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Research Article

Application of Environmentally Friendly Materials in the Design of Children's Furniture Based on Fuzzy Technology

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In today's society, children's furniture is an important piece of furniture for every household. Consumers and even companies may ignore its environmental merits since it is not a regular item of home furniture. This research focuses on the use of environmentally friendly materials in the design of children's furniture and combines fuzzy technology with structured design technology to build a fuzzy technology-based children's furniture design system. This research also introduces two intelligent systems for the design of children's furniture, analyzes the structure of children's furniture via structured design, and produces an interactive system with user experience. Finally, this component conducts a system test study based on real-world needs. The experimental research results show that the children's furniture design system based on fuzzy technology proposed in this paper has a good user experience and can play an important role in the application of environmentally friendly materials in the design of children's furniture.

1. Introduction

The degree of production, spiritual culture, and daily practices of an age and a country are all embodied in furniture. It has a strong national style and historical traits since its development reflects changes in social philosophy, popular cultural trends, and spiritual aesthetic interests. Traditional Chinese furniture has a lengthy history of development, notably Ming-style furniture, which has achieved its peak level [1]. Although traditional furniture has rich changes under different time and geographical conditions, it has always maintained a certain continuity in its modeling style and inherited the traditional Chinese philosophy and cultural and artistic heritage. Precisely because of its cultural connotation, aesthetic artistry, and design excellence, traditional furniture has become more innovative over time, and it is also widely favored by Chinese and foreign consumers in the modern market [2].

The process of psychological and physical development in childhood is the most important stage in a person's life. At the same time, childhood is the best period to develop intelligence and build character. Parents create a healthy and warm growth environment for their children to develop their body and mind. Parents play vital role. In most families in our country, children have their own private space and activity area, as well as their own desks, chairs, beds, storage cabinets, and other necessary furniture products in daily life. Therefore, furniture is a must in the process of children's growth. Few items: in my country's furniture market, the existing children's furniture products are often reduced versions of adult furniture, and the existing furniture on the market has not designed products that meet their needs for this group [3].

The design of children's furniture is not just a matter of controllable size, from the overall shape of the product to the internal functional structure, from the rationality of its material selection and color coordination, as well as the tactile experience of the surface texture after processing. Need to go through scientific and reasonable design and application.

In my country, the children's furniture industry is still in its early phases of development, but demand for children's furniture is increasing. In order to address this conflict, it is important to enhance the degree of autonomous design and processing of children's furniture in my country. Improving the design level will have a significant impact on the development of children's furniture. Children's furniture helps to bring spiritual delight and a pure and beautiful childhood in addition to meeting the necessities of children. Only by adhering to the "people-oriented" design philosophy at all times and making furniture that they love and pleasure can we really access children's daily lives and inner worlds. Therefore, the humanized design of children's furniture will also be an important topic for the furniture industry in the coming decades.

Most of the children's furniture on the market uses solid wood materials, board materials, or plastics. They launched their own products under the banner of environmentally friendly materials, but did not make further green transformations, so that the products produced by some small enterprises did not even meet the national standards. Consumers have a great impact on their health. According to surveys and tests, 87% of consumers are worried about the environmental protection of the products they buy. However, due to the high price, consumers cannot afford such high green products. Most of them choose to stay away, only about 30%. Consumers are really ready to buy or have already bought green products. Therefore, while ensuring that the product is green and environmentally friendly throughout its life cycle, the cost of the product can be reduced as much as possible, which can stimulate consumers to buy green products. In the face of increasingly fierce market competition, companies must create greener and healthier products to expand economic benefits.

2. Related Work

The literature [4] established an aesthetic grading system for furniture utilizing the analytical synthesis technique via qualitative and quantitative study and research on the aesthetic attributes of furniture. On the one hand, it has examined and synthesized objective aesthetic criteria for furniture in a complete, wide, and in-depth manner. On the other hand, it combines objective aesthetic characteristics of furniture with people's subjective aesthetic perceptions of furniture, as well as some related mathematical principles to quantify people's vague aesthetic perception tendencies, resulting in a qualitative aesthetic evaluation with more ambiguity. Such an evaluation method is more comprehensive and reasonable, and has a greater objective and fairness, and the results of the evaluation will also have a greater degree of credibility. The literature [5] evaluated and analyzed the operation activities of the actual machinery and equipment of the furniture machining process system through operation measurement. From the perspective of process analysis, the main production process flow of the enterprise processing technology system is evaluated, and the problem of overall optimization of the process flow of the processing technology system is solved. According to the production characteristics of panel furniture, the literature [6] combined with the latest ideas of cleaner production evaluation to preliminarily put forward the index system and evaluation method of cleaner production evaluation in the panel furniture industry. Through the creative combination of analytic hierarchy process and matter-element theory, to a certain extent, it overcomes the subjectivity of analytic hierarchy process due to the influence of factors such as the knowledge structure of the investigating experts and thus obtains the weight of each index more scientifically. It has a clear guiding significance for guiding the majority of enterprises to carry out cleaner production audits, and at the same time, it has taken a very important step for the final establishment of cleaner production evaluation standards for the panel furniture industry. The literature [7] applied the analytic hierarchy process to the evaluation of the conceptual design of furniture products, which can quantify and objectify the process of furniture design evaluation and decision-making. It is a scientific design price and decision-making method. Starting from the theories of sustainable development, circular economy, life cycle assessment, etc., the literature [8] proposed the concept and role of furniture green packaging based on a questionnaire survey of 15 furniture companies and established a furniture green packaging system framework. The literature [9] discussed the early stage of furniture design and its furniture design program evaluation theory. Moreover, it conducted surveys and analysis of consumer psychology questionnaires and design experts' attitude index to design evaluation indicators. Finally, it used the analytic hierarchy process to analyze the weights of the furniture design evaluation indicators and establish an evaluation model, and put forward a furniture design evaluation method based on perceptual engineering.

