Research on the Intelligent Design of Office Chair Patterns

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Abstract: (1) Background: Personalized product customization is an important direction in the development of the chair industry. This paper studies an intelligent design method for the rapid realization of personalized office chair customization; (2) Methods: based on the case-based reasoning (CBR) method, the characteristic attributes of office chair patterns are analyzed, and an attribute model is established. According to office chair data and customer demand, an intelligent design model using multi-layer weighted k-nearest neighbor (K-NN) for chair patterns is developed using the entropy weight method and an analytic hierarchy process. In addition, an example is employed for verification of the K-NN and multi-layer weighted K-NN retrieval models; (3) Results: both models are able to effectively retrieve chair type cases that meet the target requirements from the office chair pattern base; the case matching similarity of the multi-layer weighted K-NN retrieval model was higher, with an average increase of about 3.9%, and the chair pattern case results obtained by setting different customer needs are different, indicating that the case can be selected according to different customer preferences, which is more conducive to personalized product customization design; (4) Conclusions: The multi-layer weighted K-NN model for intelligent chair pattern design proposed in this paper is more conducive to personalized product customization design.

Keywords: k-nearest neighbor; office chair pattern; intelligent design

1. Introduction

China has become the global chair manufacturing center, with many brands and fierce competition. The leading enterprises in the chair profession have gradually moved towards high and mid-grade products, and have implemented competition strategies focused on differentiation and personalization. The production mode has gradually transformed from large-scale pipeline production to large-scale customized production. The rapid transformation of customer demand into intelligent design of chair products has become the direction of development in the chair industry [1].

Intelligent design is a method that has information processing at its core. It aims to improve the ability to meet customer demands for product diversification and individuation. Through the acquisition, representation, rationalization, and application of design knowledge, the compression of the product design cycle and the improvement of design efficiency can be achieved. The traditional design process for office chairs typically includes chair pattern design, trial modeling, debugging, and revision, among which chair pattern design is closely related to the personalization and differentiation of customer demands. In the existing literature related to office chair customization and intelligent design, Ding [2] proposed a product family design method for office chairs under mass customization conditions by applying ideas of standardization, generalization, and modularization. Tang [3] proposed a general office chair concept, adapting and customizing the design of office chairs in different places of use through module selection and combination; Tang [4] constructed an office chair product data system based on PDM, laying the foundation for...
an information coding system and product database structure for office chair enterprises; Zeng et al. [5] put forward a method for modeling and solving office chair configuration design problems from the perspective of customer demand. The research described above has improved the ability of products to meet the customization needs of customers, and promoted intelligent design as a development direction in office chair design. However, there is no relevant research on intelligent design in the area of key chair pattern design, which would enable enterprises to quickly achieve customer-personalized customization.

Case-Based Reasoning (CBR) is an intelligent design method based on previous practical experience. It searches for and matches the most similar cases from the database of existing cases to provide a basis for the solution to the current problem. It is characterized by its intuitive and easy-to-understand solution results. There are two main types of CBR: explanatory CBR and problem-solving CBR [6]. Explanatory CBR classifies, describes and explains the current situation using previous cases as a reference, and is commonly used in the fields of diagnosis, classification, and prediction [7–9]. Problem-solving case-based reasoning uses previous cases to propose constructive solutions for current problems, and is commonly used in engineering scheme selection and design, such as Zhang’s [10] use of CBR to build a decision support model for the preliminary design stage of a building envelope, thus improving the efficiency of intelligent building envelope design, Ren’s [11] proposal of an effective similarity determination model for CBR problems in the initial design stage of low-carbon products, Xie’s [12] application of CBR to the design process of hydro-generators, thus improving the design efficiency, or Ke’s [13] proposal of an intelligent remanufacturing design method based on vector space model (VSM) and CBR, along with a verification of its feasibility.

In view of the demand for intelligent design of office chair patterns, this paper applies the CBR method to analyze the characteristics of office chair pattern from the perspective of the demand for customer personalization, applies the K-nearest neighbor (K-NN) retrieval algorithm to construct an office chair pattern case retrieval model with combined feature weights, and carries out intelligent design research on office chair patterns.

