Design and Implementation of An Intelligent Vehicle Monitoring System

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Abstract. Illegal behaviours often occur in using public cars in the enterprise. To detect abnormal vehicle usage, we propose an intelligent vehicle monitoring system. This system adopts the architecture of separating the front end and back end. Automatically alarm for exceptional vehicle usage by data analyzing and show the statistical results in the form of dynamic charts. This system enables enterprises and institutions to effectively grasp the shared data resources and promotes the informatization, standardization, integration and intelligence of vehicle management, so as to improve work efficiency and economic benefits.

1. Introduction
In the process of using public cars, illegal behaviors such as using public vehicles privately, false reporting of fuel consumption, and false reporting of maintenance often occur, resulting in the loss of property of the company and the inflated cost of using vehicles [1,2]. It is not only time-consuming and labor-consuming but also easy to miss the inspection when using the traditional manual way to monitor the use of vehicles [3]. According to the demand of vehicle intelligent supervision under massive data, we propose an intelligent vehicle monitoring system. This system can automatically detect and alarm illegal behaviors such as using public vehicles privately, false reporting of fuel consumption, false reporting of maintenance, false reporting of travel expenses and other illegal behaviors based on the vehicle's records. The efficient and accurate detection of regulatory behavior can save manpower, financial and material resources and reduce the loss of company property [4,5].

Through the statistical analysis of vehicle running time, longitude and latitude, refueling time and refueling location, the intelligent vehicle monitoring system finds out illegal behaviors and displays the detection results in the form of visual chart. The logic architecture of intelligent vehicle monitoring system is shown in Figure 1.
Relying on the back-end data center, the system reduces the dimension of massive data and organizes massive data through data cleaning technology to form usable rule data. The platform uses data fusion analysis technology to build an intelligent audit model; it converts traditional business logic into system discriminating rules and automatically extracts exceptional information. And to help supervisors quickly identify, locate and analyse problems, verification results visually are output by digital visualization modules. It enables enterprises and institutions to effectively grasp the shared data resources and promotes the informatization, standardization, integration and intelligence of vehicle management, so then improve work efficiency and economic benefits.

2. System Design
This system adopts front-end and back-end separation technology and applies Client-Server (C/S) structure. The server is responsible for data management, and the client completes interaction tasks with users [6]. The structure is decoupled by means of JS/jQuery+NodeJS+Tomcat, where the client side is accessed using a browser such as Firefox and we develop the server side using the Java language. The system adopts SSM architecture and uses Spring Framework as the main framework to manage Spring MVC and MyBatis. Apache MyBatis, as the persistence layer framework, is responsible for the persistence operation of the MySQL database at the bottom of the system. For database connection performance optimization, we use the Druid, a connection pool designed by Alibaba, to ensure the safety and efficiency of the connection. In addition, we use Alibaba Excel as a data reading and writing tool. Based on the above components and tools, we complete the design and development of the back end.

Under the C/S structure, the system is divided into three relatively independent layers: presentation layer, function layer, and data layer [7], which is shown in Figure 2.

1) Presentation layer
The presentation layer is located on the client side, and its major function is to realize the graphical display of data and the input and output of system data. It is responsible for sending the request submitted by the user, sending the request to the server, and receiving the response data.

2) Functional layer
The functional layer is located on the Java server side, which contains interface and transaction processing logic. It responds to requests from the client side and calling the corresponding algorithms and logic to connect to the data layer. It sends data operation requests to the database through SQL statements, processes the requested data, and returns it to the client.

3) Data layer
The data layer is located on the server side of the database, which contains the system's data and data processing related logic. It receives data manipulation requests from the Java server side and responding to data additions, deletions, updates, queries and other operations according to the requests, and then returning the response results to the Java server.

3. System Function
In order to meet the business needs of the company's official vehicle management and facilitate the auditing of the inspectors. We equip the back end of the system with data import and export module, data cleaning module, fuel consumption verification module, overhaul verification module, and trip verification module, etc., which implement data processing and exceptional vehicle use judgments. The front end is equipped with an overview of the company's car usage, exceptional records, cost statistics, comprehensive query and other interfaces which realizes the visualization of data. Moreover, the system settings include parameter settings and database backup and recovery functions. The main function modules of the system are shown in Figure 3.

![Intelligent vehicle monitoring system](image)

**Figure 3.** Main function modules of the system.

The following is a detailed description of the back-end modules:

1) Data import and export module
The data import module provides a data import interface for managers to import Excel tables into the target database. The data export module provides managers with a data export interface, which can export audit results as Excel files or comprehensive vehicle usage reports.

