Personalized Art Design of Wheel Rims Based on Image Mapping of Image Requirements

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***Abstract*—In the customization of wheel rims, to convert users' emotional images and needs into design solutions, research is conducted based on pixel theory, using clustering algorithms, principal component analysis and other technologies to establish image association sample libraries, obtain image mapping relationships, and construct a wheel rim shape design platform system and system design improvements. The results showed that unlike methods such as support vector machines, the K-means algorithm had higher classification accuracy and smaller average absolute error. The classification accuracy of the K-means algorithm was 93.15%, and the support vector machine was 84.33%. The minimum average absolute error of the K-means algorithm was 0.56. In the application of the wheel personalized customization platform system, the improved design improved user satisfaction and ease of use, with corresponding scores of 4.40 and 4.35, respectively. The research method can transform user image needs into wheel shape design schemes to meet user needs.**

Keywords—Wheels; art design; styling design; user needs; image clustering

I. Introduction

A. Research Background

With the development of society and the progress of the times, as well as the rise of Internet technology and e-commerce, people's consumption level is gradually improving, and their desire for personalized needs is gradually increasing [1-2]. Users also have high requirements for product design. The personalization of products has become a concern for people, and research on user customization methods has a relatively short history, and there is also little research on user customization experience and methods.

The development of automobiles drives the development of wheel rims. Currently, wheel rims are moving towards lightweight, high-strength, and aesthetically pleasing directions to meet the functional and market demands in the future [3-4]. In addition to various innovative designs in structure and manufacturing technology, there are also new requirements for the appearance of the wheel rims. With the development of Internet technology, the rim industry will continue to innovate in products and business models. Personalized customization and rapid design of rims have become the development trend in the rim design field.

B. Research Progress and Challenges

Multidimensional research has been conducted on personalized customization both domestically and internationally. Based on the existing research on personalized customization systems, scholars have proposed different customized prototype systems and methods according to different needs. There are relatively few applications of personalized customization in wheel rims, especially in platforms that involve users in custom design. For the form of wheel customization, users usually customize colours, materials, and sizes during the customization process, and the range of changes in wheel shape is relatively small. At present, there is a lack of suitable tools and simple operating methods for customizing personalized wheel shapes. How to enable users to easily operate and efficiently customize the wheel shape has become an urgent problem that needs to be solved.

At the same time, the rim shape design based on image correlation conforms to the development trend of the Internet era [5-6]. The constructed image association sample library has a complete variety and rich quantity, and users can personally participate in wheel customization design. During the customization process, users can select image images and vocabulary in the system to obtain image wheels; you can also participate in customization according to your own preferences, and choose and customize the color, texture decoration, number of spokes, and material of the wheels. However, at this stage, there is a lack of personalized customization tools that are suitable for users. There is relatively little research on the construction of knowledge bases or databases to assist in the process of product styling design, and the application expansion of completed databases is also insufficient.

C. Research Method and Objective

To meet the image needs of users and achieve their personalized wheel customization requirements, research is conducted on wheel customization methods based on image association and guided by image guidance. Through this approach, we aim to provide users with relevant customized platforms, allowing them to have a greater sense of participation and a greater sense of achievement.

D. Novelty and Importance

The innovation of research mainly includes two aspects. One is to establish image associations between the user's emotional intention, wheel body elements, and metaphorical elements, more effectively guiding users to customize according to image associations. The second is to use the K-means algorithm to establish a hub ontology element library and a vehicle element library, and establish an association between the two, in order to maximize the satisfaction of user personalized customization needs. The importance of research lies in achieving more accurate expression and implementation of users' emotional needs and fuzzy images, providing users with a more reliable personalized customization method, and further improving their sense of participation, joy, and achievement.

E. Organization Structure

The research is divided into six sections. Section II is a literature review, which introduces the research status of domestic and foreign scholars on automotive component customization, user participation customization, and clustering algorithms. Section III conducts a customization requirement analysis, determines the priority of wheel customization, constructs an image-related sample library, and conducts a customization platform system. Section IV analyzes the results, studying the clustering effect and customization effect of images. Discussion is given in Section V. Section VI summarizes research methods and other content, pointing out research shortcomings and future research directions.

II. Related Works

In the continuous development of the automotive industry, there is a demand for personalized customization among users, and personalized customization of automotive components has become a new research direction. In the process of customizing automotive structural components, Jankovics et al. introduced additive manufacturing to optimize it. Through topology optimization, additive manufacturing maximized its advantages, saving materials and shortening redundant printing time. After practical verification, it was found that the vehicle pillars manufactured by this method had high performance [7]. To improve the performance of automotive components, Dalpadulo et al. optimized them through additive manufacturing, utilized computer-aided methods for relevant design management, and obtained corresponding integrated computer-aided design platforms. The results showed that the designed automotive components had good performance [8]. Sharma et al. introduced the Lean Six Sigma framework when facing component failures and made appropriate adjustments based on organizational goals. The study also provided an outlook for this method [9]. Kim et al. conducted a manufacturing safety assessment of automotive steering knuckle parts based on dynamic analysis and topology optimization techniques to improve the manufacturing performance of automotive components. After relevant verification, it was found that the stiffness of the manufactured parts was strengthened [10]. In the optimization of automotive component parameters, Vinodh used methods such as grey Taguchi to optimize design parameters such as hardness, and conducts variance analysis. From the correlation analysis of standard test samples, it can be seen that the proposed method can obtain the optimal process parameters of the components [11].