2. Materials and Methods

2.1. Office Chair Pattern Intelligent Design Planning

Chair pattern design consists of the preliminary design of the office chair’s appearance, structure, and function. In the traditional design of office chair products, in order to meet customer needs, designers need to spend a lot of time on chair pattern design, whereby it is difficult to effectively use an enterprise’s existing product information resources, making it an inefficient process. The chair pattern intelligent design scheme is shown in Figure 1.
Based on the analysis of customer demand and an office chair case database, this paper determines the characteristic attributes office chair pattern. According to the office chair pattern characteristic attributes and the collected customer demand information, the analytic hierarchy process (AHP) is used to establish a customer preference evaluation matrix consisting of the product’s structure, function, and appearance, and the subjective weight of these three aspects of product performance for the customer is established. At the same time, the entropy weight method (EWM) is used to calculate the amount of information provided by the characteristic attributes of the candidate cases in the office chair pattern case database, and the objective weight of each feature is determined. The product characteristic attributes, subjective weight and objective weight are used as the correction parameters of the K-NN retrieval model. The most similar cases in the case database are searched to provide a scientific decision-making reference for designers in office chair pattern design. 

2.2. Feature Analysis of Office Chair Patterns

Office chairs are a multi-attribute, multi-variable modular product, as shown in Figure 2, with the structure mainly consisting of a backrest, armrests, a seat board, and a supporting component. Each part is made individually, and then they are all assembled into a whole chair. In the production and sales stages, manufacturers can change the configuration of the office chair according to the individual demands of customers. Aspects such as the fabric and color of office chairs are variable; meanwhile, the specific configuration of the armrests, the pneumatic lifting, the scaffold, and the wheels can be changed without changing the basic function, shape, and technology of the seat and back.

![Figure 2. Basic composition of an office chair.](image)

To achieve the personalized customization of office chair products, the design of the chair pattern should be closely related to customer demands. However, for various reasons, customer demands, mainly with respect to the three aspects of the product’s structure, function, and appearance, are often ambiguous, contradictory, or hidden. In the design of an office chair, as shown in Figure 3, the structure, consisting of the exterior dimensions of the seat structure, includes the seat height, the seat width, backrest height, armrest height, and so on, which are designed according to principles of ergonomics; meanwhile, functions include seat height adjustment, armrest rotation angle, back elevation angle adjustment, and other functional characteristics; and appearance includes seat material, color, style, etc. Therefore, a case representation model for an office chair pattern can be established on the basis of an expression of information related to an office chair’s structure, function, and appearance, and can be used to describe the basic information regarding office chair products.
Figure 3. Office chair pattern characteristic attributes.

2.3. Similarity Calculation Method

Case retrieval is the key stage in case reasoning, wherein the nearest neighbor retrieval method is widely used because it is a case retrieval method that obtains solutions on the basis of high degrees of similarity [14]. The distance between data in space is usually taken as a quantitative indicator of similarity. In general, the shorter the distance is, the higher the degree of similarity. When analyzing office chair feature data, the office chair pattern feature data types mainly include: accurate real value data, character data, interval real value data. The similarity measurement methods for different data types are as follows [15]:

(1) Accurate real value data

Accurate real value data mainly comprise the real value vectors of the structure size attributes of office chairs, including the back height, back width, and seat depth. The importance of different attributes for office chair pattern design varies. Equating the different attributes does not reflect the actual situation in reality. Therefore, a method for attributing weighting is adopted so that those attributes that undergo larger changes have smaller weight coefficients than those that undergo smaller changes. The specific calculation formula is as follows:

\[
sim_1(x_i, y_i) = 1 - \left( \sum_{i=1}^{n} w_i |x_i - y_i| \right)^{\frac{2}{l}}
\]

In this formula, \(n\) is the number of structural dimensions of office chairs, \(x_i\) is the \(i\)-th attribute value of an instance in the office chair instance database, \(y_i\) is the \(i\)-th attribute value of the target product of office chair design, \(w_i\) is the weight coefficient of the \(i\)-th attribute of the office chair.

(2) Character value data

Character value data are mainly used to describe the attribute characteristics of demands related to office chair functions and appearance, including material, style, use occasion, etc. Attribute similarity is determined by comparing the similarity of two semantic character segments. The calculation formula is as follows:

\[
sim_2(x_i, y_i) = \begin{cases} 
1, & x_i = y_i \\
0, & x_i \neq y_i 
\end{cases}
\]

In this formula, \(x_i\) is the \(i\)-th attribute value of an instance in the office chair instance base, \(y_i\) is the \(i\)-th attribute value of the target product of office chair design.

