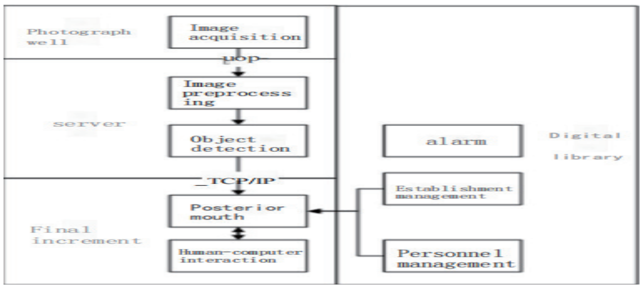

Figure 1:System functional framework diagram

2.Module design

2.1.Communication and data sampling module

The network communication module is responsible for data communication and forwarding among computer, mobile phone, server and camera. Network interface is essentially a communication framework which can satisfy the information exchange between communication parties. The communication parties do not need to know the process of sending and receiving data. They only need to call the API according to the corresponding interface.

In all scenarios, TCP/IP is used for communication. TCP is a control protocol that works at the transport layer and can provide communication connections to applications. It can automatically adapt to various changes when the network fluctuates, and maintain the reliability of communication when network congestion occurs. IP protocol is the international network communication protocol, in the Internet world, IP address is ID card and pass, any place, as long as it can be connected with the network, can send 0 and 1 composed of data, you can use the IP protocol, do not need any specific hardware support, is the most widely used protocol. In this system, the monitoring camera and computer end are in the same LAN network, which can be easily communicated by IP address.

The main functions of communication and camera management module include adding and deleting cameras, configuring camera IP, adding description information, and configuring alarm tasks that cameras need to complete. In order to make the best use of the existing cameras in different communities and reduce the use cost as much as possible, the system needs to be internally compatible with the cameras of various manufacturers that are common in the world, and can directly use the existing monitoring cameras in the communities. Register the camera through the camera IP, display the online and offline status of the camera, and retrieve the image data of a single designated camera at any time. Custom description and monitoring function selection are carried out for specific cameras. Defined by the administrator, specify a camera for flame monitoring alarm or electric vehicle identification alarm.

2.2.Data analysis module

2.2.1.Data preprocessing

The common camera data format is 24 frames, which can generate 24 images per second. It takes at least 5S for the electric vehicle to appear in the camera image and push up the elevator. With frame extraction technology, extracting an image every 2S for target detection can reduce the amount of data computation to 1/48 of the original in the case of no missing detection. The elevator and the electric vehicle parking shed are in a static state for a long time. To complete the electric vehicle detection in the elevator and corridor and the flame detection in the electric vehicle parking shed, it will waste a lot of computing resources if the images of the camera are sent into the model for recognition at all times. If static time is excluded and only changes in the image are judged, the number of images requiring target detection can be greatly reduced. The optical flow method is used to pre-screen images, and only the camera images are selected when compared with the previous images, and then the image recognition model is used for detection, which can greatly improve the recognition efficiency without affecting the recognition accuracy.

In order to verify whether pre-screening can successfully reduce the amount of surveillance camera data sent into the target detection model, the experiment is designed as follows. Two 30-second elevator surveillance videos were selected, one of which showed no one inside the elevator and the other showed the elevator opening and personnel entering the elevator. The video is imported into the pre-screening function for frame extraction and pre-screening by optical flow method. After the screening is completed, the frame number is counted before it is sent to the target for detection.The experimental results are shown in Table 1.

table 1.Video preprocessing contrast

Experimental process	Detection object	Incoming target detection frame number
There is a pre-screening process	30-second video of someone moving	52
There is a pre-screening process	30-second video of someone moving	8
No pre-screening process	30-second video of someone moving	721
No pre-screening process	30-second video of someone moving	721

As can be seen from Table 1, compared with the video with the same number of frames, the image data sent to the target detection model is significantly reduced by more than 90% when there are people in the elevator after the video is pre-screened using the extraction frame and optical flow method. When there is no load in the elevator, the amount of data sent to the target detection is reduced by 99%. When the hardware resources are not enough, the image preprocessing can greatly save the computing resources. Although the frame extraction and optical flow screening will cause a small part of the pictures containing electric vehicles to be discarded, as it takes a long time for electric vehicles to get up and down the elevator, as long as an image is sampled during the elevator process of electric vehicles, the recognition results will not be affected.

2.2.2.Model building

As a single-branch detection network, YOLO series network has the characteristics of fast detection speed and high detection accuracy. YOLOv5 has been widely used for its lighter network and better detection effect. Because this data set is small, we choose the popular YOLOv5 model as the basic model. YOLOv5 uses Mosaic data enhancement, and Mosaic data enhancement uses 9 pictures. The pictures are processed by random scaling, random cropping and random arrangement and then spliced into a picture as training data. Mosaic data enhancement enriches the data set and makes the model more robust. The overall performance of YOLOv5 is better than that of EfficientDet, and because YOLOv5 is a lightweight model, it is smaller in size, which saves a lot of computing resources while ensuring the accuracy of model detection.

In this system, yolov5s.pt is used as the pre-training weight of the model, and the parameter epoch=300 is set, and the training is carried out by using GPU. The variation diagram of the recision ratio and Recall ratio of the model on the test set with epoch is shown in Figure 2. As can be seen from Figure 2, with the increase of epoch, both Precision and Recall gradually tend to 1. It shows that the model can ensure the recognition accuracy while grasping the high recall rate, and the probability of missed detection and false detection of this model is within the acceptable range.

