Research on emotion evaluation model based on automobile style keywords

Gareth Zhu[1], Zepei Wang[1,2,*], Pengchun Tang[1], Tony He[1], Jiaxin Wang[1], Yuanhua Lang[1], Siqi Wang[1], Wenjuan Shao[1], Kenny Huang[1], Shuang Yan[1]

[1]Phoenix Auto Intelligence, 401121, chongqing
[2]To whom correspondence should be addresses.

E-mail: wangzp1@changan.com.cn

Abstract. Aiming at the problems of automobile enterprises' product design and use experience emotion evaluation model, such as insufficient data collection range, high cost, low data accuracy, low utilization rate of unstructured data, based on Text mining technology, emotion analysis technology and LDA Topic model algorithm is used to research topic discovery. And apply the results of theme discovery to the knowledge service of automotive style evaluation, construct a comprehensive evaluation model based on emotional evaluation of automotive style. Finally, the feasibility and practicality of the model were verified through an example. This study can effectively analysis consumers' emotional tendencies towards products and their comprehensive evaluation of automotive style, enrich the existing product evaluation methods and methods of automotive enterprises, and provide decision-making support for the design of new car models for automotive enterprises.

Keywords: design style; driving style; automobile; LDA model; emotional evaluation model

1 Introduction

At present, the cognitive models for automobile styles were divided, shape segmentation and automatic feature recognition according to automobile style, and take it as the basis to support the innovative design of computer-aided product style. Styles were divided into styling style and driving style, mainly from the perspective of style innovation, style segmentation and feature recognition. The formation of Alfa Romeo automotive Style is the precipitation of brand history, is beyond childish and imitation, get rid of impetuous and low taste, and thus tend to or reach a sign of mature demeanor character [1]. For automobile styling design, Lu [2-3] studied the cognitive mechanism of automobile style features through eye tracking experiments and Likert questionnaire, and the research results provided references for enterprise planning and selection of automobile styling style features. Similarly, in order to improve the appearance design of autonomous vehicles in China, Jiang [4] focused on the design of automobile tail,

R. Appleby et al. (eds.), *Proceedings of the 2nd International Conference on Intelligent Design and Innovative Technology (ICIDIT 2023)*, Atlantis Highlights in Intelligent Systems 10,
https://doi.org/10.2991/978-94-6463-266-8_50

and the design of automobile feature surface was regarded as the key attribute of automobile modeling. Wang [5] conducted a cluster analysis of automobile styling styles according to the similarity of automobile model styles, and proposed the development trend of automobile styling styles in the future. Xu [6] extracted the styling features of BMW automobiles by morphological analysis method, and quantified the parameterization of the features. Meanwhile, through gray modeling analysis, he deduced the evolution process of automobile modeling, predicted the features of new modeling, and provided evaluation schemes for future automobile modeling design. Zhang[7] proposed a vehicle shape feature recognition model based on the mapping relationship between the local feature component set and the vehicle model set. At the same time, based on the user's safety needs and the induction of African style characteristics, the mapping relationship between interior design samples and user's sense of security was constructed by using Kassie engineering analysis method, and the differences in automobile interior fabrics produced by different manufacturing methods in automobile styles were analyzed [8-9]. Li [10] proposed the application strategy of new Chinese interior design style in automotive interior design from three perspectives: automotive interior layout, color and material matching, and interior component design.