(3) Interval real value data

Interval real value data mainly describe the characteristic attributes of office chair function parameters, such as adjustable seat height and backrest angle range. The similarity calculation formula is as follows:

\[
\begin{cases} 
\sim_3(A_i, B_i) = 1 - (0.5(|y_1 - x_1|^{r} + |y_2 - x_2|^{r}))^{\frac{1}{r}} \\
A_i = [x_1, x_2], B_i = [y_1, y_2]
\end{cases}
\]

\(r\) is a positive integer.
In the formula, $A_i$ and $B_i$ are the interval values of the $i$-th characteristic attribute of the office chair type, where $A_i$ is the value in the instance library and $B_i$ is the value of the target product.

2.4. Analysis of K-NN Retrieval Model

The K-nearest neighbor (K-NN) retrieval method is used to sort the items in the database by calculating the similarity of the data items, so as to find the $k$ items most similar to the target data. The basic idea is to set an object $D$ in the dataset and calculate the set of the $k$ nearest objects to it. If most objects in set $E$ belong to the same category, then $D$ will also be classified as belonging to this category [16]. Thus, it is shown in Figure 4 that when $k$ corresponds to the inner circle, the black circle to be allocated will be classified as a green triangle, and when $k$ corresponds to the outer circle, the black circle to be allocated will be classified as a red square.

![Figure 4. Examples of K-NN algorithm.](image)

In the K-NN retrieval method based on similarity calculations, the influence of each characteristic attribute of an instance on the retrieval results is equivalent. In practical applications, in order to improve the accuracy of the retrieval results, characteristic attribute weights are usually introduced for the purposes of correction. At present, methods for determining attribute weights can mainly be divided into subjective weighting methods and objective weighting methods. Subjective weighting methods have the advantage that weightings are determined according to the meaning of the attributes, but their objectivity is poor. Objective weighting methods are advantageous in that they determine weights without needing to consider the actual meaning of attributes, but they cannot reflect the differing degrees of attention that decision makers may devote to different attributes, and sometimes the determined weights will be inconsistent with the actual importance of attributes.

In the personalized design of office chair products, different customers have different sets of priorities for product design, and there will be varying degrees of demand bias for each attribute of the product. Product characteristics data have an important influence on product design rationale. Therefore, based on the two aspects of customer demand and product data characteristics, this paper establishes the subjective weight of customers’ consideration of office chair products in terms of the three aspects of structure size, function, and appearance using the Analytic Hierarchy Process (AHP), and then establishes the objective weight of information entropy of office chair product feature data using the Entropy Weight Method (EWM), and constructs a combination weight optimization K-NN retrieval model.

2.4.1. AHP

AHP [17] is a kind of subjective weighting method that is suitable for dealing with certain types of complex fuzzy decision-making problems, especially those that cannot be addressed by quantitative analysis. In the design of office chairs, the subjective weight coefficient of the structure, function, and appearance attributes of the office chair is divided
by AHP. The process is as follows: For \( n \) attributes to be compared, the expert scoring method is used to establish the following discriminant matrix:

\[
S = \begin{bmatrix}
1 & p_{12} & \cdots & p_{1j} \\
p_{21} & 1 & \cdots & p_{2j} \\
\vdots & \vdots & \ddots & \vdots \\
p_{i1} & \cdots & p_{ij-1} & 1
\end{bmatrix} \quad i = n, j = n
\] (4)

In the formula \( p_{ij-1} = \frac{1}{p_{i,j}} \), \( p_{ij} \) represents the ratio of importance of the \( i \)-th attribute to that of the \( j \)-th attribute for a customer, and its importance level is as shown below in Table 1.

**Table 1. Level of importance.**

| Serial | Classification of Importance | \( p_{ij} \) |
|--------|-------------------------------|-------------|
| 1      | \( i \) and \( j \) are equally important | 1           |
| 2      | \( i \) is a little more important than \( j \) | 2           |
| 3      | \( i \) is more important than \( j \) | 4           |
| 4      | \( i \) is more important than \( j \) | 6           |
| 5      | \( i \) is absolutely more important than \( j \) | 8           |

After the consistency test of the judgment matrix, the feature vector of the matrix is solved. After the normalization of the feature vector, the subjective weight for the customer of the size, function, and appearance of the office chair’s structure can be determined, and this is used as the first-level weight of the retrieval model.