Foreign children's furniture has been around for far longer than domestic children's furniture, and their current level of development much surpasses ours. Its design, growth and sales strategy, and brand culture are all smart. Other nations categorize children's furniture pretty thoroughly, there is a significant volume of manufacture and sales, and there are various expert design teams [10]. The majority of the countries represented are Europe and the USA. Their creations are often appropriate for youngsters of all ages. Some furniture may be disassembled and reassembled in a number of ways to meet various needs and goals [11]. Foreign furniture, on the other hand, is firmly related to children's physical and mental characteristics, making great use of iconic cartoon patterns, bold and vivid colors, and other elements that delight children. Moreover, some of their design concepts are worth learning from our designers [12].

Looking at the overseas children's furniture market, in addition to the traditional learning function, the computer is equipped with a new learning function in the furniture. Appropriately increasing the size of furniture and prolonging the service life of the furniture is new, and this is a new design concept. It is common for two children in a household abroad, so one room with two beds, one high and one low, or parallel or staggered, is more popular [13]. Compared with China, the overseas children's furniture market started earlier. The children's furniture market in the USA and Northern Europe and Denmark is the most mature. The American children's furniture market has expanded year after year, and its development status is comparable to that of the adult furniture market [14]. American children generally have a large number of electronic products and sundries. In order to make the children's items a good place, parents are willing to buy tailor-made high-quality furniture for their children. The prosperity of the market has made the styles of American furniture products changeable and rich in styles. In addition, green environmental protection is also an important part of its concern [15]. FLEXA is the largest and highest grade children's furniture brand in Europe. It represents the highest quality and latest fashion of children's furniture in the world. In addition to health, environmental protection, and safety, its biggest feature is the partization of furniture, which not only provides parents with the convenience of "installation," but also meets the requirements of children for furniture in different periods. These characteristics make Freysha children's furniture highly favored by consumers [16].

3. Design Algorithm of Children's Furniture Structure

From a design perspective, design is to standardize the customer's "requirements" CNs (user domains) into "functional" FRs (functional domains), map the "function" FRs to the "design parameters" DPs (physical domain) of the product system, and map DPs to the "design process" PVs (process domain), which is a continuous mapping process, as shown in Figure 1. Domains are the boundaries of different design activity domains. They are the most basic and important concept of axiomatic design (AD), which runs through the entire design activity process.

3.1. Customer Domain. The user domain is the demand domain, which represents the user's needs for the product (CNs, customers' needs > description, specifically refers to the market customers' requirements for the use of the product, including the user's needs for the use of the product, etc.). It also includes the company itself (design, manufacturing, marketing, and after-sales service departments) demands for product production efficiency, production cost, and product quality [17].

3.2. Functional Domain. A functional domain is a set of functional requirements and constraints (FRs, or function requirements) that a product must meet in order to meet a set of user needs. A product's or technical system's function is an abstract description of the activities that it can do, and it reflects the product's purpose and qualities. Functional requirements are the description of the design objectives and the collection of functions that the design scheme can deliver for a certain product design.

