Shared Car Hygiene Monitoring Platform Based on YOLOv7

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Abstract: ***With the continuous development of the global shared car industry, China is expected to become the world's largest shared car market by 2025. However, the cleanliness of the vehicle interior environment has become an important factor restricting the development of the shared car industry. To address the hygiene issues of shared cars, this study proposes a monitoring platform based on YOLOv7. By using object detection technology to monitor the interior environment in real time and combining the Internet of Things and mobile applications to improve cleaning efficiency. Multiple data augmentation techniques are used in the training model, and its effectiveness is verified in experiments. In terms of hardware design, the ESP32-CAM is used to implement the camera control and data upload functions. The experimental results show that the platform can effectively monitor the garbage situation in the vehicle, provide cleaning and maintenance references for shared car companies, and provide technical support for the development of the industry.***

Keywords: Shared Car; YOLOv7; Artificial Intelligence; Single Chip Microcomputer; Internet of Things; Mobile Application.

1. INTRODUCTION

By 2025, the number of time-sharing rental cars in China will reach 600,000, and the number of shared travel person-times in China will reach 37 million per day. The corresponding market capacity will be as high as 380 billion yuan per year, and the associated market capacity brought by potential demand is expected to reach 1.8 trillion yuan. China will become the world's largest shared car market. Surveys show that among the top five concerns of surveyed consumers about time-sharing rental services, the dirty and messy interior environment (43%) is the second-largest concern. Therefore, the maintenance, cleaning, and preservation of the vehicle interior environment have become important factors restricting the development of shared cars.

One of the reasons for the poor hygiene is the lack of an effective hygiene supervision and reporting system, resulting in an imbalance between responsibilities, rights, and interests, making it difficult to consumers to cherish items that do not belong to them. In this situation, consumers' public awareness is seriously insufficient, resulting in a poor hygiene condition of shared cars, which seriously affects the user experience of customers. Another reason is that cleaning staff can only clean regularly, but cannot clean efficiently, resulting in low cleaning efficiency. To address these two problems, this project uses hardware that combines a single-chip microcomputer and related modules, and through the Internet of Things and target recognition technology, to monitor the usage situation of customers and provide cleaning staff with information to achieve efficient cleaning.

2. TECHNICAL ROUTE

When the customer scans the code to get on the shared car, the server remotely controls the single-chip microcomputer to take the first photo. When the customer finishes using the car, the second photo is taken, and the two photos are uploaded to the cloud server. The garbage target detection model is used to identify the change in the amount of garbage in the car, and the changed data is transmitted to the shared car company. The shared car company will formulate corresponding integral reward and punishment systems. The single-chip microcomputer will detect the air quality every minute after the use ends and upload it to the cloud server, and transmit the air quality and the amount of garbage to the application. The application will display the internal environment data of the shared car on the map to help the cleaning staff clean efficiently. Meng (2023) researched the evaluation system of green cabling of cables based on neural network [1]; Wu et al. (2025) addressed small-sample object detection of surface cracks in concrete structures of high-rise buildings via multi-level transfer learning [2]; Zheng and Jiang (2025) proposed a new methodology for Chinese term extraction from scientific publications [3]; Zhao et al. (2023) identified smart warehouse tracks using Res2Net-YOLACT+HSV [4]; Shen et al. (2025) applied the whale optimization algorithm to financial payment fraud detection [5]; Mao (2026) presented a clustering-based approach to image compression using the K-means algorithm [6]; Dong and Li (2025) generated faces based on a DCGAN model [7]; Jie (2024) applied artificial intelligence technology to industrial defect detection [8]; Luo (2026) analyzed the integration of computer application technology and information management [9]; Ya (2025) studied EDA technology in digital circuit design and its application methodologies [10]; Wang (2026) researched the application of computer science and technology in the context of big data [11]; Ma (2025) proposed a unified framework for congestion diagnosis and dynamic mitigation in complex networks [12]; Jin (2025) optimized order allocation algorithms for industrial internet platforms [13]; Gao (2025) explored the international intelligent operation model of industrial electrical enterprises under the dual-track collaboration of digitalization and greening [14]; Zhang (2026) developed a hybrid LSTM-GARCH model integrating volatility factors from the US financial markets [15]; Han et al. (2026) devised a dual-scale model with collaborative reasoning and multi-feature fusion for robust AI-generated image detection [16]; Shen et al. (2026) built a survival risk prediction model for colorectal cancer patients based on graph convolutional networks and TCGA multi-omics data integration [17]; Tian et al. (2025) introduced a business intelligence approach to ad recall using cross-attention multi-task learning for digital advertising [18]; Yuan et al. (2025) proposed a mixture-of-experts network for multi-modal fake news detection [19]; Gao et al. (2025) presented a hierarchical reasoning and LoRa-enhanced large model framework for root cause analysis in distributed systems [20]; Xiao et al. (2022) developed an ultrasmall Fe_3O_4-decorated polydopamine hybrid nanozyme that enables continuous conversion of oxygen into toxic hydroxyl radicals via GSH-depleted cascade redox reactions for intensive wound disinfection [21]; and Zheng et al. (2023) detected rebar cross-sections using an improved YOLOv5s algorithm [22].