2.4.2. EWM

EWM [18] determines the degree of variation of the index by calculating the information entropy of the index, thus providing the objective weight. Usually, the lower the degree of calculated index information entropy, the greater the degree of variation, the greater the amount of information contained, and the more important the role in the overall evaluation; this cannot be ignored, and therefore, a larger weighting will be determined. In turn, the greater the information entropy, the smaller the amount of information contained, and the lower the value; therefore, its weight in the whole should be lower. The calculation steps of EWM are as follows:

Suppose there are \( m \) product cases and \( n \) evaluation indexes. The original index data matrix is as follows:

\[
X_{ij} = \begin{bmatrix}
x_{11} & \cdots & x_{1j} \\
\vdots & \ddots & \vdots \\
x_{i1} & \cdots & x_{ij}
\end{bmatrix} \quad i \in m, j \in n
\] (5)

Data standardization:

\[
Y_{ij} = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)} \quad i \in m, j \in n
\] (6)

Information entropy calculation is as follows:

\[
E_j = -\ln(n)^{-1} \sum_{i=1}^{n} P_{ij} \ln P_{ij}
\] (7)

Among which:

\[
P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}}
\] (8)
The weight of the information for each attribute is:

\[ W_j = \frac{1 - E_j}{n - \sum_{j=1}^{n} E_j} \quad j = 1, 2, \ldots n \]  
(9)

2.5. Office Chair Pattern Retrieval Model

Combined with the above office chair pattern case similarity and weight calculation method, the office chair pattern case similarity calculation formula is as follows:

\[ \text{Sim} = \frac{1}{n} \sum_{j=1}^{n} W_i W_{ij} S_{ij} \quad i \in m, j \in n \]  
(10)

\[ S_{ij} = \begin{cases} 
\text{sim}_1(x_j, y_j) & \text{The } j\text{-th property is accurate real value} \\
\text{sim}_2(x_j, y_j) & \text{The } j\text{-th property is character value} \\
\text{sim}_3(x_j, y_j) & \text{The } j\text{-th property is interval real value}
\end{cases} \]  
(11)

In the formula, \( m \) is the number of first-level weights, \( n \) is the number of characteristic attributes of office chairs, \( W_i \) is the first-level weight, and \( W_{ij} \) is the second-level weight.

3. Results

To illustrate the effectiveness of the above method, this paper takes office chair product data of a chair company in Zhejiang province as an example. According to the case representation model, the office chair pattern case data set, which contains 255 cases, is established. The data are shown in Table 2. The main characteristic parameters are: seat height, seat depth, seat width, back height, back width, armrest height, backrest maximum angle, lifting mode, armrest type, headrest, style, fabric and five-star foot.

Table 2. Office chair pattern case data set.

| Number | Case1 | Case2 | Case3 | Case4 |
|--------|-------|-------|-------|-------|
| Structure | Seat height | 41–49 | 43 | 43–51 | 42 |
| Structure | Seat depth | 48 | 52 | 47 | 47 |
| Structure | Seat width | 46 | 50 | 48 | 47 |
| Structure | Back height | 50 | 58 | 47 | 57 |
| Structure | Back width | 46 | 50 | 46 | 44 |
| Structure | Armrest height | 20 | 18 | 22 | 23 |
| Function | Backrest angle | 155–120° | 180–150° | 120–90° Fixed |
| Function | Lifting mode | Barometric | Fixed | Barometric Fixed |
| Function | Armrest type | Linked | Fixed | Fixed Fixed |
| Function | Headrest | Adjustable None | None | None |
| Appearance | Style | Swivel | Four-legged | Swivel Bow |
| Appearance | Fabric material | Mesh Fabric Mesh | Mesh |
| Appearance | Five-star foot | Steel Steel Nylon Steel | |

The characteristic parameters of customer demand are listed in the target case of Table 3. According to the characteristic parameters of the target case, the chair pattern design results obtained by K-NN retrieval method are as follows:
Table 3. The results of K-NN office chair pattern retrieval.

