Evaluation Method of Vehicle Technology Status Based on Big Data Analysis Technology

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Abstract This paper presents a method, which uses big data analysis for maintaining data of a vehicle type to evaluate the technical status of a vehicle. The failure rate of parts can reflect the technical status of each system of the vehicle. By establishing an evaluation model of vehicle technical status and data mining, the vehicle technical status of the entire vehicle model is displayed as the vehicle mileage changes. At the same time, combined with the current information and maintenance data of the vehicle, its current technical status can be effectively estimated, and it can provide a reference for the owner to target the maintenance of his vehicle.

1 Introduction

With the sustained and rapid development of China's economy and society, the number of motor vehicle ownership in China continues to grow rapidly, and the demand for vehicle maintenance has also greatly increased, which has promoted the rapid development of the automotive maintenance industry. Vehicle transactions are increasingly appearing in people's life. With the improvement of the informatization level of the auto-repair industry and the accumulation of massive auto-repair data, the method of using big data technology to analyze and evaluate the technical status of vehicles has more and more practical value.

Traditional methods for assessing the technical condition of automobiles [1–4] mainly rely on the skills and experience of professional technicians and evaluate only one aspect of the vehicle to make qualitative judgments on the external technical conditions and working conditions of vehicles, supplemented by simple appliances to perform an intuitive inspection of the technical condition of vehicles. These methods are time consuming, low efficient, and have certain limitations.

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Big data analytics are now widely used [6, 7]. This paper presents a method, which uses big data analysis of maintenance data of a vehicle type to evaluate the technical status of a vehicle. The failure rate of parts can reflect the technical status of each system of the vehicle. The more maintenance data of a vehicle type, the more accurate the evaluation of the technical condition of the vehicle is. This method is highly objective and efficient. By establishing an evaluation model of automotive technical conditions and data mining, the technical status of the entire vehicle model as a function of vehicle mileage is demonstrated. At the same time, combined with the current information and maintenance data of the vehicle, the current technical status of the vehicle can be effectively estimated, and it can provide a reference for the owner to repair and maintain the vehicle in a targeted manner.

2 Evaluation Method of Vehicle Technical Condition

2.1 Overview of Evaluation Methods

The evaluation of the technical condition of the vehicle is composed of six aspects: the use of the vehicle, power performance, economic performance, safety performance, stability, and maintenance score. Among them, the use status is reflected by the ratio of the service life of the vehicle to the service life, the ratio of the mileage of the vehicle and the mileage limit of the model; the power performance is the comprehensive status between the failure status of the key components of the vehicle's power system and the failure rate of the power system of the model reflected; economic performance is comprehensively reflected by the number of key component failures of the vehicle fuel system and the fuel system failure rate of the vehicle model; safety performance is comprehensively reflected by the number of key component failures of the vehicle brake system and the vehicle brake system failure rate; The interval between the service mileage and the service time are comprehensively displayed; the maintenance score is based on the auto maintenance of the vehicle to extend the service life as a benchmark to build a maintenance score index.

2.2 Evaluation Model Establishment

2.2.1 Evaluation System

1. Usage

The evaluation of vehicle use status mainly reflects the current status of the vehicle's inherent attributes through the mileage and years of use, and then reflects the vehicle's own technical status. Among them, the mileage can reflect the vehicle condition information, the number of years can reflect the life information of the vehicle, and the vehicle identification number code can match the basic information of the vehicle model. By comparing the number of years of use with the maximum service life of the model and the ratio of the actual mileage to the reference value of the maximum mileage of the model vehicle, the estimated state of the vehicle over its full life cycle is obtained. Vehicle usage scores are obtained using the following model:

$$U = \left(1 - \frac{U_1}{U_{1_{\lim}}}\right) \times B_{11} + \left(1 - \frac{U_2}{U_{2_{\lim}}}\right) \times B_{12}$$

Among them, U_1, $U_{1_{\lim}}$, U_2, and $U_{2_{\lim}}$ are the numbers of years of use, the mileage, and the corresponding limits. With reference to the "Requirements for the Mandatory Standard for Motor Vehicles," the mileage limit of the vehicle is set to 600,000 km and the service life of the vehicle is set to 12 years. B_{11} and B_{12} are the index weight values, which are obtained by analytic hierarchy process. The score of the vehicle usage status is obtained by combining the mileage and the number of years of use.

2. Power performance

The evaluation of vehicle power performance is mainly based on the number of failures of the vehicle power system and the failure rate of the vehicle power system. Among them, the failure rate of the power system is reflected by the failure rate of the key components of the power system, and the failure rate of the components is calculated from the replacement of the components in the vehicle maintenance data. The dynamic performance evaluation score is obtained by the following model:

$$D = (1 - D_1) \times B_{21} + (1 - D_2) \times B_{22}$$

Among them, D stands for vehicle dynamic performance score, B_{21} and B_{22} are indicator weight values. D_1 is the normalized value of the number of failures of the vehicle power system (mapped to the [0, 1] interval), D_2 is the standardized value of the failure rate of the vehicle's power system (mapped to the [0, 1] interval), and the vehicle's power performance score.

3. Economic Performance

The economic performance is represented by the failure rate of the fuel supply system. The failure rate of the fuel supply system is reflected by the failure rate of key components of the fuel supply system. The failure rate of the components is calculated by the replacement of components in the vehicle maintenance data of the model. The economic performance evaluation score is obtained by the following model:

$$F = (1 - F_1) \times B_{31} + (1 - F_2) \times B_{32}$$

Among them, F stands for vehicle economic performance score, B_{31} and B_{32} are index weight values. F_1 is the standardized value of the number of failures of the fuel system of the vehicle (mapped to the [0, 1] interval) and F_2 is the standardized value of the failure rate of the vehicle's fuel system (mapped to the [0, 1] interval).