In view of the important influence of driver's driving style on fuel economy and emission performance of hybrid electric vehicles, Hao [11] conducted cluster analysis on driving style through K-means clustering, which improved the adaptability of vehicle control strategy and driving style and improved vehicle driving fuel economy. Qin [12] studied the impact degree of vehicle body during driving caused by driving operations, determined the optimal power distribution mode of different types of vehicle driving conditions, and established the energy management strategy of driving style recognition. At the same time, Li [13] integrated the adaptive control strategy of driving style recognition, built the recognition model of two driving styles, and proposed the equivalent consumption minimization strategy combined with the PI fuzzy update rules of the adaptive equivalent factor algorithm. With the development of pure electric vehicle technology, Ji [14] selected 15 feature parameters related to driving safety, and through statistical analysis of each feature parameter, proposed the threshold boundary of multi-parameter combination, and identified dangerous driving behaviors, providing a reliable assessment basis for fleet management and road safety. Similarly, in order to reveal the law of the influence of driving style on energy consumption of pure electric vehicles, Zhao [15] designed a vehicle energy consumption model by using the experimental idea of controlling univariate factors, obtained the energy distribution of each component in the experiment, and conducted a quantitative analysis of energy consumption. The research results pointed out the direction for optimizing vehicle energy consumption. Finally, Qiu [16] proposed a braking energy recovery method considering the coupling effect of driving conditions and driving style by analyzing the influence law of driving conditions and driving style on vehicle braking energy recovery, which provided a theoretical basis for the economic development of new energy vehicles. The above research was only related to automobile design style and driving style, and there is no relevant research on the integration of automobile style elements and perceptual evaluation mapping model.

In the process of using emotional evaluation model to study automobile style, the core content is the fusion of style elements and perceptual evaluation mapping model. In the past, the methods of obtaining users' emotional evaluation mostly relied on questionnaires, focus interviews and expert scores, etc. Now, similar data structure can be obtain through crawler technology. In terms of the difficulty in obtaining data by using the traditional emotional evaluation model, the scope of the survey is not wide enough, the cost of labor and time is high, and the quality of the obtained data were evaluated with many problems such as insufficient scale subdivision and low data authenticity [17-18]. In view of the above problems, this paper combines the previous research foundation, based on the technical advantages of big data analysis and the good foundation of Product evaluation theory research, and starts the research from the perspective of providing knowledge service for automobile style optimization decision. Text mining, emotion tendency analysis and LDA theme modeling constructed the automobile style Emotion evaluation model. The research of this model will provide automobile enterprises with knowledge service of product evaluation, and at the same time, it can help enterprises grasp the emotional tendency of consumers to products, and provide better decision-making for enterprises.

2 The construction of emotion evaluation model

There is a great correlation between the value orientation and personality preference of automobile manufacturers and customers, so the evaluation process of automobile style has a strong subjective initiative. The automobile emotion evaluation model proposed in this paper is provide to the decision-making level and management level of the enterprise to fill and modify the model according to the original evaluation method or evaluation means, and then form the final evaluation model of the enterprise itself. According to the model presented in this paper, both enterprises and individuals can analyze online review data and dig out its hidden meaning, so as to provide knowledge services and powerful decision-making references for automobile enterprises and consumers. Therefore, this paper uses text mining technology and emotion tendency analysis technology, and use unsupervised algorithm to establish LDA, and then builds the automobile style emotion evaluation model. The model process is shown in Fig.1.

The analysis of Fig.1 shows that the process of Automotive Style evaluation model is to capture the comment data of automotive Style through web crawler technology and process the text data. The text data include noun recognition, word frequency statistics and feature word extraction. Finally, according to the "Word set for Sentiment Analysis" published by KKI, we analyze the sentiment tendency, LDA topic and semantic network of the corpus data. By using the LDA topic model to mine the topic of the review corpus, we can find many potential optional topics. Based on ABC analysis method, this paper selects six dimensions needed for comprehensive evaluation of automobile style, which are vehicle performance, appearance, logistics, driving experience, service and price. In addition, according to the short -, medium - and long-term

promotion process of time, we pay attention to the changes of the dimension combination over time. At the same time, the arrangement of dimensions also changes with external conditions and changes with the needs of enterprises.