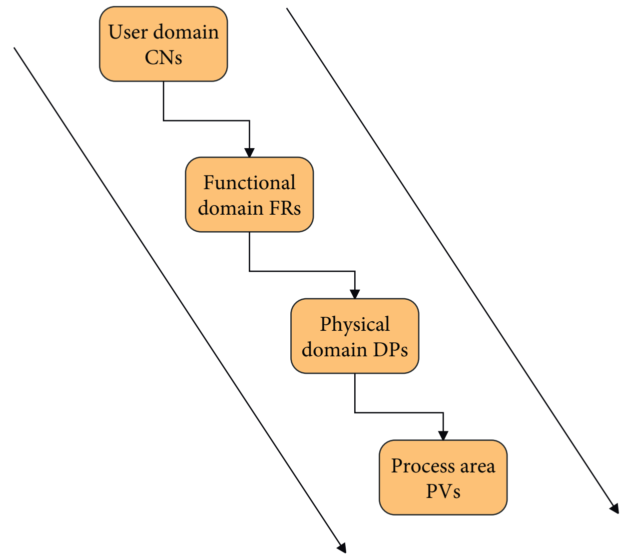

Figure 1: Design activity domain and its process.

3.3. Physical Domain. The physical domain describes the entire structural parameter design process of the product. It is a collection of physical structural parameters to achieve functional requirements, that is, the design parameters (DPs, design parameters) constructed in the physical domain to meet the expressed FRs. Design parameters refer to the product structure parameters that can realize the function. In the physical domain, the product is gradually refined from the abstract overall design stage to the concrete design [18].

3.4. Process Domain. The process domain describes the manufacturing process and processing methods of the product. In order to produce products expressed by FRs, a set of process variables (PVs, process variables) need to be formulated to describe the process. The process domain is specific to the technological process and manufacturing method of the product [19].

The mapping of the four design domains can be expressed by formula as follows [20]:

$$FR = A \cdot DP \text{or} \{FRs\}_{m\times 1} = [A]_{m\times n} \cdot \{DPs\}_{n\times 1},$$
$$DP = B \cdot PV \text{or} \{DPs\}_{m\times 1} = [B]_{m\times n} \cdot \{PVs\}_{n\times 1}. \quad (1)$$

The matrix [A] is used as an example to discuss the characteristics of the mapping relationship, and the design matrix A can be expressed as [21]

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A_{m1} & A_{m2} & \cdots & A_{mn} \end{bmatrix}. \quad (2)$$

The elements of matrix [A] are determined by the following formula

$$A_{ij} = \frac{\partial F\ R_i}{\partial D\ P_j}. \quad (3)$$

According to the matrix [A], the design is divided into three situations: noncoupled design, quasi-coupled design, and coupled design.

(1) When $m = n$, according to the different situations of the matrix, it can be divided into the following three situations:

$$[A] = \begin{bmatrix} X & 0 & \cdots & 0 \\ 0 & X & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & X \end{bmatrix}, \quad (4)$$

$$[A] = \begin{bmatrix} X & 0 & \cdots & 0 \\ 0 & X & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & X \end{bmatrix}, \quad (5)$$

$$[A] = \begin{bmatrix} X & 0 & \cdots & 0 \\ 0 & X & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & X \end{bmatrix}. \quad (6)$$

(1) When [A] is a diagonal array, it is noncoupled design. As shown by formula (5), that is, functional requirements correspond to design parameters, and there is no coupling between functions.

(2) When [A] is a triangular array, it is a quasi-coupled design. As shown in formula (6), the design parameters are expanded in a certain order, which is called quasi-coupled design.

(3) When [A] is a general matrix, it is a coupled design. As shown by formula (7), the design function and the design parameter are coupled with each other.

(2) When $m > n$, the design is a coupled design or under-design.

When the number m of product functional requirements (FRs) is greater than the number n of design parameters (DPs), there may be functions sharing the same parameters, which is a coupled design. Or the function is not fully satisfied.

(3) When $m < n$, the design is a coupled design or redundant design.

When the number m of required functions FR is less than the number n of design parameters (DPs), a function requirement may be determined by multiple design parameters, and the design is a coupled design or a redundant design.

For example, when designing a microwave oven door, its functional requirements (FRs) are [22]:

(1) FR_1—it provides a passage for food in and out.

(2) FR_2—it is convenient to observe the food processing process.

(3) FR_3—it isolates electromagnetic pollution.

DPs are selected as follows:

(1) DP_1—vertical hanging door.

(2) DP_2—transparent material is used on the door.

(3) DP_3—the door adopts isolation electromagnetic radiation material. The design matrix is as follows:

$$\begin{bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{bmatrix} = \begin{pmatrix} X & 0 & 0 \\ 0 & X & 0 \\ 0 & 0 & X \end{pmatrix} \begin{bmatrix} DP_1 \\ DP_2 \\ DP_3 \end{bmatrix}.$$

This design is a noncoupled design.

The traditional reconfigurable design method uses the analytic hierarchy process and the "Z" mapping method. As shown in Figure 2, the entire design process starts from the abstract summary at the top level for the overall design and then layer by layer to the detailed design at the bottom. The product structure is divided into the component layer, the component layer is divided into the parts layer, and the parts are further divided into the feature layer.