2) Data cleaning module
The data cleaning module implements reexamining and verifying data, with the purpose of deleting duplicate information, correcting existing errors, and providing data consistency. It includes data denoising (removing errors in the data, data that deviates from the expected value, such as invalid zeros in GPS data.), data deduplication (removing a large number of repeated data in the data) and data
3) Fuel consumption verification module

The vehicle fuel consumption verification module is used to monitor whether the vehicle has exceptional fuel consumption and refueling information. As long as the GPS vehicle location latitude and longitude records are uploaded in this module, the number of kilometers traveled by the vehicle in the specified time period (usually in months) can be obtained through integral calculation. Then, we weighted the vehicle fueling cost data during this period to get the fuel consumption of the vehicle during this period. Finally, the vehicles with abnormally high fuel consumption in the problem performance characteristics can be checked by comparing the calculated fuel consumption with the normal fuel consumption of the vehicle. In addition, based on the vehicle mile-age calculation module, using the time point of the vehicle refueling bill as the driving data to edit the logic judgment program. First, we enter the latitude and longitude location information of the gas station in the analysis model, then we do the difference operation between this information and the latitude and longitude location information of the vehicle at that time, and finally we can get the distance between the vehicle and the gas station at that time, so we can program to determine the reasonableness of the distance and output the result.

4) Maintenance verification module

The vehicle maintenance monitoring module is used to count vehicle maintenance costs. It can generate visual reports and monitor exceptional costs based on standard costs for general vehicle maintenance. First, the administrator can inquire the specified vehicle through the license plate number after logging in, and then the vehicle cost will be displayed in the visualization interface after confirmation, and then the vehicle cost will be ranked and counted, and finally the exceptional cost vehicle and cost exceptional alarm information will be obtained according to the uploaded vehicle maintenance cost information table.

5) Itinerary verification module

The itinerary verification module is used to monitor whether there are unreasonable itineraries, such as long-term deviation from the planned route, inconsistent destinations, long-term driving and other issues. In this module, managers can query by keywords such as license plate number, driver number, and work order number. After selecting the query method and confirming, some information will be displayed in the visual interface which includes the vehicle information, driver information, dispatch work order information, historical work order and so on. At the same time, the system will auto-generate several reasonable driving paths based on the location information of the starting and ending points in the record that is being viewed, and draw them in the map display control. The actual driving path of the vehicle will be generated by the system through the uploaded GPS vehicle position longitude and latitude records simulation, and draw it out in the map display control. It can realize the alarm of long-term deviation of planned route, mismatch between destination and ticket information and other questions. The administrator can start further con-firm and verify based on the alarm. The module can determine whether the driver has illegal continuous driving problems based on GPS time information and location records to ensure driving safety.

6) Parameter setting module

The parameter setting module allows the administrator to set system parameters, including the threshold of each monitoring item.

4. Key Technology

1) Raw data upload

The system realizes single file upload or multi file batch upload. When uploading, the system automatically determines the file name and type, and passes it to NodeJS in the form of file stream. NodeJS then forwards the file stream to the back end. In the back end, the system extracts the data in the file through algorithm and cleans up the data.

2) Threshold Range Definition Algorithm
We apply different thresholds for different types of data in the monitoring process. For thresholds such as fuel consumption and expenses, we have got the histogram between the numerical interval and the frequency of occurrence through statistical calculation of the data in recent years, and obtained the interval containing 95% of the data as the threshold. And for the thresholds of the average value of costs such as 100 kilometers and 10,000 kilometers, a scatter diagram is drawn by taking kilometers and costs as the abscissa and ordinate, and then the scatter diagram is fitted to a straight line. Finally, the slope of the straight line is taken as the median of the threshold, and an appropriate interval is taken as the threshold.

3) Exception classification processing module

The exception classification processing module for handling exceptional data is mainly divided into three sections: fuel consumption monitoring section, mileage monitoring section and maintenance monitoring section. Each module has a different algorithm to process the corresponding data values, and can be run independently, which makes the module universal, compatible and available on a large scale, thus playing an auxiliary role in splitting data for future enterprises. Anomalous data after big data analysis can assist people to make reasonable decisions in real applications, which is performing content analysis and calculations on big data through deep learning to improve data accuracy, and effectively display big data through strong visualization. The flow chart of exception classification algorithm is shown in Figure 4.

![Flow chart of exception classification algorithm](image)

**Figure. 4** Flow chart of exception classification algorithm.

5. Conclusion

Intelligent vehicle supervision system is a system with open architecture and good human-computer interaction interface, and it is easy to expand and maintain. It realizes the automated computer management of the vehicles of agencies, enterprises and institutions, and provides accurate, precise and fast vehicle information for each unit.

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