3. GARBAGE TARGET DETECTION

3.1 Model Selection

The YOLOv7 model is a YOLO version released by the Chien-Yao Wang team in 2022, and its paper has been accepted by the international top conference CVPR (IEEE International Conference on Computer Vision and Pattern Recognition). The YOLOv7 model outperforms most current object detectors in terms of speed and accuracy within the range of 5 FPS to 160 FPS, and has the highest accuracy of 56.8% AP among all known real-time object detectors with 30 FPS or higher on GPU V100.

3.2 Data Collection and Processing

1) Data collection and preprocessing. The training data comes from web crawlers and real-world shooting, and a total of 1320 images are obtained. All images are annotated using the LabelImg software. To increase the data volume, data augmentation is performed, and the images are expanded to 6600 through rotation, inversion, brightness change, adding noise, etc. The collected images are divided into training set, validation set and test set according to 6:2:2.

2) Model evaluation metrics. In this paper, precision (P), recall (R), average precision (AP), and mean average precision (mAP) are selected as the model evaluation metrics. The calculation formulas are as follows:

$$\text{Precision}=\frac{T_p}{T_p+F_p}\times 100\% \tag{1}$$

$$\text{Recall}=\frac{T_p}{T_p+F_N}\times 100\% \tag{2}$$

$$AP=\int_0^1 P(r)dr \tag{3}$$

Taking the detection and recognition of paper as an example, in the formula, T_p represents the number of correct predictions by the model, F_p represents the number of incorrect predictions or failures to predict by the model, and F_N represents the number of predictions of non-paper types. The value of mAP is the average of the APs of each type.

3.3 Experimental Platform

The training and testing models are in the same environment, and the environmental configuration is shown in Table 1.

Table 1: Training Environment Configuration Table

Hardware configuration or software environment	Model or name	Parameters or version
CPU	Intel(R) Xeon(R) Gold 6330	2.00 GHz

GPU	RTX 3090	Video memory 24GB
System	Ubuntu	9.4.0
Network framework	Pytorch	1.11
Computing architecture	Cuda	11.3
Programming language	Python	3.8

3.4 Experimental Results and Analysis

The input image size is 640×640 pixels, the training batch is set to 32, the number of training epochs is set to 150, and the initial learning rate is 0.01. As can be seen from Figure 2, after 50 iterations, the oscillation decreases significantly, and after 100 iterations, the improvement gradually stabilizes and converges. The optimal model during training is selected for testing, and the final average precision reaches 0.94.

Table 2: Experimental Training Results Table

Category name	P/%	R/%	mAP@0.5
All	0.904	0.883	0.939
Paper	0.963	0.972	0.965
Plastic	0.962	0.857	0.939
Food	0.829	0.884	0.945
Cigarette	0.895	0.967	0.963
Glass	0.882	0.758	0.905
Metal	0.805	0.828	0.968
Battery	0.968	0.913	0.935
Medicine	0.930	0.891	0.892

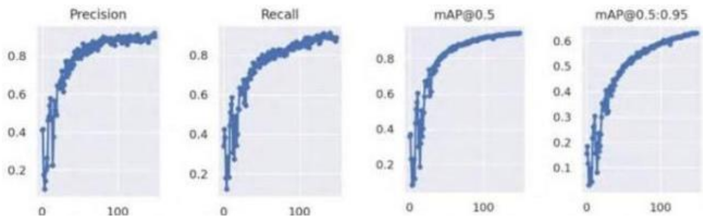

Figure 2: Experimental Training Results Diagram

4. SOFTWARE DESIGN

The mobile phone application is installed on the cleaners' mobile phones, which can save the time consumption of users choosing shared cars. This application provides functions such as querying the locations of nearby shared cars, querying relevant information about shared cars (such as the cleaning situation inside the car), and navigating to near the specified shared car. Through the APIs provided by the backend server, the mobile phone application can obtain the required data content. At the same time, with the help of certain communication protocols, the server can also actively push data to the client, enabling the mobile phone application to obtain relevant data in real time. In addition, some Internet companies provide SDKs related to navigation and positioning, such as Amap. The client can use this to obtain the user's location information and relevant data of shared cars (such as location information, internal cleaning situation, battery power, etc.) in real time, so as to further implement the navigation service function as shown in Figure 3:

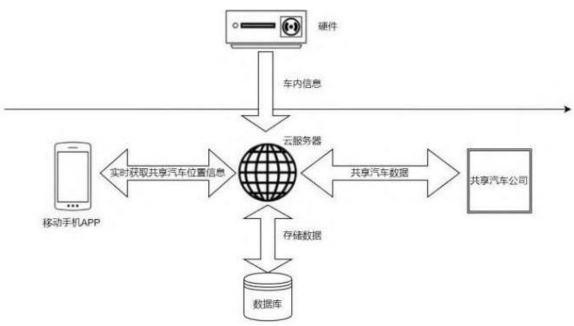

Figure 3: Schematic Diagram of the Overall System Structure

The App system module is shown in Figure 4.