| Rank | 1          | 2          | 3          | 4          | Target |
|------|------------|------------|------------|------------|--------|
|      | Similarity | 0.8762     | 0.8553     | 0.8531     | 0.8383 | -      |
|      | Seat height| 44–52      | 42.5–50.5  | 46         | 42–50  | 45     |
|      | Seat depth  | 46         | 43         | 48         | 49     | 50     |
|      | Seat width  | 50         | 46         | 47         | 48     | 48     |
|      | Back height | 70         | 62         | 50         | 49     | 53     |
|      | Back width  | 45         | 44.5       | 42         | 47     | 46     |
|      | Armrest height | 20       | 20         | 17         | 24     | 20     |
|      | Backrest angle | 155–120° | 155–120°  | 120–90°    | 120–90° | 155–120° |
|      | Lifting mode | Barometric | Barometric | Barometric | Barometric | Barometric |
|      | Armrest type | Fixed     | Fixed      | Fixed      | Fixed   | Fixed  |
|      | Headrest    | Fixed     | None       | None       | None    | Fixed  |
|      | Style       | Swivel    | Swivel     | Swivel     | Swivel  | Swivel |
|      | Fabric      | Mesh      | Mesh       | Mesh       | Mesh    | Mesh   |
|      | Five-Star foot | Nylon | Nylon     | Nylon      | Nylon   | Nylon |

The four cases with the highest degrees of similarity have respective similarities of 0.8762, 0.8553, 0.8531 and 0.8383. Taking the target case as the benchmark, the retrieval case comparisons are as shown in Figure 5. This indicates that the case obtained by the K-NN chair pattern retrieval method has a high degree of consistency with the characteristics of the target case, and the higher the similarity ranking of the retrieval cases is, the more the indicators meet the needs of the target case.

Figure 5. The results of K-NN office chair pattern retrieval.

In the actual design, different customers have different preferences with respect to office chairs. Designing products that correspond to customer preferences is key to the personalized customization of office chairs. Therefore, based on the above office chair pattern data set, according to customer preferences, a customer evaluation matrix of office chair patterns is established as shown in Table 4. Here, the customer is set to think that the appearance is the most important, followed by function and then structure.

Table 4. The customer bias in the evaluation matrix.

|      | Structure | Function | Appearance |
|------|-----------|----------|------------|
|      | 1         | 2        | 4          |
|      | 1/2       | 1        | 2          |
|      | 1/4       | 1/2      | 1          |
The results of the weighted K-NN retrieval model based on customer preferences are as shown in Table 5.

**Table 5. The results of the weighted K-NN office chair pattern retrieval.**

| Rank | 1     | 2     | 3     | 4     | Target |
|------|-------|-------|-------|-------|--------|
| Similarity | 0.9107 | 0.8889 | 0.8797 | 0.8703 | -      |
| Seat height | 44–52 | 45    | 42.5–50.5 | 41–51 | 45    |
| Seat depth | 46    | 52    | 43    | 47    | 50    |
| Seat width | 50    | 50    | 46    | 52    | 48    |
| Back height | 70    | 60    | 62    | 70    | 53    |
| Back width | 45    | 50    | 44.5  | 38    | 46    |
| Armrest height | 20    | 27    | 20    | 22    | 20    |
| Backrest angle | 155–120° | 155–120° | 155–120° | 150–120° | 155–120° |
| Lifting mode | Barometric | Barometric | Barometric | Barometric | Barometric |
| Armrest type | Fixed | Fixed | Fixed | Linked | Fixed |
| Headrest | Fixed | Fixed | None | None | Fixed |
| Style | Swivel | Swivel | Swivel | Swivel | Swivel |
| Fabric | Mesh | Leather | Mesh | Mesh | Mesh |
| Five-Star foot | Nylon | Nylon | Nylon | Nylon | Nylon |

The four cases with the highest degrees of similarity have respective similarities of 0.9107, 0.8889, 0.8797 and 0.8703. Compared with Table 4, the matching similarity of the weighted K-NN chair pattern retrieval model increases by 3.9% on average. Taking the target case as the benchmark, the retrieval case comparisons are shown in Figure 6.

**Figure 6.** The results of weighted K-NN office chair type retrieval.

Figure 6 shows that the retrieval results of the weighted K-NN model fit more appearance and function parameters of the target case, and are closer to the target case, indicating the guiding role played by customer preference in the selection of cases, and the degree of matching with the target case is better, which is more in line with the actual design requirements of the personalized customization of office chair products.

If the characteristic parameters of customer demand remain unchanged, the customer preference place the greatest importance on the structural dimension, with appearance second, and function third, as Table 6.
Table 6. The customer bias in the evaluation matrix.

| Structure | Function | Appearance |
|-----------|----------|------------|
| Structure | 1        | 1/2        | 1/4        |
| Function  | 2        | 1          | 1/2        |
| Appearance| 4        | 2          | 1          |

The retrieval results are shown in Table 7. The retrieval case comparisons based on the target case are shown in Figure 7. It is shown that the adjusted weighted K-NN model has more parameters fitting the target case in terms of structural parameters, indicating that the case can be selected on the basis of the varied preferences of customers, thus being conducive to personalized customization design.