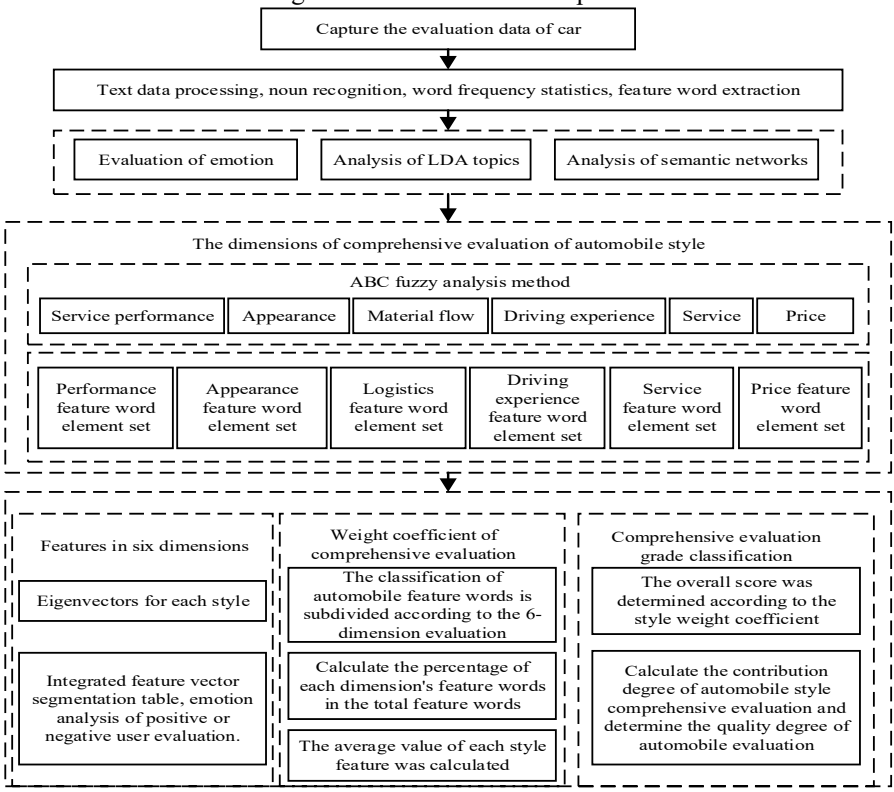

Fig. 1. Flow chart of automobile style evaluation model

Through text analysis, the feature words of automobile design style and driving style are extract and combined into a feature set, that are finally classify into six different dimensions. In order to determine the weight coefficient of comprehensive evaluation of automobile products, this paper subdivides the six dimensions of automobile style feature words, calculates the percentage of each series of feature words in each dimension in the total feature words, and finally takes the average proportion of each style as the weight coefficient. Finally, the automobile style is classified, the comprehensive score are calculate according to the weight coefficient, and the contribution degree of automobile style comprehensive evaluation is calculated, and the advantages and disadvantages of automobile style evaluation are determined.

3 Design of Automotive Style

3.1 Automotive Style

Data mining of automobile style comments are carry out by crawler technology. The main functions of the review mining process include: the extraction of automotive Style features, the extraction of comment views, the calculation of sentiment values of comment views, and the LDA topic model.

3.2 Acquisition of automotive Style characteristics

Automobile style features mainly include automobile parts, functions, services and other objective subject terms. Therefore, in the process of extracting automobile style features, the extraction approach is divide into two parts. The first part extracts the characteristics of the automobile itself from the automobile user manual and the product user guide on the official website. The second part are basing on word segmentation, part-of-speech tagging and word frequency statistics to find out the nouns of high frequency words as candidates for automobile feature words. Finally, through manual screening, we can extract the features of automobile user reviews and enrich the original features of the product itself. The product feature set F_{i} is extracted from the automobile manual, and the vehicle feature set extracted from the user comments is denoted as F_j, then the total feature set of the automobile is denoted as $F = F_i + F_j$.