Olsen et al. analyzed the effectiveness of user participation in customization in advertising production and conducted experiments. Users participated in the formulation of specific information and supported collaboration with others. During the customization process, the perceived relationship between users and the company was enhanced, and the effectiveness of brand presentation was improved [12]. Kucirkova used the application level of story production as a platform in the design field of children's institutions, allowing children to participate in story production, emphasizing children's initiative, and achieving personalized design, in order to provide inspiration for relevant researchers and make the produced stories more popular among children [13]. During the process of interactive customization of product styling, Zeng et al. conducted specific discussions on the issue of cognitive ambiguity, analyzed the fuzzy effect, classified it as cognitive ambiguity in decision-making, and designed relevant spatial mapping strategies and selected clustering strategies to alleviate cognitive ambiguity. Through example analysis, it was found that the clustering strategy had a good effect in solving cognitive ambiguity problems [14]. Quach et al. studied mobile users and analyzed their perceived differences in personalized preferences, including differences in discomfort with ambiguity. Through cluster analysis, the analysis results of participant data were obtained. From the results, it can be seen that the user experience showed differential changes [15].

In summary, most of the methods used in automotive component customization are relatively professional, with complex operational processes and less involvement in personalized customization by users. Additionally, there is insufficient research on wheel shape customization. In this regard, the research focuses on the design of car wheel rims from the perspective of personalized customization by users. Based on the good performance of clustering methods in cognitive fuzzy problems, it is applied to user fuzzy image analysis. Compared to previous research, research has provided users with an efficient platform for customizing wheel shape, facilitating personalized customization and enhancing their sense of participation.

III. Personalized Customization Design of Wheel Rims based on Customization Requirements and Sample Library

In order to design wheel rim styles that meet users' desired aesthetics, research is conducted to analyze personalized user needs and determine customization priorities. Through methods such as K-means algorithm and principal component analysis, the wheel rims and non-wheel rim images are classified, and ontological image element library and metaphorical image element library are constructed. The mapping of image associations between the two libraries is established. Wheel rim customization is then carried out, and a customization platform system is developed.

A. Determination of Personalized Customization needs and Priorities for Wheel Rims

In the process of social development, users' pursuit of product styling differences is gradually becoming apparent. How to prioritize users' individual customization needs and ensure that their needs can be accurately and comprehensively reflected in the customized design of wheel rims is the first thing to be solved in personalized wheel rim design. In this regard, research will conduct a specific analysis of the personalized customization needs of wheel rims. During the customization process, the image guided customization method and image non wheel images are used to recommend image wheels to users. The process of analyzing user personalized needs is shown in Fig. 1.

In Fig. 1, the elements of customized wheel design are first analyzed, and the factors that affect the shape of the wheel are summarized and refined to obtain a set of elements for wheel design. During this process, the wheel rim features are analyzed and classified into two types: common features and selective features. The customized information on wheel rim design elements is obtained using statistical survey methods. User customization elements are determined and organized by allowing users to choose images and vocabulary to showcase their personal needs, thus obtaining user needs. During this process, methods such as user interviews and big data analysis are used to collect and analyze user needs based on user log files or actual usage data. The wheel rim requirements are refined and classified into five categories, such as craftsmanship and personality. In addition, the priority order of the wheel rim requirements parameters is judged to determine the priority of wheel rim requirements. This provides a clearer understanding of user customization needs, resulting in a better customization experience. The selected images are decomposed into features, and the image is segmented to obtain user customization needs. The relationship between wheel rim features and user needs is analyzed, and the main elements of wheel rim design are extracted. The essential elements required for the wheel rim style are classified as common demand features, which are basic needs and do not require customization. Non-essential elements are classified as selective demand features and must exist in the customization system. The hierarchical structure contained in this feature is shown in Fig. 2.

In Fig. 2, the selective features of the wheel rims are divided into four categories: structural and technological. By using the focus interview method and literature review method, the design elements of the wheel rim are extracted, and the results are organized. Combined with the hierarchical structure classification in Fig. 2, the collected elements are sorted and classified to obtain the classification results of the main design elements of the wheel rim, as shown in Fig. 3.

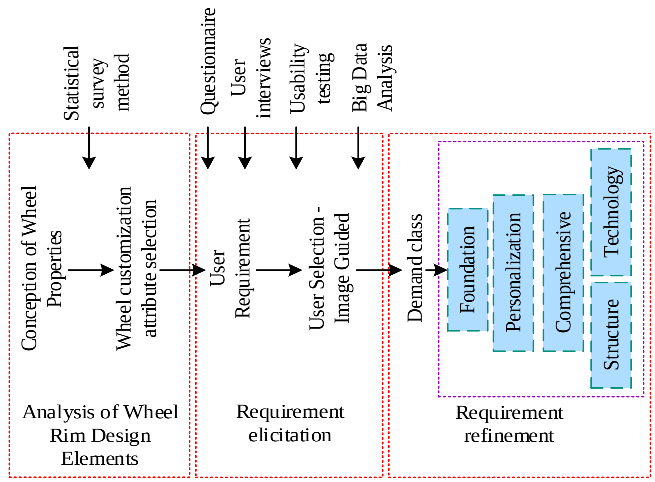


Fig. 1. Related analysis process.

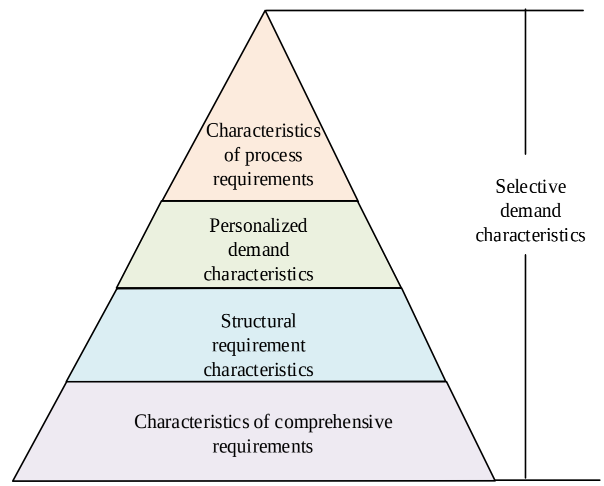


Fig. 2. Related hierarchy.