Fuzzy numbers are utilized to define the design domain and its mapping relationships, and the system is rebuilt using fuzzy matrix changes, fuzzy similar recognition, and redesign, which is referred to as fuzzy reconstruction.

The unpredictability of design jobs is shown in Figure 3. The design process starts with the identification of societal needs, which is followed by the systematic organization of a set of functional requirements and design constraints. Ingenuity and creative design are used to produce products or prototypes. Analyzing or testing the prototype determines the product's quality and functions. By comparing the function to the goal function, the gap is found. The set that more **accurately** meets the functional requirements is regenerated and iterated until the design concept fully meets the customer's needs.

Therefore, how to design a complex product system? Generally speaking, the user needs of complex products are not proposed by consumers, but by professional users.

No matter from the design process of network design or complex product design, the key to design is how to find the system or subsystem (product or component) that "best fits" the design goal. This process is essentially a fuzzy solving process; that is, according to the fuzzy needs of users, the target parameters are extracted, the existing systems or products are identified by the fuzzy similarity, and the most similar systems or products (sub-systems or sub-components) are found, as shown in Figure 4.

Fuzzy reconfigurable theorem:

Definition 1. Fuzzy design relationship matrix [A]

$$\left[\underset{\sim}{A}_{ij}\right] = \begin{bmatrix} \underset{\sim}{A}_{11} & \underset{\sim}{A}_{12} & \cdots & \underset{\sim}{A}_{1n} \\ \underset{\sim}{A}_{21} & \underset{\sim}{A}_{22} & \cdots & \underset{\sim}{A}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \underset{\sim}{A}_{m1} & \underset{\sim}{A}_{m2} & \cdots & \underset{\sim}{A}_{mn} \end{bmatrix}. \quad (7)$$

It satisfies

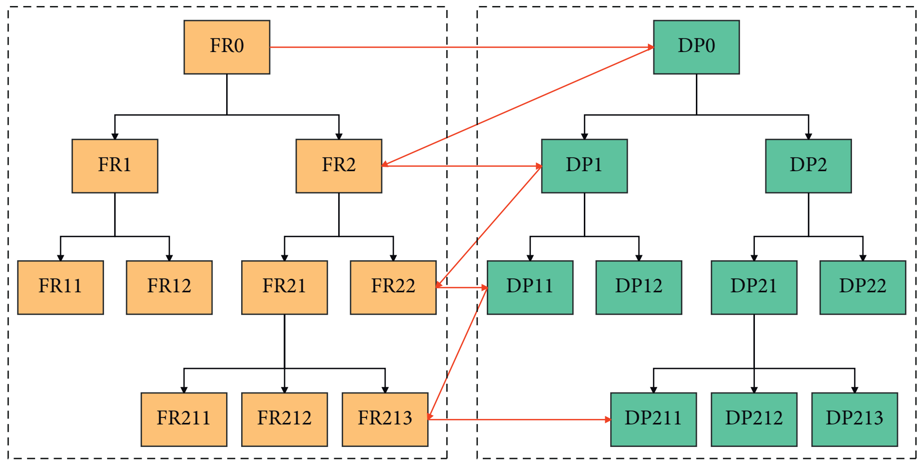

FIGURE 2: Principle of mapping from functional domain to physical domain.

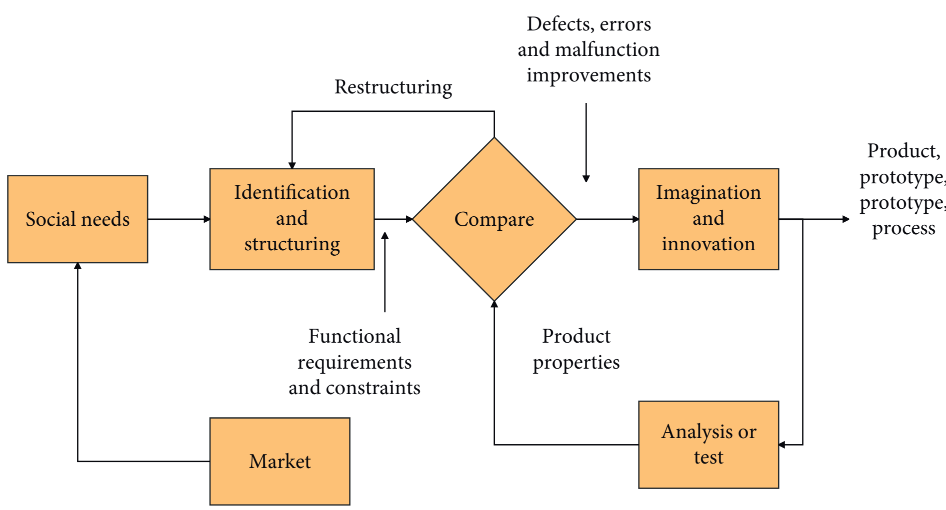

FIGURE 3: Design network [23].