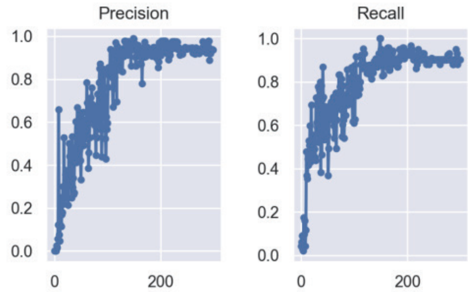

Figure 2 Model Precision and Recall Change Diagram with epoch

2.3.Data storage module

There are two types of data in the EV management system that need to be stored in the database: monitoring camera information and staff information. Each type of data corresponds to a table. Surveillance camera information includes ID, IP address, location of the surveillance camera, and working mode. Staff information includes: account number, password, permission level, etc. After logging in to the system management mode, an administrator can add, delete, or modify other information. The structure of the database is shown in Figure 3.

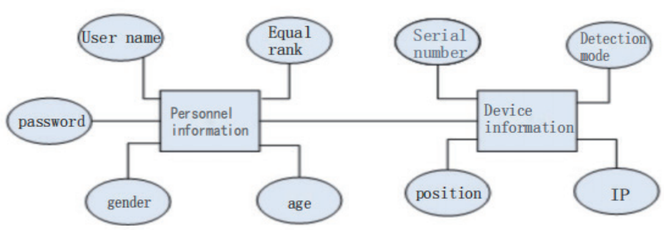

Figure 3 Database structure diagram

According to the design of the common database, a unique ID number is assigned when the surveillance camera is registered. The registrant manually enters the IP address of the camera. The system device management module uses the ID as the unique label for management, and the client communicates with the camera through the IP address. The working mode of the camera represents the image returned by the camera when the system is working for electric vehicle detection or flame detection. In the information stored by the staff, the account and password are used for comparison when the staff log in, and the authority level is used to determine the identity of the staff, so that the system can give different working permissions respectively.

2.4.Back-end management module

The equipment management background manages the monitoring camera data and staff data in the database, corresponding to the front-end interface, operates the database to add, delete and check the monitoring camera information, and calls different models to process the image data of the corresponding cameras according to the camera categories. The software system needs to control the user’s authority. The main tasks of authority control are to complete login verification, edit the surveillance camera and staff information, and assign authority. Analyze the client request, and judge whether the operator has any operation beyond the authority according to the authority distribution.

2.5.Man-machine interaction module

The human-computer interaction module of the electric vehicle management system, that is, the client includes a computer terminal and a mobile phone APP terminal.

Based on the web framework, the computer uses HTML as the theme framework, and cooperates with JavaScript scripting language to realize various click responses of users and exchange data with the server. The computer UI design is mainly divided into user login interface, monitoring camera management interface, real-time camera monitoring interface, abnormal alarm interface and so on. (The interface display on the computer side will be presented in the system test section.)

The software mobile APP is based on Android system and developed in Java language. Android is the most common mobile device, and it has the highest market share among the existing mobile smart devices. Because of its open source, almost all devices except Apple have good support for Android. The system has UI, login and registration, equipment list viewing, abnormal alarm and other functions. For the mobile device management interface, users can add and delete devices with the account with administrator rights.

3.System test

After the design of each part of the system was completed, the comprehensive system test was carried out. The test scene was a webcam built in the elevator alone. The main test of the system is three functions: equipment management and image information collection function, image recognition model function, system background management function.

3.1.User management function testing

Figure 7-1 Obtain a configuration file based on the system design requirements. Write staff's basic information, account name, password, permission level, etc. into the configuration file, and put the configuration file into the specified folder as required.

Open the software and enter the prepared account name and password for test login. The test case should cover all possible situations in daily use. The test results are shown in Table 2

Table 2 Login test

Whether the account exists	Is the password correct?	Login result
is	is	Login success
is	no	Wrong account number or password.
no	is	Wrong account number or password.
no	no	Wrong account number or password.

3.2.Device management function test

Connect the camera in the elevator to the LAN of the test computer in advance. Open the software on the test system, add a new camera, add a camera according to the camera information, and set the configuration mode to EV recognition mode.

Select a specified camera and delete the camera. The connection status of the corresponding camera is disconnected and the camera disappears from the device list.

3.3.Image recognition function

Open the monitoring camera screen, and the normal state is displayed in the space-time elevator. Push the electric vehicle into the elevator. It can be seen the client recognizes that there is an electric vehicle entering the elevator, successfully recognizes and sends an alarm. At the same time, alarms and pictures are received on the mobile APP.

Change the camera mode to Flame recognition mode. A lighter is used to simulate the flame. After the lighter catches fire, it is placed within the shooting range of the camera. The flame is identified successfully, and the alarm is synchronized on the client and mobile APP.

Concluding remarks

With the development of our economy and the continuous improvement of urbanization rate, electric vehicles with their low cost and not easy to traffic jam have become the choice of more and more people. Electric vehicles not only bring great convenience to people, but also bring a lot of safety risks, among which the fire caused by electric vehicles charging or spontaneous combustion is the most serious.

In this paper, an EV management system is designed to solve the problems of upstairs charging of EV in the management of the community, such as easy fire and rapid expansion of the EV charging point. Explore the use of the lowest cost in the reconstruction of the old residential area under the current social background for image acquisition by using the existing surveillance cameras in the residential area, and configure the specific cameras. Use the existing camera data to carry out target detection on the camera image data in the elevator and the parking point of electric vehicles without increasing the hardware cost or very little. Alarm the fire of electric vehicle upstairs and electric vehicle parking spot. The system can provide certain guarantee for community safety, and also provide reference for the design of other new residential areas and the management and upgrading of electric vehicles in old residential areas.

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