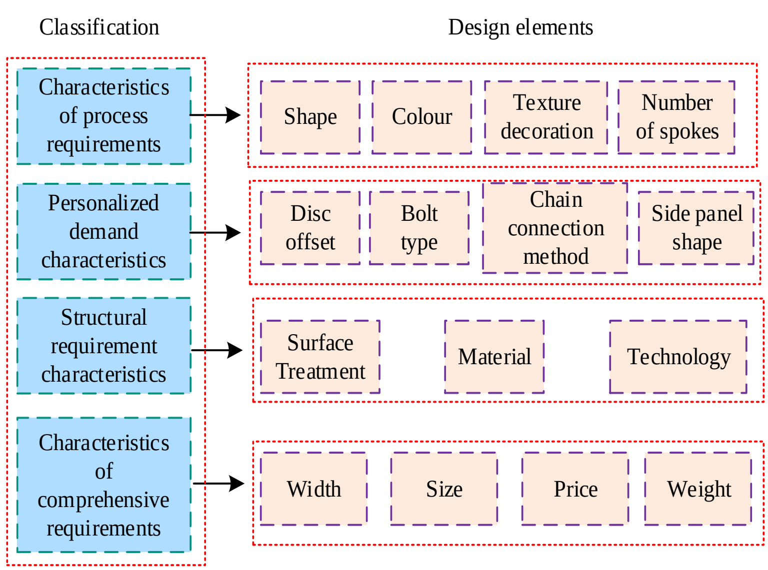


Fig. 3. Classification results of main design elements of wheel rims.

In Fig. 3, after sorting, four main design elements are obtained, including personalized categories, process categories, and other categories, each containing different design elements. Among the personalized elements, there are four design elements, namely shape, color, texture decoration, and number of spokes. This type of element is the core part of it, and it is considered as a personalized requirement feature. Research will analyze this type of feature, and other categories will not be discussed. The corresponding wheel shape is selected based on the features selected by the user for image segmentation, and the wheel color and texture are customized based on the color and texture in the image. The mapping between wheel attributes and user needs to better customize wheels is utilized for users. When customizing, the customization of selective requirements is considered and the wheel feature matrix is set as shown in Eq. (1).

$$D_{4\times n} = (D_1, D_2, D_3, D_4) = \begin{bmatrix} d_{11} & \cdots & d_{1n} \\ d_{21} & \cdots & d_{2n} \\ d_{31} & \cdots & d_{3n} \\ d_{41} & \cdots & d_{4n} \end{bmatrix} \tag{1}$$

In Eq. (1), D_1 represents the customized feature attribute set of the wheel structure class, d_{1n} represents the n-th feature attribute in D_1. D_2, D_3, and D_4 represent the customized feature attribute set of wheel rim technology, comprehensive, and personalized categories, respectively. d_{2n}, d_{3n}, and d_{3n} represent the n-th feature attribute in D_2, D_3, and D_4. Before customization, image vocabulary selection is carried out, and image guided customization is used to guide users, stimulate their inner needs, and identify their implicit needs. Based on user emotional preferences, determine customization priorities. By using quantitative methods, the user preference is calculated and a category preference matrix C_4^u is constructed for the wheel feature attributes of user U, as shown in Eq. (2).

$$C_4^u = (c_1, c_2, c_3, c_4) \tag{2}$$

In Eq. (2), u represents user U, and the preference of user U for structural requirement features is set as c_1. The user's preference for process requirement features, personalized requirement features, and comprehensive requirement features is c_2, c_3, and c_4, respectively, $c_i \in [0,1]$. i represents the serial number. 0 and 1 represent the lowest and highest preference, respectively. The higher the preference, the higher the priority of the corresponding category requirements. The relationship between the preference degrees of these four demand characteristics is shown in Eq. (3).

$$\sum_{i=1}^{4} c_i = 1 \tag{3}$$

As the research mainly focuses on personalized demand characteristics, the value of c_3 is set to [0.5, 1], and the other three categories are set to [0, 0.5]. To calculate the priority of wheel customization, the impact of a single feature of a certain category on other categories should be considered, and the impact matrix of that feature should be set, as shown in Eq. (4).

$$D_4^S = (\alpha, \beta, \eta, \lambda)^T \tag{4}$$

In Eq. (4), the individual feature customization elements of the wheel rim are set as S, and the degree of S 's influence on the wheel rim customization is D_4^S. α, β, η, and λ respectively represent the degree of S 's influence on the wheel rim structure, process, personalization, and synthesis. The values of these parameters are within [0, 4], and the specific values are determined by professional technical personnel. The larger the value, the more important it is. The priority values f_i of internal design elements for class customization features are calculated, as shown in Eq. (5).

$$f_i = C_4^u \times D_4^S = c_1\alpha + c_2\beta + c_3\eta + c_4\lambda \tag{5}$$

In Eq. (5), the higher the value f_i, the higher the priority of the corresponding customization element. The customized wheel elements are sorted according to the order of f_i values. In addition, the image cutting effect is evaluated by analyzing the grayscale contrast of the target and background regions through regional contrast $C'(t)$, with t representing the threshold. The larger the value $C'(t)$, the better the segmentation effect, as shown in Eq. (6).