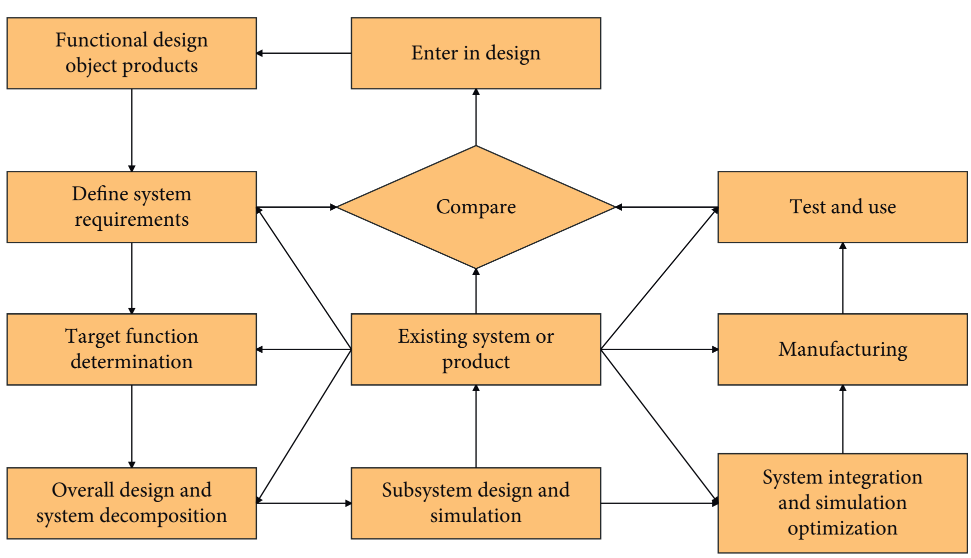

FIGURE 4: Process of complex product development and design.

$$\{FR_s\}_{m\times 1} = \left[\underset{\sim}{A}_{ij}\right]_{m\times n} \times \{DP_s\}_{n\times 1}. \quad (8)$$

$\{FR_s\}$—it is the fuzzy vector of functional requirements

$$\{FR_s\}_{m\times 1} = (FR_{s1}, FR_{s2}, FR_{s3}, \ldots, FR_{si}, \ldots, FR_{sm}). \quad (9)$$

$\{DP_s\}$—it is the fuzzy vector of the physical domain

$$\{DP_s\}_{n\times 1} = (DP_{s1}, DP_{s2}, DP_{s3}, \ldots, DP_{si}, \ldots, DP_{sn}). \quad (10)$$

$\underset{\sim}{A}_{ij}$ —it is the correlation (coupling) relationship between functional requirements FR_{si} and DP_{sj}.

Theorem 1. *In a system, a certain function always has the structure with the highest degree of correlation with it. Therefore, after the matrix is normalized, there is one and only one element in any column or row of the matrix with the largest value.*

Theorem 2. *After the fuzzy design matrix $[\underset{\sim}{A}]$ is standardized, there is always a threshold input, and $[\underset{\sim}{A}]$ is cut and transformed into a diagonal or triangular matrix to satisfy the reconfigurability of the system.*

Corollary 1. *Each system has the ability to repair; however, the capability to rebuild varies. It also indicates that reconfigurability is a need for the survival and advancement of natural and artificial systems.*

The main coupling relationship is ignored by fuzzy reconfigurable theory, which focuses on the primary coupling relationship. When dealing with complex circumstances, we often use this approach: the most difficult aspect or component of the issue is addressed first [24].

We set U to be the domain of discourse, called mapping

$$\mu_{\underset{\sim}{A}}: U \longrightarrow [0,1],$$
$$x| \longrightarrow \mu_{\underset{\sim}{A}} \in [0,1]. \quad (11)$$

A fuzzy subset $\underset{\sim}{A}$ on U is determined, mapping $\mu_{\underset{\sim}{A}}$ is called the membership function of $\underset{\sim}{A}$, and $\mu_{\underset{\sim}{A}}(x)$ is called the degree of membership of x to $\underset{\sim}{A}$.

The set composed of all fuzzy subsets 4 on U is the power set of U, which is denoted as $\&(U)$. The fuzzy subset is referred to as the fuzzy set.