3.3 Analysis of automobile style emotion evaluation

Crawler technology is use to analyze the emotion evaluation of automotive Style corpus information. In the method of emotion evaluation weight calculation, the formula of emotion evaluation of the whole sentence is:

$$Score = \frac{\sum_{i=1}^{m} P_{\mathrm{m}} + \sum_{j=1}^{n} P_{\mathrm{n}}}{m+n} \tag{1}$$

Where P_m is represented a positive set of auto-style feature words, P_n is represented a negative set of auto-style feature words, m represents the number of feature words whose polarity value is positive, n is the number of feature words with negative polarity. The affective tendency weight of each corpus can be calculate according to formula (1).

After calculating the weight of the emotional tendency of the automobile style corpus, it is necessary to determine the positive and negative polarity of the corpus, and the judging conditions are as follows:

$$class = \begin{cases} c_1 & Score > 0 \\ c_2 & Score = 0 \\ c_3 & Score < 0 \end{cases} \tag{2}$$

Where c_1 represents the corpus with positive polarity, indicating that the emotional tendency is positive, c_2 indicates neutral polarity and neutral affective tendency, c_3 represents a corpus with negative polarity, indicating a negative emotional tendency.

At the same time, the automotive Styles review corpuses are divide into polarity classifications, and all positive sentiment evaluation corpus is regrouped into a new positive review corpus. All negative sentiment evaluation corpuses are reassemble into a new negative comment corpus. Finally, the remaining corpus was composed of neutral comment corpus. The percentages of positive comment corpus, negative comment corpus and neutral comment corpus in the original comment corpus are calculate as follows.

$$C = \frac{A}{B} \times 100\% \tag{3}$$

Where A refers to different categories of review corpus, B is the total product review corpus, C is the percentage of different types of review corpus.

3.4 LDA analysis

It was founded that the semantic of the document should be considered when judging the relevance of the document, and the LDA is often used in semantic mining. In the LDA, there are three layers, namely document D , topic Z and term W, which can effectively model the text and transform the text information into digital information that is easy to model: $D = (W_1, W_2, \cdots W_N)$, $C = (D_1, D_2, \cdots D_M)$, $z = (Z_1, Z_2, \cdots Z_k)$. Where N is the number of lexical items, M is the number of documents, C is the corpus, k is the number of topics, and z is the potential thesaurus.

3.5 Evaluation score calculation

By mining the review data of a certain brand of cars, ABC fuzzy analysis method is used to determine the dimensions of car evaluation, and combining the feature set F of automotive Style, the feature vector of automotive Style under each dimension is formed as follows: $T_k = (f_{k1}, D_{k2}, \cdots D_{kn})$. Where T_k represents the automobile style feature vector of dimension k, f_{kn} represents the dimension k and there are n feature words. This paper integrates the automobile style feature vector of 6 dimensions for research.

The feature subdivision of the 6 dimensions of automobile style is determined. According to the different weight value of each dimension for evaluating automobile style, the weight value of the 6 dimensions is calculated by weighted average of the topic feature words of each dimension.

$$w_{\mathrm{k}} = \frac{\sum_{i=1}^{n} \frac{a_{\mathrm{ik}}}{F_{\mathrm{i}}}}{n} \tag{4}$$

Where w_k is the weight of dimension k in 6 dimensions, a_{ik} is the number of feature words in dimension k of the i product, F_i is the total number of feature words in 6 dimensions of class i automobile style, and n is the number of automotive Styles with n. In this paper, the weight values of six dimensions are denoted as weight vectors $W = \left(w_1, w_2, w_3, w_4, w_5, w_6 \right)$. Where w_1, w_2, w_3 , w_4, w_5, w_6 represents the weight values of car performance, appearance, logistics, driving experience, service and price in six dimensions of automotive Style respectively.