$$C'(t) = \frac{|f_o - f_b|}{f_o + f_b} \tag{6}$$

The segmentation effect Evaluate through regional consistency $U'(t)$. The larger the value $U'(t)$, the better the segmentation effect, as shown in Eq. (7).

$$U'(t) = 1 - \frac{1}{h}\sum_i \left\{ \sum_{(x',y')\in R_i} \left[f(x',y') - \frac{1}{A_i} \sum_{(x',y')\in R_i}^{n} f(x',y') \right]^2 \right\} \tag{7}$$

In Eq. (7), h represents the normalization coefficient. In a binary image, $i = 2$, the i-th segmented sub block is R_i, and the size of the segmented sub block is A_i. $f(x',y')$ represents an image.

$$S'(t) = \frac{1}{h}\sum_{(x',y')} \mathrm{sgn}\left[f(x',y') - f_N(x',y') \right] \Delta(x',y') \mathrm{sgn}\left[f(x',y') - t \right] \tag{8}$$

In Eq. (8), $f_N(x',y')$ represents the grayscale mean of the N domain pixels, and the generalized gradient of each pixel is set to $\Delta(x',y')$. The higher the value $S'(t)$, the better the segmentation effect.

B. Sample Library Construction of Wheel Image Association

After determining the priority of customized elements, a sample library of wheel image association is constructed based on pixels. The research focuses on the ontology metaphor element, which is an image carrier that can comprehensively and accurately express the shape features of the wheel, and is the "image" of the image. The metaphorical element is an associative image generated by the characteristics of the concrete wheel shape, which belongs to subjective sensation and is used as the "meaning" of the image in conjunction with human subjective sensation. The ontological element can express the shape of the wheel, while the metaphorical element is people's understanding of the wheel. The sample library of wheel products includes images of wheel products, as well as non-wheel images similar to the wheel. These images are combined to form a wheel image association sample library. This sample library includes an ontology element library and a vehicle element library. A representative sample of 114 wheels is collected from countries such as the UK and Germany. After removing similar samples and screening, 10 samples of different categories are obtained. Through online search and other means, 174 adjectives are collected for tire styling style, such as cute, practical, and retro. By combining expert analysis and evaluation using the KJ method, these adjectives are processed to obtain 10 adjectives, which are selected the most frequently. The antonyms of these 10 adjectives are found and vocabulary groups are formed with them, as shown in Table I.

TABLE I. IMAGERY VOCABULARY GROUP

Number	Vocabulary group
1	Minimalist - cumbersome
2	Retro Modern
3	Decoration - Simple
4	Fun - Stupid
5	Textured - no texture
6	Motion - Static
7	Composite - Single
8	Traditional - avant-garde
9	Lightweight - bulky
10	Fragile - Strong

In Table I, these image vocabulary groups demonstrate the different feelings that wheel shape gives, such as simplicity and complexity. 10 samples are randomly selected and a survey is conducted through a questionnaire to analyze the vocabulary group values of different wheel samples. The number of participants in the survey is 40. Data are organized and principal component analysis is conducted. From the analysis results, it can be seen that the image vocabulary of the wheel is mainly explained by three factors, namely factor 1 (sensory factor), factor 2 (complexity factor), and factor 3 (texture factor), which treat the vocabulary that appears multiple times as a common vocabulary. In factor 1, common factors include composite, modern, sporty, avant-garde, and lightweight, minimalist in factor 2, and textured in factor 3. After analysis, for the ontology image element library, the wheels it contains have corresponding perceptual vocabulary. Based on perceptual imagery, these vocabulary can be divided into seven categories: simple - cumbersome, moving - static, composite - single, textured - non textured, retro - modern, traditional - avant-garde, and lightweight - bulky. According to the number of spokes, the samples in the ontology pixel library are classified into categories such as five spokes. Among them, the multiples of five belong to the category of five rays, while the division of other rays is similar. The K-means algorithm is selected to classify image samples and corresponding datasets are constructed. The algorithm adopts the intra class variance criterion function, as shown in Eq. (9).

$$E=\sum_{i=1}^{k}\sum_{x\in c_i}\left(dis\left(x,m_i\right)\right)^2 \tag{9}$$

In Eq. (9), m_i is the mean point of the cluster $C*_i$ and x is the point within the cluster. According to the classification of perceptual vocabulary, the ontological elements of a five spoke wheel can be divided into seven categories, with each category aggregating similar features into a group of ontological elements. In this group, each ontology pixel has a subclass group with high similarity to it. Due to the high sales volume of Wufu wheel rims, their sample library was sampled and contoured. Cluster analysis is conducted on the samples based on the three characteristics of composition, V-shaped curve, and spoke edge. Extract spoke lines using MATLAB software and binarize 207 ontology pixel samples, with a labeled sample size of 50. According to the nearest domain classification method, clustering is performed using the K-means algorithm to obtain the corresponding cluster clusters. To obtain the mapping relationship between ontology and vehicle elements, analyze the relationship between their morphological features, select a grayscale co-occurrence matrix, and extract features. Features are the key factor in distinguishing things, and designers convey different emotional images by assigning different styling features to things in the process of designing products. The product itself includes design elements in its design, such as points, lines, surfaces, and other patterns. From the perspective of design, due to the complexity and variability of the front design of the wheel rim, it has a significant impact on the wheel rim design. In the front design, the form of the front panel of the wheel has the greatest impact on the shape of the wheel. Therefore, in the design of the wheel shape, the main feature is the front panel form, with the side spoke feature as a supplement. Using second-order moments (energy), correlation, homogeneity, and contrast (moment of inertia), the relationship between ontological and metaphorical elements is evaluated. In the correspondence between primitive and metaphorical elements, a single ontological element may correspond to multiple metaphorical elements, so some metaphorical elements may correspond to the same ontological element; Multiple ontological elements may also correspond to multiple metaphorical elements, so there will be corresponding relationships between ontological element groups and metaphorical element groups. Extract some ontology and metaphor elements for mapping, provide examples to illustrate the corresponding rules between ontology and metaphor elements, and use image recognition technology to process them.