The commonly used representation methods of fuzzy sets are as follows:

(1) Zad notation

$$\underset{\sim}{A} = \left(\frac{\underset{\sim}{A}(x_1)}{x_1} + \frac{\underset{\sim}{A}(x_2)}{x_2} + \cdots + \frac{\underset{\sim}{A}(x_n)}{x_n}\right). \quad (12)$$

(2) Vector representation of fuzzy sets

$$\underset{\sim}{A} = \left(\underset{\sim}{A}(X_1) + \underset{\sim}{A}(X_2), \cdots, \underset{\sim}{A}(X_n)\right). \quad (13)$$

Generally, if there is $0 \le ai \le 1$, $i = 1,2, \ldots, n$, then $a = (a_1, a_2, \ldots, a_n)$ is called a fuzzy vector. Therefore, the fuzzy vector $a = (a_1, a_2, \ldots, a_n)$ can represent the fuzzy set $\underset{\sim}{A}$ of $U = (x_1, x_2, \ldots, x_n)$ in the universe.

We set $\underset{\sim}{A} \in \&(U)$, and for $\vee\lambda \in [0,1]$, it is recorded as $(\underset{\sim}{A})_\lambda = A_\lambda \longrightarrow^{\text{def}} \left\{x | \underset{\sim}{A}(x) \ge \lambda\right\}$.

A_λ is the λ-cut set of $\underset{\sim}{A}$. Among them, λ is called the threshold or confidence level. Its characteristic function is

$$x_{\mu_\lambda}(x) = \begin{cases} 1, \mu_\lambda(x) \ge \lambda, \\ 1, \mu_\lambda(x) < \lambda. \end{cases} \quad (14)$$

λ-cut set is an important method to connect the fuzzy set and the classic set.

A certain characteristic index is tested and counted, and the membership function is based on the ratio of the number of occurrences of the statistics to the total number of times. For example, the comfort index of a vehicle is usually expressed by acceleration. The membership function of <good comfort> is established, and acceleration is taken as the universe of X. <Good comfort> is expressed as a number of clear intervals for statistics, such as (0.9~1.2) and (0.8~1.3).

$$\mu_{\text{goodcomfort}(1)} = \frac{m}{n}. \quad (15)$$

If there are $n = 20$ and $m = 15$, then there is $\mu_{\text{goodcomfort}(1)} = m/n = 15/20 = 0.75$

According to the actual situation, some functions with parameters are determined to represent the membership function of a certain type of fuzzy concept (the domain of the universe is a real number R), and the parameters are determined by experiment or experience. The commonly used distribution types are rectangular distribution, trapezoidal distribution, K-th parabolic distribution, normal distribution, etc.

$$\mu_d(x) = \begin{cases} 1, & a \le x \le b, \\ 0, & \text{other}. \end{cases} \quad (16)$$

Large trapezoidal distribution

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} 1, & x \ge a, \\ 0, & x < a. \end{cases} \quad (17)$$

Small trapezoidal distribution

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} 1, & x \le a, \\ 0, & x > a. \end{cases} \quad (18)$$

This type of distribution is used to describe situations that are greater than or less than a certain index or between two indexes. For example, the stress intensity that a certain part can bear is x, and $\underset{\sim}{A}$ is a subset of "strength greater than α." When $a = 300\,\text{MPa}$, there are $\mu_{\underset{\sim}{A}}(350) = 1$ and

$\mu_{\underset{\sim}{A}}(280) = 0$. For example, the yield strength of the bogie frame material is required to be x, and A is the subset of "yield strength greater than or equal to α and less than or equal to b."

The trapezoidal distribution is shown in Figure 5.

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} 0, & x < a, \\ \dfrac{x-a}{b-a}, & a \le x < b, \\ 1, & b \le x < c, \\ \dfrac{d-x}{d-c}, & c \le x < d, \\ 0, & x \ge d. \end{cases} \quad (19)$$

Small trapezoidal distribution

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} 1, & x < a, \\ \dfrac{b-a}{b-a}, & a \le x \le b, \\ 0, & x > b. \end{cases} \quad (20)$$

Large trapezoidal distribution

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} 0, & x < a, \\ \dfrac{x-a}{b-a}, & a \le x \le b, \\ 1, & x > b. \end{cases} \quad (21)$$

Triangular distribution (special case of trapezoidal distribution)

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} \dfrac{x-a}{b-a}, & a \le x \le b, \\ \dfrac{c-x}{c-b}, & b \le x < c, \\ 0, & \text{other}. \end{cases} \quad (22)$$

In formula (23), a, b, and c represent the left boundary, median, and right boundary. When $a = b = c$, the fuzzy number becomes the deterministic index. Therefore, the deterministic index is a special case of the fuzzy number.

In mechanical design, many parameters belong to the normal distribution, and the fuzzy membership function is

$$\mu_{\underset{\sim}{A}}(x) = e^{(-x-a/\sigma)^2}. \quad (23)$$

Among them, a is the mean, and eight is the mean square error, for example, the braking performance index x of the bogie (indicated by braking distance), we take $a = 2.0$ km, $0 = 0.4$ km, and then there is $\mu_{\underset{\sim}{A}}(1.7) = 0.56$, $\mu_{\underset{\sim}{A}}(2.2) = 0.78$.