Table 7. The results of weighted K-NN office chair pattern retrieval.

| Rank | Similarity | Seat height | Seat depth | Seat width | Back height | Back width | Armrest height | Backrest angle | Lifting mode | Armrest type | Headrest | Style | Fabric | Five-Star foot |
|------|------------|-------------|------------|------------|-------------|------------|----------------|----------------|--------------|-------------|----------|--------|--------|---------------|
| 1    | 0.9987     | 46          | 48         | 47         | 50          | 42         | 17             | 120–90°        | Barometric   | Fixed       | None     | Swivel | Mesh   | Nylon         |
| 2    | 0.9940     | 43–51       | 50         | 48         | 47          | 46         | 22             | 120–90°        | Barometric   | Fixed       | None     | Swivel | Leather| Nylon         |
| 3    | 0.9917     | 42.5–50.5   | 43         | 46         | 62          | 44.5       | 20             | 155–120°       | Rotary       | Fixed       | None     | Swivel | Mesh   | Nylon         |
| 4    | 0.9914     | 44–52       | 46         | 52         | 70          | 45         | 20             | 150–120°       | Barometric   | Fixed       | Fixed   | Swivel | Mesh   | Nylon         |
| Target| -          | 45          | 50         | 48         | 53          | 46         | 20             | 155–120°       | Barometric   | Fixed       | Fixed   | Swivel | Mesh   | Nylon         |

Figure 7. Retrieval results with different weights.

4. Conclusions

Chair pattern design is an important aspect of the personalized customization of office chairs, and is often dependent on the knowledge and experience of designers. It is difficult to make effective use of an enterprise’s existing product information resources, resulting in inefficient design. Therefore, this paper analyzed the characteristic attributes of office chairs, established a characteristic attribute model of office chair pattern consisting of structural, appearance and functional attributes, and constructed a retrieval model for office chair pattern design based on the K-nearest neighbor retrieval principle and the case reasoning.
method. To verify the effectiveness of the method, chair pattern case data were analyzed. The results showed that the case retrieval method was able to realize the rapid design of office chairs and improve design efficiency, indicating the feasibility of this method. The study found that the greater the number and clarity of the characteristic attributes used in the retrieval process, the more consistent the results were with the target case. However, in the actual personalized customization process, customer demand for products is often fuzzy, contradictory, or hidden, and it is difficult to obtain sufficient and complete target case information resources. Therefore, a future direction of research will focus on how to extract characteristic attributes from customer information resources and achieve appropriate case retrieval results with less characteristic resources.

In an attempt to address the problem in the process of personalized customization whereby customers have different product preferences, in combination with objective office chair pattern characteristic attributes and the subjectivity of actual customer demands, a multi-layer chair pattern characteristic weight method combining AHP and EWM was proposed to weight the K-NN retrieval model. The case retrieval results in Tables 3 and 5 show that the case matching similarity of the weighted K-NN model is higher than that of the K-NN model, and the average increase is about 3.9%. At the same time, the similarity and sequence of cases retrieved by the weighted K-NN model and the K-NN model changed. For example, for the K-NN model, as presented in Table 3, the similarity of RANK1 was 0.8762, and for the weighted K-NN model, as presented in Table 5, RANK1 corresponded to the same case, but the similarity was 0.9107; RANK2 in Table 3 changed to RANK3 in Table 5, while the case in RANK2 and RANK4 in Table 5 changed compared to the results presented in Table 3. This indicates that the customer demands play a guiding role in the selection of cases, and the degree of matching with the target case is better, which is more in line with the actual design requirements of the personalized customization of office chair products.

In addition, by setting different weight ratios, the similarity and sequence of chair cases retrieved by the weighted K-NN model will change, such as RANK1–RANK4 in Tables 5 and 7. This indicates that the case can be selected on the basis of the varying preferences of customers, making it conducive to meeting the needs of personalized customization design. However, it also shows that for the weighted K-NN model, the determination of the weight ratio relationship to bring the retrieval results closer to customer needs, thus improving the effectiveness of the retrieval case results, still needs further research.

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