C. *Personalized Customization Platform Construction for Wheel Rims*

Personalized customization of the wheel rim is conducted, which can be divided into two parts: the wheel rim customization process and customization decision-making. The former is based on user demand information and related image correlation mapping, carries out step-by-step retrieval, guides users, and achieves wheel customization. The latter communicates with users online based on customized solutions to obtain corresponding solutions. Overall, the customization process is shown in Fig. 4.

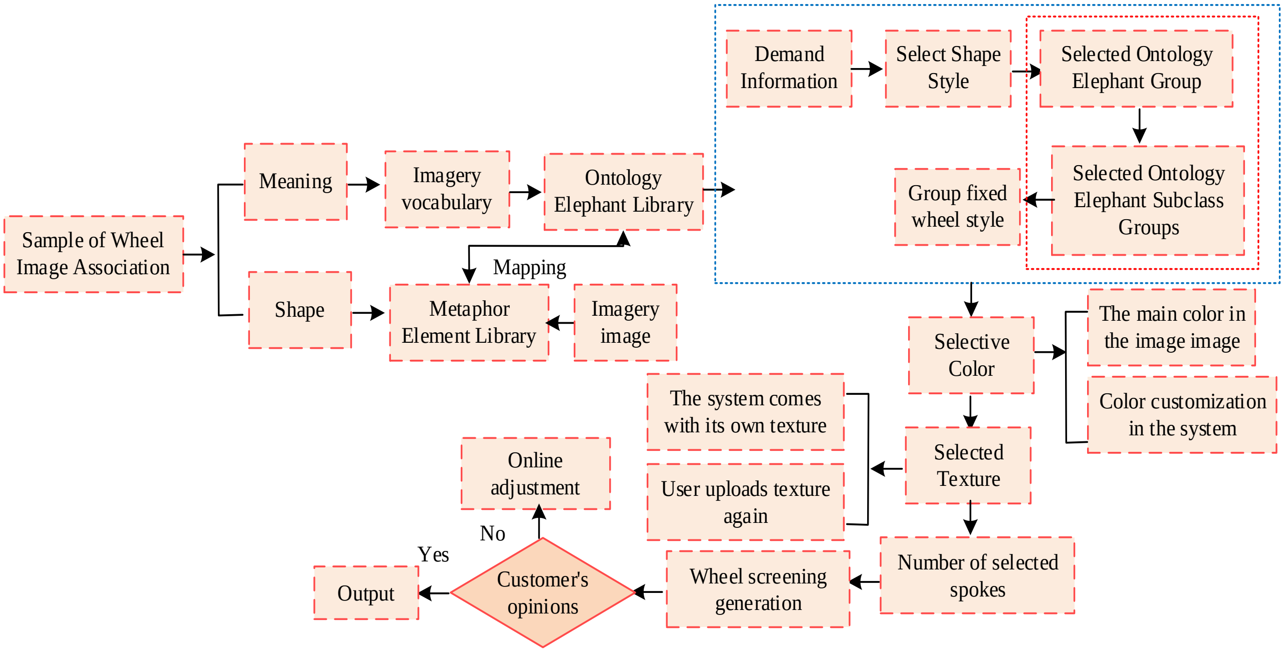


Fig. 4. Customization process.

In Fig. 4, the expression of user needs is transformed into image selection form, and the wheel image association samples are selected. The system decomposes the features to obtain user demand information. By selecting imagery vocabulary, the user's tendency towards wheel style is judged. Based on the image association mapping relationship between the primitive and metaphorical elements, as well as the perceptual image classification of the ontological elements, the user is guided purposefully to filter the wheels and select their preferred colors and textures, thereby outputting the wheels that the user is satisfied with. A customized platform system is designed with a functional structure that includes three modules: information management, customization, and expansion. The information management module can set user preferences. The personalized customization module is the core part of the system functions, including image selection, texture decoration selection, and other parts. The logical relationship of this module is shown in Fig. 5.

In Fig. 5, in the customized information input function (user selection), image images and vocabulary are selected to obtain wheel shape and image style. In the image feature decomposition function, based on segmentation technology, image features are decomposed to obtain three modules: shape, color, and texture decoration. Users can select these modules. In the design element sorting function, determine the sorting of shapes, colors, etc. based on the set user preferences. If the user has not set a preference, the wheels will be customized according to the system default order.

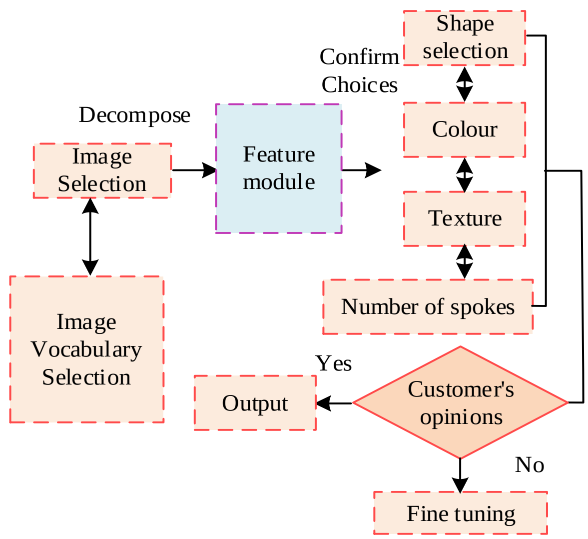


Fig. 5. Related logical relationships.