4. Safety Performance

The safety performance evaluation score of a vehicle is comprehensively expressed by the number of times the vehicle's brake system is repaired and the brake system failure rate of the vehicle model. The safety performance evaluation score is obtained by the following model:

$$S = (1 - S_1) \times B_{41} + (1 - S_2) \times B_{42}$$

Among them, S is the vehicle safety performance score, B_{41} and B_{42} are the index weight values. S_1 is the standardized value of the number of failures of the braking system of the vehicle (mapped to the [0, 1] interval), and S_2 is the standardized value of the failure rate of the braking system of the vehicle model.

5. Stability

The vehicle stability score is a combination of the average service interval and the average service mileage interval. Among them, the average maintenance interval refers to the average maintenance frequency of the vehicle in a certain period time. The frequency reflects the stability of the vehicle equipment. Frequently repaired vehicles have poor stability. The average value of the difference in mileage between multiple repairs reflects the stability of the performance of the vehicle through the average interval between repairs. The stability evaluation score is obtained by the following model:

$$T = T_1 \times B_{51} + T_2 \times B_{52}$$

Among them, T is the vehicle stability score, B_{51} and B_{52} are the index weight values. T_1 is the standardized value of the average maintenance time interval of the vehicle (mapped to the [0, 1] interval), T_2 is the standardized value of the average service mileage interval (mapped to the [0, 1] interval), and the standardized value can further intuitively reflect the vehicle in the overall situation.

6. Vehicle Maintenance

Vehicle maintenance can improve vehicle performance and extend vehicle life. Vehicle maintenance score calculation method: If keywords such as "maintenance" are retrieved from the vehicle maintenance records, it is counted as one vehicle maintenance; the maximum number of maintenance times $Q_{\max}$ is 4 in a prescribed unit period, and the minimum number of maintenance times $Q_{\min}$ is 0 within the statistical period. The number of vehicle maintenance Q is normalized (mapped to the [0, 1] interval), and the maintenance score is obtained by the following model:

$$H = y_{\min} + \frac{y_{\max} - y_{\min}}{Q_{\max} - Q_{\min}} \times (Q - Q_{\min}) = \alpha \times Q = \frac{1}{4} \times Q$$

It can be known from the mapping interval that $y_{\min} = 0$, $y_{\max} = 1$, combined with the minimum maintenance times $Q_{\min} = 0$ and the maximum maintenance times $Q_{\max} = 4$, the coefficient is calculated $\alpha = \frac{1}{4}$, and the maintenance score H is calculated by the model.

From this, the vehicle performance evaluation score model is as follows:

$$P = (U \times B_1 + D \times B_2 + F \times B_3 + S \times B_4 + T \times B_5) \times P_1 + H \times P_2$$

Among them, P is the score of vehicle technical status, U, D, F, S, T, and H are, respectively, the use score, power performance score, economic performance score, safety performance score, stability score, and vehicle maintenance score. Among them, the five indicators of usage score, dynamic performance score, economic performance score, safety performance score, and stability score are the key indicators, B_i, $i = 1, 2, 3, 4, 5$ are the key weights, and the key weights are analyzed through hierarchy. The vehicle maintenance score is an auxiliary indicator. The weight of the comprehensive score of the key indicators and the vehicle maintenance score are P_1, P_2, and the default is [0.95, 0.05].

Set the description table of the technical status of the vehicle based on the scoring standard module. As shown in Table 1, the technical status of the vehicle is divided into five levels. There are certain differences between the technical statuses of the different levels. Corresponding the calculated total score P of the comprehensive index with the division values of each level in the description table, the corresponding technical condition level and corresponding technical condition description are obtained.

Table 1 Description table of technical status of vehicles

Technical condition level	Score	Specific description
First level	$P > 90$	During the use of the vehicle, there were no excessive repairs, good maintenance, and key systems remained in good condition
Secondary	$70 < P \leq 90$	During use, the performance of the vehicle starts to deteriorate, and each system is damaged to maintain normal working conditions
Third grade	$50 < P \leq 70$	During use, the number of system assembly failures is high, and the performance of the vehicle is moderately aging
Fourth grade	$30 < P \leq 50$	The vehicle cannot be used normally, and all critical systems are severely damaged
Fifth grade	$P \leq 30$	The vehicle was completely inoperable and was about to be scrapped

2.2.2 Evaluation Method Steps

This method uses the analytic hierarchy process (AHP) method [7, 8] to determine the weight of the key indicators of the vehicle use status and the vehicle performance evaluation system. The comparison matrix of the two places is provided by expert experience.

S_1: extract the vehicle maintenance data of the vehicle type to be evaluated in a certain period of time, and preprocess the data. Among them, the vehicle type of the vehicle to be evaluated is identified through the vehicle identification code (VIN code) of the vehicle basic information. The vehicle maintenance data includes the vehicle's repair date, repair mileage, repair items, and repair accessories. The preprocessing process includes data quality verification and data extraction.

S_2: according to the data preprocessed in step S_1, obtain the evaluation index data of vehicle technical conditions.

S_3: use AHP to determine the weight of each index in the evaluation index system of automobile technical condition, further build the evaluation model and calculate the score of automobile technical condition.

3 Conclusion

In today's society, the pace of life is fast and the cost of living is high. Most car owners do not have a good sense of maintaining their cars on schedule. This phenomenon has exacerbated the deterioration of the technical level of cars. The method for assessing the technical condition of the automobile in this article allows the owner to effectively evaluate the technical condition of the automobile and timely maintenance of the automobile, which mining automobile maintenance data from a new perspective and can prolong the service life of the automobile.

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