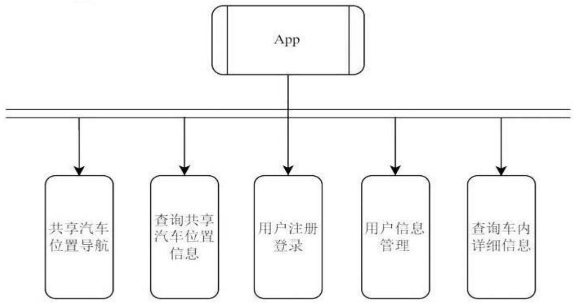

Figure 4: App System Module

The navigation process is as follows:

The user clicks on a specified vehicle on the mobile phone and selects navigation, thus entering the navigation interface for the user to choose the navigation mode. After completing the above steps, the navigation can start. The navigation flow chart is shown in Figure 5:

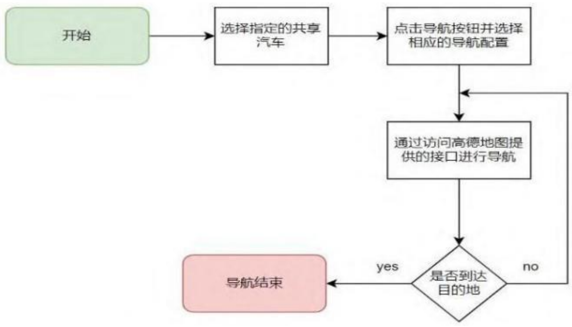

Figure 5: Schematic Diagram of the Navigation Process

Design of the cloud server:

1) The main functions of this server include issuing cleaning tasks, evaluating cleaning results, sending instructions to in-vehicle sensors, and collecting various information about the vehicle.

2) It is responsible for uploading the collected vehicle data to the server of the shared car company to analyze and evaluate the internal condition of the vehicle and retain all key information in the relevant process.

3) Upload the vehicle information to the shared car company to assist the shared car company in more effectively evaluating and maintaining the cleanliness and hygiene of the vehicle.

4) As the core hub of information flow, the most important function of the cloud server is to process, store, and forward the obtained information, and implement the upload and download of control instructions. The historical data stored in the server is crucial for the shared car company to provide query services, providing a valuable information resource library for the company to support its daily operation and decision-making process.
Database design:

By analyzing the entities involved in the entire system design and the relationships between entities, it can be determined that the database tables should at least include user information tables, vehicle information tables, vehicle usage record tables, etc.

5. HARDWARE DESIGN

Based on the ESP32-CAM prototype, an independent PCB board was drawn, which can meet the requirement of controlling two cameras simultaneously. The PCB board was printed on the JLCPCB platform and the 3D shell was printed. Due to the insufficient number of pins on the development board, a hardware connection method was adopted. All the pins of the two OV2640s except Vsync were connected together and connected to the chip, and the two Vsyncs were connected to different pins on the development board. Then, the potential changes of different pins were controlled through code to control different cameras to take pictures. Vsyne is a signal in the camera module used to synchronize image acquisition. Its function is to mark the start and end of the image frame, ensuring the complete acquisition of image data and its transmission in the correct order.

When the product starts, it first connects to Wi-Fi, then initializes the camera, sensor module and internal storage function. After completing the above operations, the photo-taking function starts. The pictures are stored in the chip in Base64 format and encapsulated into JSON format. Then, it connects to the server according to the internal storage URL and sends the generated JSON data to the specified path of the server in POST format. At the same time, the DHT11 module is used to measure the temperature and humidity, and the MQ-2 module is used to measure the smoke, which are also sent to the server in JSON format. Finally, the HTTP connection is closed.

6. CONCLUSION

This study designed and implemented a shared car hygiene supervision platform based on the YOLOv7 model and hardware devices such as single-chip microcontrollers. The platform can monitor the cleanliness of the in-vehicle environment in real time, improve the efficiency and accuracy of cleaning work, and provide technical support for the development of the shared car industry.

By monitoring the change in the number of in-vehicle garbage, the platform transmits the monitoring data to the shared car company to help it formulate an integral reward and punishment system, promoting the maintenance and cleaning of the in-vehicle environment. At the same time, the designed mobile phone App provides convenient query and navigation functions for cleaning personnel, improving the cleaning work efficiency.

In summary, the platform provides a practical solution for the shared car industry, helps to improve the user experience, and promotes the healthy development of the industry.

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