Based on the data analysis of six dimensions from the positive review corpus, the score of positive product reviews in each dimension was calculated, and the positive score vector was formed as follows $k_{\mathrm{i}} = \left(a_{\mathrm{i}}, b_{\mathrm{i}}, c_{\mathrm{i}}, d_{\mathrm{i}}, e_{\mathrm{i}}, f_{\mathrm{i}} \right)$. Where k_{i} is the positive score vector value of Class i automobile style, and $a_{\mathrm{i}}, b_{\mathrm{i}}, c_{\mathrm{i}}, d_{\mathrm{i}}, e_{\mathrm{i}}, f_{\mathrm{i}}$ are the scores vector value of vehicle performance, appearance, logistics, driving experience, service and price in the six dimensions of product in the positive review corpus. Similarly, the negative review corpus were extracted for numerical analysis based on six dimensions to calculate the score values of negative product reviews in each dimension. The negative scores vector formed according to the scores values of each dimension are as follows $l_{\mathrm{i}} = \left(a_{\mathrm{i}}, b_{\mathrm{i}}, c_{\mathrm{i}}, d_{\mathrm{i}}, e_{\mathrm{i}}, f_{\mathrm{i}} \right)$. Where l_{i} is the negative score vector of Class i products, and $a_{\mathrm{i}}, b_{\mathrm{i}}, c_{\mathrm{i}}, d_{\mathrm{i}}, e_{\mathrm{i}}, f_{\mathrm{i}}$ are the score values of car performance, appearance, logistics, driving experience, service and price in the six dimensions of automotive Style in the negative review corpus respectively.

By calculating the positive score vector and negative score vector, the comprehensive evaluation scores of automobile style are calculated. The comprehensive scores matrix of automobile product is calculated as follows:

$$S_{\mathrm{i}} = \begin{bmatrix} W_{\mathrm{k1}} & W_{\mathrm{l1}} \\ \vdots & \vdots \\ W_{\mathrm{ki}} & W_{\mathrm{li}} \end{bmatrix} \begin{bmatrix} p_1 & \cdots & p_{\mathrm{i}} \\ q_1 & \cdots & q_{\mathrm{i}} \end{bmatrix} \qquad E = \begin{bmatrix} W_{\mathrm{k1}} p_1 + W_{\mathrm{l1}} q_1 & 0 \\ \vdots & \vdots \\ 0 & W_{\mathrm{ki}} p_{\mathrm{i}} + W_{\mathrm{li}} q_{\mathrm{i}} \end{bmatrix} \tag{5}$$

Where $\begin{bmatrix} p_1 & \cdots & p_{\mathrm{i}} \\ q_1 & \cdots & q_{\mathrm{i}} \end{bmatrix}$ are affective tendency coefficient matrix, p_{i} is the proportion of positive comment corpus in the total comment corpus, q_{i} is the proportion of negative comment corpus in the total comment corpus. Among them, p_{i} and q_{i} are calculate according to formula (3).

According to the above calculation, the evaluation dimension performance of various automobile styles can be measure according to the automobile styles emotion evaluation model. Finally, the contribution value of automobile style evaluation is calculate as follows:

$$V_i = W_{ki} p_i + W_{li} q_i - 10 \tag{6}$$

When $V_i < 0$ the formula results in a poor comprehensive evaluation of the automotive Style, and the automotive Style is not worthy of recommendation. When $0 \le V_i < 1$ the formula results in the comprehensive evaluation of automobile style pass. When $V_i \ge 1$ the formula results in a better comprehensive evaluation of the automotive Style, and the larger the value of V_i, the higher the evaluation of the automotive Style.

4 Verification and Analysis

Grab a car brand from a 4S head office in a region, and get the evaluation data of four models of cars. According to the ABC fuzzy analysis method, the evaluation dimensions of automobile style are extracted, and the following six automobile style evaluation dimensions, namely performance, appearance, logistics, driving experience, service and price, are calculated subsequently. According to formula (4), the average weights of different dimensions are calculated, and their weights are respectively 17% for performance, 14% for appearance, 16% for logistics, 25% for driving experience, 23% for service and 5% for price. The weight vector is recorded as W=(0.17,0.16,0.05,0.25,0.23,0.14).