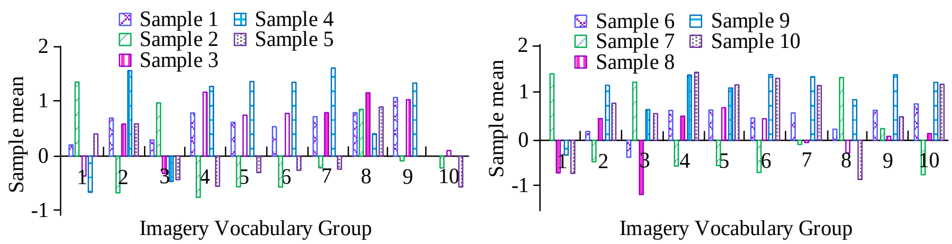
IV. Results and Discussion

In the process of personalized customization of wheel rims, the principal component analysis results on emotional vocabulary analysis was analyzed. The classification of image samples and the effect of wheel customization were analyzed. The relationship between ontological and metaphorical elements was analyzed through indicators such as contrast. Questionnaire surveys and interviews were used to analyze the situation of wheel customization. In addition, the study also designed a customized platform system expansion module. This module is mainly prepared for the expansion and modification of the image association sample library. The library is a source library that provides users with choices. The ontology element library in the library has two sources of wheels. One is that physical wheels refer to wheel samples that have been put into production or have already been produced. The second is virtual wheel rims, which include designer designed wheel rims or conceptual wheel rims, as well as wheel rim styles optimized by computers based on certain patterns, such as obtaining various lightweight wheel rim styles through software parameter settings.

A. Principal Component Analysis of Sensory Vocabulary

MATLAB software randomly selected 10 samples, and a survey was conducted through a questionnaire to analyze the vocabulary group values of different wheel samples. The number of participants in the survey was 40. The data were organized and the sample mean was obtained as shown in Fig. 6.

In Fig. 6, more than half of the data belonged to positive values, indicating that the selected samples met the research objectives. A positive value indicated that the corresponding samples tended to be "stationary", while a negative value indicated a feeling of "moving". In Fig. 6 (a), in Image Vocabulary Group 2, the mean of Sample 4 was 1.61. In image vocabulary group 7, the mean of sample 4 was greater than 1.5, with a mean of 1.64. The absolute values of the sample mean for the other vocabulary groups were all less than 1.5. In Fig. 6 (b), in Sample 6, its mean on the "fun stiff" side was relatively large, with a sample mean of 1.41, which was 0.10 larger than Sample 7. Overall, the mean of all positive values in the sample was 0.84, the absolute value of the mean of negative values was 0.53, and the mean absolute value of both was 0.68. By selecting the absolute value of the sample mean greater than 0.68, the tester's image preference vocabulary for the sample was obtained. On this basis, principal component analysis was conducted on it, and the results are shown in Table II.



(a) 1-5 sample mean (b) 6-10 sample mean

Fig. 6. Sample mean plot.

TABLE II. PRINCIPAL COMPONENT ANALYSIS RESULTS

Factor	Vocabulary group	Factor load capacity	Eigenvalue	Explained variance	Accumulated variation
1	Composite - Single	0.943	5.741	56.454	56.454
	Retro - Modern	0.932			
	Fun - Stupid	0.921			
	Motion - Static	0.920			
	Traditional - avant-garde	0.880			
	Lightweight - bulky	0.861			
	Fragile - Strong	-0.632			
2	Decoration - Simple	0.833	2.467	25.432	83.011
	Minimalist - cumbersome	-0.953			
3	Textured - no texture	0.989	1.366	13.743	96.788

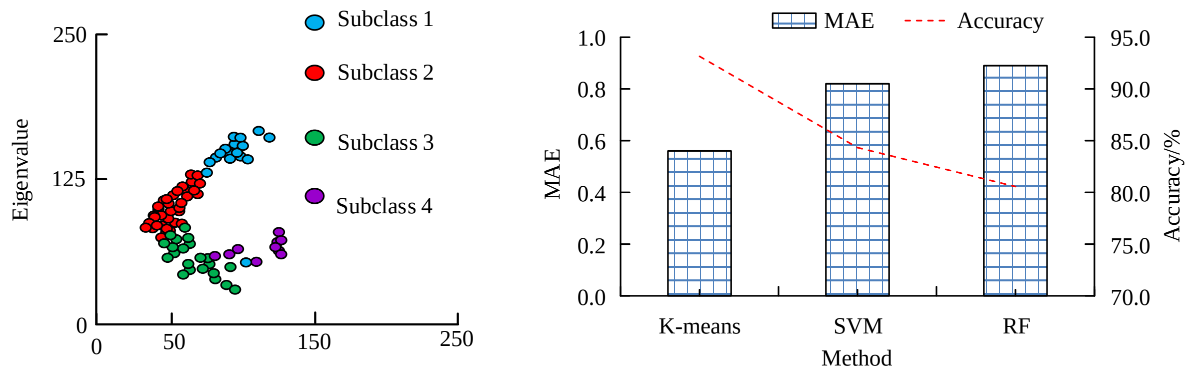
In Table II, the factor load corresponding to different vocabulary groups was different. The factor load of the single compound vocabulary group was 0.943, while the maximum factor load of the non-textured vocabulary group was 0.989. Based on the number of times the vocabulary group appears in the survey questionnaire, seven types of vocabulary groups were obtained, including single compound vocabulary groups.