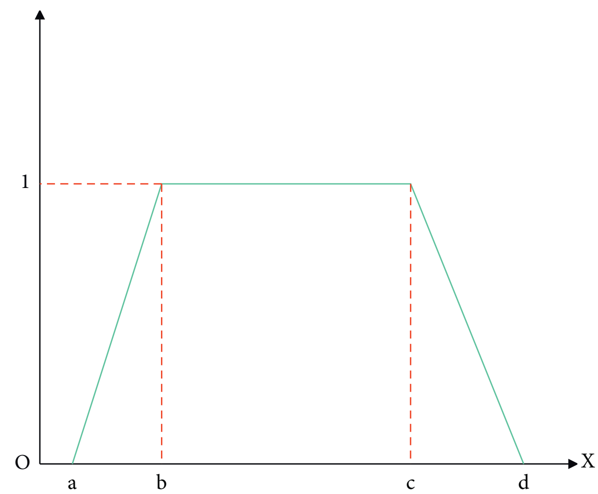

Figure 5: Schematic diagram of trapezoidal distribution.

If the membership function is used to solve the problem, the fuzzy number is in [0, 1]. The membership functions for several parameters in the performance domain and component characteristic parameter domain have yet to be established. Experts present a collection of relative values or related indicators to identify its qualities. Different parameters' fuzzy numbers have different sorts and dimensions; thus, they must be standardized to eliminate the differences in types and dimensions, which requires translating various fuzzy numbers into the interval [0, 1]. For a single characteristic parameter, it can be directly calculated by the membership function, and the principle of maximum membership is adopted; that is, the one with the largest membership is considered to meet the design goal, or the λ-cut set is adopted.

For example, in the domain $U = \{u1, u2, u3, u4, u5\}$, ui represents the axle load of a certain bogie design parameter, and its values are 15, 18, 20, 16, 14 in sequence. The trigonometric function distribution (take $a = 10$, $b = 16$, $c = 22$) is used to obtain the degree of membership as $\mu_{\underset{\sim}{A}} = 0.83/\mu_1 + 0.67/\mu_2 + 0.33/\mu_3 + 1/\mu_4 + 0.67/\mu_5$.

From formula (15), when taking 1, 0.83, 0.67, 0.33, there are

$$\begin{aligned} \mu_{\underset{\sim}{A}1} &= \{\mu_4\}, \\ \mu_{\underset{\sim}{A}0.83} &= \{\mu_1, \mu_4\}, \\ \mu_{\underset{\sim}{A}0.67} &= \{\mu_1, \mu_2, \mu_4, \mu_5\}, \\ \mu_{\underset{\sim}{A}0.33} &= \{\mu_1, \mu_2, \mu_3, \mu_4, \mu_5\}. \end{aligned} \quad (24)$$

For multi-parameters, the closeness of distance is used to calculate and define $X = \{x_1, x_2, \ldots, x_n\}$. $\overline{U}_j$, $\overline{F} \in F(X)$

$$d(\overline{U}_j, \overline{F}) = \left(\sum_{i=1}^{n} \left| u_{ij} - f_i \right|^p \right)^{1/p}. \quad (25)$$

When $p = 2$, it is Euclidean distance. When $p = 1$, it is the Hamming distance.

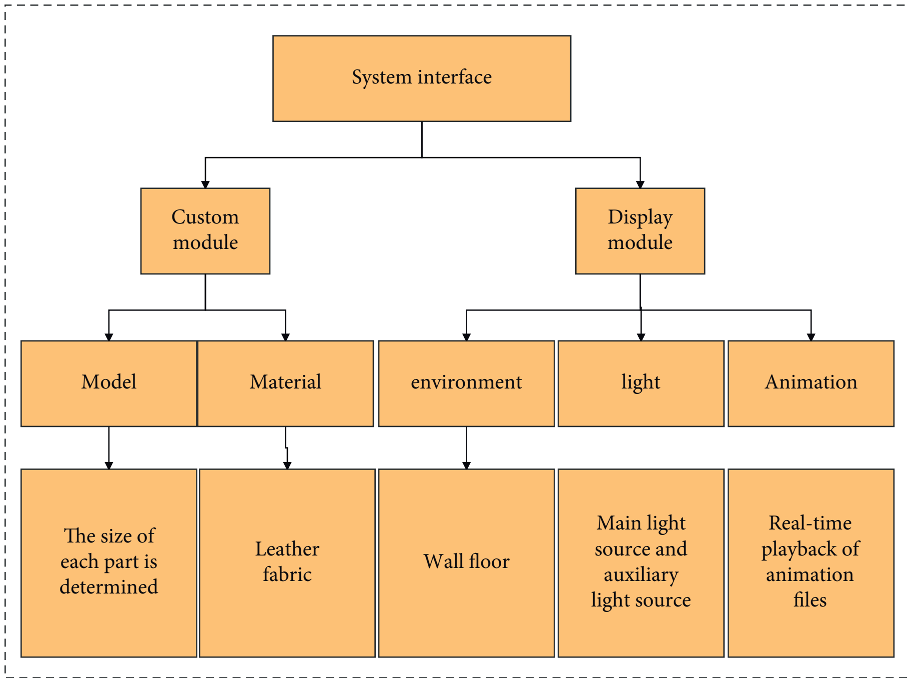

Figure 6: System frame structure diagram 1.