Extract 4 models of cars for text mining, and extract the positive corpus of the car. LDA theme analysis and word frequency analysis are carried out to extract relevant feature words. Calculate the attention scores of the six dimensions of automotive Style in the positive comment corpus, as shown in Fig. 2.

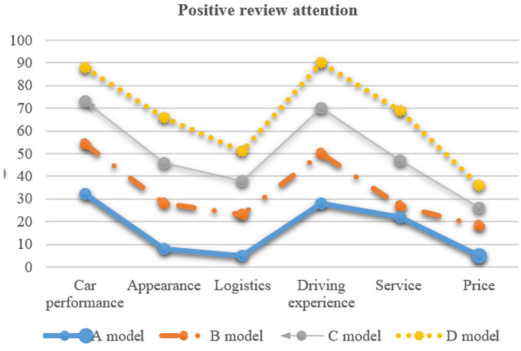

Fig. 2. The attention of six dimensions of the positive comment corpus

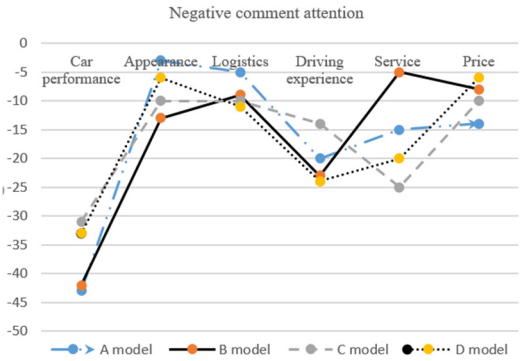

Fig. 3. The attention of six dimensions of the negative comment corpus.

Similarly, through statistical methods, the attention scores of six dimensions of automotive Style in the negative comment corpus are calculated. The product attention score of negative comment corpus as shown in Fig.3.

There are found from the analysis of Figure 2-3 that the advantages and disadvantages of automobile style in different dimensions can be obtained. From this, we can know in which dimensions the automotive Style performs well and in which dimensions it performs poorly, which needs further improvement and optimization.

Substitute formula (3) to calculate each p_i and q_i value in the emotional tendency coefficient matrix

$\begin{bmatrix} p_1 & \cdots & p_i \\ q_1 & \cdots & q_i \end{bmatrix}\begin{bmatrix} p_1 & \cdots & p_i \\ q_1 & \cdots & q_i \end{bmatrix}$, and get the emotional tendency coefficient matrix $\begin{bmatrix} 0.6406 & 0.6823 & 0.7817 & 0.7387 \\ 0.1064 & 0.1254 & 0.1117 & 0.1432 \end{bmatrix}$.

At the same time, the product score matrix $S_i = \begin{bmatrix} 9.413 & 0 & 0 & 0 \\ 0 & 10.446 & 0 & 0 \\ 0 & 0 & 12.496 & 0 \\ 0 & 0 & 0 & 12.004 \end{bmatrix}$ is calculated according to formula (5).

According to formula (6), the contribution degree of the comprehensive evaluation of four types of vehicle styles is:

A model: V_A=-0.5867, B model: V_B= 0.445 9, C model: V_C = = 2.496, D model: V_D = 2.004.

The higher the score of comprehensive evaluation contribution, the better the user experience of the car, and therefore the better the automotive Style evaluation. By modeling the automotive Styles review data in six dimensions and analysing the automotive Style from different dimensions, we can find the comprehensive evaluation price difference of JL series cars, while the overall evaluation of model B cars is at the qualified

level. However, the comprehensive evaluation of model C and model D cars is relatively high, which is consistent with the fact that these two series of cars are more popular with consumers. It is feasible to analysis cars from six dimensions of automotive Style.