B. Analysis of the Correspondence between Image Clustering and Primitive Image Elements

MATLAB software selected 207 ontology pixel samples, including 50 labeled samples. In order to analyze the classification performance of image samples, Support Vector Machine (SVM) and Random Forest (RF) were selected for comparison, and the performance of the K-means algorithm was analyzed in Fig. 7.

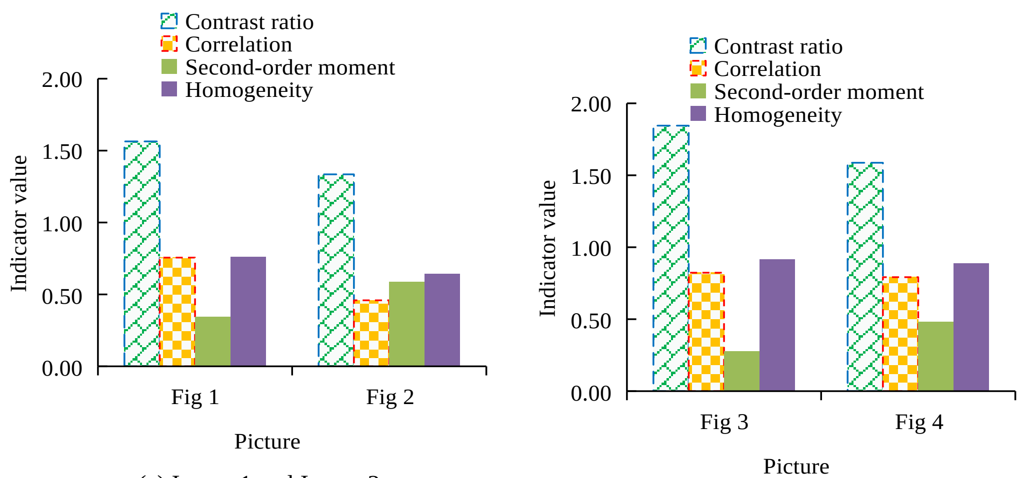
Fig. 7 (a) shows the classification results of the K-means algorithm. In this subgraph, the subcategories of four pixel class groups was well classified, and there was partial overlap between adjacent subcategories, indicating the existence of the same pixel among the subcategories, which was consistent with the statement in the research method. In Fig. 7 (b), compared to algorithms such as SVM, the accuracy of the research method was higher. The classification accuracy of

K-means algorithm was 93.15%, which was 8.82% higher than SVM algorithm and 12.59% higher than RF algorithm. It can be seen that the classification performance of the research method was good. The corresponding relationship between the original vehicle elements was analyzed and 4 images were randomly selected from the original vehicle element sample library. Images 1 and 2, 3 and 4 were all original vehicle element relationships and analyzed through correlation and other characteristics, as shown in Fig. 8.



(a) Classification results (b) Clustering effect

Fig. 7. Classification results.



(a) Image 1 and Image 2 (b) Image 3 and Image 4

Fig. 8. Data feature.

In Fig. 8 (a), the correlation value of Image 1 was 0.732, which was 0.004 higher than that of Image 2. The homogeneity values of Image 1 and Image 2 were 0.877 and 0.891, respectively. In Fig. 8 (b), the homogeneity value of Image 3 was 0.914, which was 0.027 higher than Image 4. The correlation value between Image 3 and Image 4 was relatively close, with the former being 0.031 higher than the latter. From this, it can be seen that there was a high degree of similarity between the two selected pairs of images, with a certain degree of correlation and mapping.

C. *Analysis of the Customized Effect and Design Improvement Effect of Wheel Rims*

20 test users related to the automotive industry were selected, and their satisfaction was calculated with using the system's customized wheels. Data were collected through a survey questionnaire. The satisfaction rating was on a scale of 1-5, with higher scores indicating greater satisfaction. The user satisfaction results are shown in Fig. 9.

In Fig. 9, there were certain differences in satisfaction among different users, and overall, the user satisfaction value was relatively high. User 1's satisfaction score was 4.32 points, which was 0.35 points higher than User 2. The highest score for user 5 was 4.62 points. The satisfaction score of User 15 was 3.97, with an average score of 4.13. According to user feedback, the system preference setting was relatively vague and there was no browsing record. In response to this, design improvements were made by adding a browsing record section and numerically setting the preference for feature attributes, resulting in user related ratings as shown in Fig. 10.

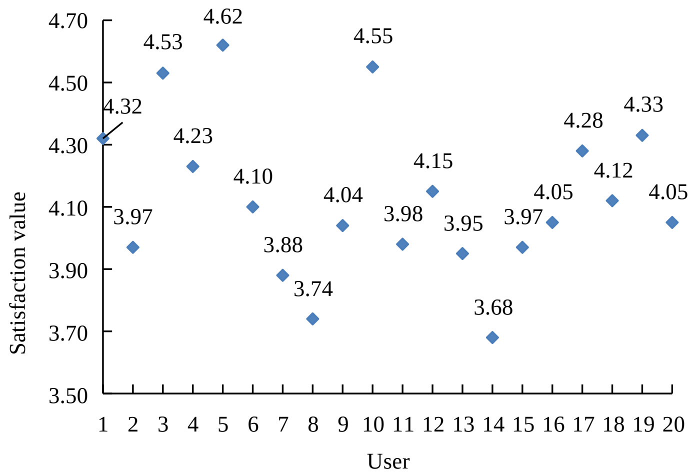


Fig. 9. Satisfaction results.