5 Conclusion

Based on the problems such as insufficient collection range, high cost, low data accuracy and low utilization rate of unstructured data, the automotive Styles evaluation model are constructing by using text mining technology and sentiment analysis technology. And take the certain car as an example for verification. Automobile enterprises and individuals can evaluate a certain type of automobile they want to analysis according to the automobile styles evaluation model constructed in this paper, which can effectively analysis consumers' emotional evaluation of the automobile and the performance of the product in different dimensions, and find out the degree of advantages and disadvantages of the product in different dimensions. The research results can assist the designer to determine the reasonable research direction of the automobile in the early stage, provide data support for the design scheme, reduce the unnecessary repetitive work in the product development process, and increase the work efficiency and the feasibility of the scheme determination.

References

1. Zhao D Y, He R J 2011 Brand Styling and Feature Research of Alfa Romeo J. ZhuangShi, p:72-4
2. Lu Z L, Zhang Y, Cheng B, et al 2016 A Study on the Cognitive Mechanism of Car Styling Based on Style Feature J. Automotive Engineering, p:280-7
3. Lu Z L, Cheng R D, Shi Q Y, et al 2016 Vehicle Styling Feature Derivation and Evaluation Based on Natural Language Processing J. Automotive Engineering, p:553-60
4. Jiang L 2017 Analysis of the Design Style of the Fastback in Automobile Exterior Design J. Packaging Engineering, p:193-9
5. Wang Y X X S, Zhao J H, Zhao D H 2017 Automobile Design Style Based on Styling Surface Features J. Packaging Engineering, p:169-76
6. Xu J, Wang X Y, Huang P, et al 2016 Research on prediction methods of automobile styling based on the grey correlation theory J. Journal of Machine Design, p:114-7
7. Zhang P, Xue C Q 2011 A Style-innovation-oriented Automobile Feature Recognition Method J. Journal of Mechanical Engineering, p157-63
8. Wang Y X, Zhong X 2020 Research on African-style Car Interior Design Based on Users' Sense of Safety J. Industrial Design, p:54-5
9. Chen R, Gu Y L, Mao Y 2010 Different weaving technique for automobile interior fabric and their style differences J. Technical Textiles, p:28-31
10. Li Z H, Duan Q J, Liu H 2021 Research on the Application of new Chinese Interior Design Style in Automotive Interior Design J. Design, p:78-81
11. Hao J X, Yu Z P, Zhao Z G, et al 2017 A Study on the Driving Style Recognition of Hybrid Electric Vehicle J. Automotive Engineering, p:1444-50

12. Qin D T, Zhan S, Zeng Y P, et al 2016 Management Strategy of Hybrid Electrical Vehicle Based on Driving Style Recognition J. Journal of Mechanical Engineering, p:162-8
13. Li K L, Lin X Y. Adaptive control strategy of plug-in hybrid electric vehicle integrated with driving style recognition J. Journal of Fuzhou University (Natural Science Edition),p:811-7
14. Ji S B, Zhang K, Li L, et al 2022 Driving Style Classification Method Based on High-frequency Data from Pure Electric Vehicles J. Journal of Tong Ji University (Natural Science), p:273-81
15. Zhao J W, Hu M H, Rong Z B, et al 2021 Effect of driving style on the enemy consumption of an electric vehicle J. Journal of Chongqing University, p:103-15
16. Qiu M M, Yu W, Zhao H, et al 2022 Braking Energy Recovery Control Strategy for PHEVs Considering Coupling Influence of Driving Cycle and Driving Style J. Journal of Mechanical Engineering, p:143-52
17. Kong D Y, Huang S R, Ma S J 2022 Perceptual Evaluation Method of Automobile Styling Design Based on Sentiment Analysis J. Journal of Tong Ji University (Natural Science), p:1817-23
18. Song J, Zhan H F, Yu J H 2019 Construction of Product Design Comprehensive Evaluation Model Based on Web Reviews Data J. Computer Applications and Software, p:88-93+110