In Fig. 10, after design improvements, user satisfaction and ease of use ratings improved. In terms of satisfaction, user 12 scored 4.36 points, which was 0.01 points higher than user 17. The user satisfaction scores were all 4.40 points, 0.27 points higher than before the improvement. The average score of ease of use for operation was 4.35 points, which was 0.97 points higher than before the improvement. From this, it can be seen that the system constructed through research had a good application effect.

To further validate the effectiveness of the wheel customization design proposed in the study, it was compared with other similar methods, namely the personalized customization schemes for automotive parts in references [16], [17], and [18]. The study selected 404 users from sales stores of different automotive companies to voluntarily participate in this test (there was no statistical difference in the basic information of the selected users), and the evaluation indicators included Satisfaction Usability and Comprehensive experience evaluation. Among them, the comprehensive experience evaluation is based on a 10 point scale and mainly evaluates the comprehensive experience of customized solutions. The comparison results of the four methods are shown in Table III.

From Table III, it can be seen that in the comparison of Satisfaction and Usability scores, the differences in literature [16], literature [17], and literature [18] are relatively small, but there are significant differences compared to the methods used in this study. Meanwhile, in the Comprehensive experience evaluation, the method used in this study scored as high as 9.43, indicating the best overall experience. This proves that this research method can better provide personalized customization solutions for users and achieve better results.

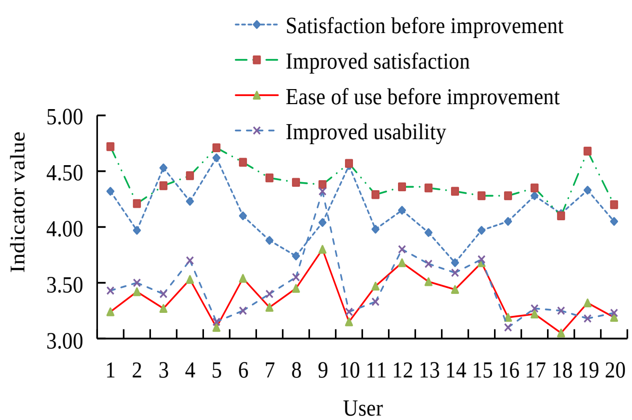


Fig. 10. User related rating.

TABLE III. COMPARISON OF FOUR PERSONALIZED CUSTOMIZATION EFFECTS

Methods	Satisfaction	Usability	Comprehensive experience evaluation
Reference [16]	4.03	4.21	8.54
Reference [17]	3.98	4.02	8.61
Reference [18]	4.17	4.15	8.75
This research	4.82	4.76	9.43

V. Discussion

This study proposes how to transform user's emotional imagery and customization needs into wheel design solutions in wheel customization, meet user customization needs, and improve user satisfaction. This study is based on the elephant element theory, establishing an image association between the ontology elephant element and the vehicle elephant element in the elephant element theory, allowing users to customize the wheel shape of non-wheel images through a customization platform. The results show that in the classification of image samples using K-means algorithm, compared with SVM and other algorithms, the classification accuracy of the research method is higher, at 93.15%. The reason is that, the K-means algorithm is easy and has high efficiency and scalability when processing large image datasets. Using the K-means clustering algorithm can effectively achieve automatic classification of wheel and non-wheel images. In the analysis of the correspondence between the objects of this metaphor, four randomly selected images paired in pairs showed a high degree of similarity, proving the correlation and mapping relationship among them. Compared to the mapping relationship between product design and imagery established by Luangrath et al. [19] through association analysis and factor analysis methods, the method used in this study achieved the same effect, promoting the expansion and development of imagery in product design. In user testing related to the automotive industry, user satisfaction and ease of use ratings have been significantly improved after design improvements. This is because the car wheel customization design method proposed in this study can reduce unnecessary interference, provide users with more targeted design solutions, and thus provide an efficient customization tool.

VI. Conclusion

In order to design wheel shapes that meet the user's image needs, research is conducted to analyze the personalized needs of users and determine customization priorities. By using K-means algorithm and other methods, wheel graphs and non wheel graphs are classified, ontology and vehicle pixel libraries are constructed, and image association mapping is constructed between the two. On this basis, personalized customization of the wheel rims is carried out and a corresponding customization platform system is established. The results showed that in the principal component analysis of perceptual vocabulary, the factor load of different vocabulary groups was different. The factor load of the single compound vocabulary group was 0.943, and the maximum factor liability of the non textured vocabulary group was 0.989. Based on the number of times the vocabulary group appeared in the survey questionnaire, seven categories of vocabulary groups were obtained, including single compound vocabulary groups. Compared to other algorithms, the K-means algorithm performed better in classifying image samples. The classification accuracy of K-means algorithm was 93.15%, which was 8.82% higher than SVM algorithm and 12.59% higher than RF algorithm. There was a high degree of similarity, correlation, and mapping in the relationship between the object and its elements. The homogeneity value of Image 3 was 0.914, which was 0.027 higher than Image 4. The correlation value between Image 3 and Image 4 was relatively close. The customization effect of the personalized wheel customization platform system was good, and after the design improvement, the user satisfaction scores were all 4.40 points. It can be seen that the application effect of the research method is good. However, there is a large number of sample libraries for wheel image association, and the study only takes the common five spoke wheel as an example for analysis and exploration. The expansion and classification of wheel and non-wheel images in the library need to be continuously updated in the future. At the same time, the research mainly focuses on customized design of wheel rims from the perspective of shape, and further analysis needs to be carried out by incorporating factors such as materials, structure, technology, and stress.

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