We set $X = \{x_1, x_2, \ldots, x_n\}$, and $\overline{F} \in F(X)$. The closeness of $\overline{U}_j, \overline{F}$ is

$$\sigma\left(\overline{U}_j, \overline{F}\right) = 1 - c\left(d\left(\overline{U}_j, \overline{F}\right)\right)^{\alpha}. \quad (26)$$

Among them, a and c are coefficients. We take $c = 1/n$, $a = l$, $p = 2$, and then there is

$$\sigma\left(\overline{U}_j, \overline{F}\right) = 1 - \frac{1}{n}\sqrt{\sum_{i=1}^{n}\left|u_{ij} - f_i\right|^2}. \quad (27)$$

In the actual design, the importance of the n indicators of the target object $\overline{F}$ is different, and the weight vector is introduced

$$W = \left(w_1, w_2, w_3, \ldots, w_i, \ldots, w_n\right), \sum_{i=1}^{n} w_i = 1. \quad (28)$$

Then, the weighted distance closeness is

$$\sigma\left(\overline{U}_j, \overline{F}\right) = 1 - \sqrt{\sum_{i=1}^{n}\left(w_i\left(u_{ij} - f\right)\right)^2}. \quad (29)$$

Practice shows that the calculation result of formula (29) is difficult to reflect the difference, and it is improved to

$$\sigma\left(\overline{U}_j, \overline{F}\right) = 1 - \sum_{i=1}^{n}\left(w_i\left|u_{ij} - f\right|\right). \quad (30)$$

The one with the largest distance $\sigma(\overline{U}_j, \overline{F})$ is considered to meet the design goal, and the weight w can be obtained according to customer needs or given by experts.

4. Application of Environmentally Friendly Materials Based on Fuzzy Technology in the Design of Children's Furniture

The custom design method for children's furniture discussed in this article does not completely allow customers to "do anything they want," but it does allow them to preserve previously built children's furniture for future use. Furthermore, authentic items are featured in this article at specialty stores. Customers may choose children's furniture on the spot, change the size in the system, or go through the model library to find various sofa designs. Customers then choose materials and colors depending on their own preferences. Customers may also create autonomously, such as while playing video games, and fully experience the pleasures of individual consumption by adjusting space and illumination, as well as seeing animations in the view.

The customization module of the custom design system 1 includes the size customization and material customization of the sofa. The size customization is mainly the length, width, and height of the various parts of the sofa (cushion, backrest, armrest), as shown in Figure 6.

The customization module of custom design system 2 includes style customization and material customization. The system divides the model styles of the sofa into two categories: European style and modern style. The sofa materials are leather and fabric, respectively. The environment under the display module includes three parts: a supporting coffee table, space, and lighting. The last part is the animation preview module, and the system frame structure is shown in Figure 7.

Following the creation of the system, it may be used to investigate the usage of ecologically friendly materials in the

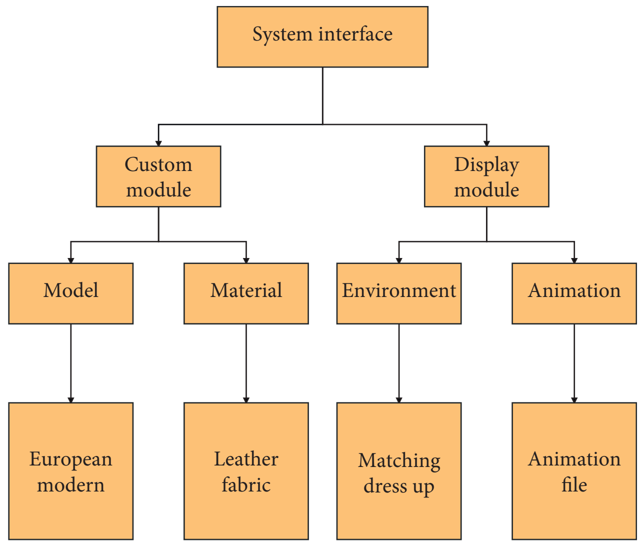

Figure 7: System frame structure diagram 2.

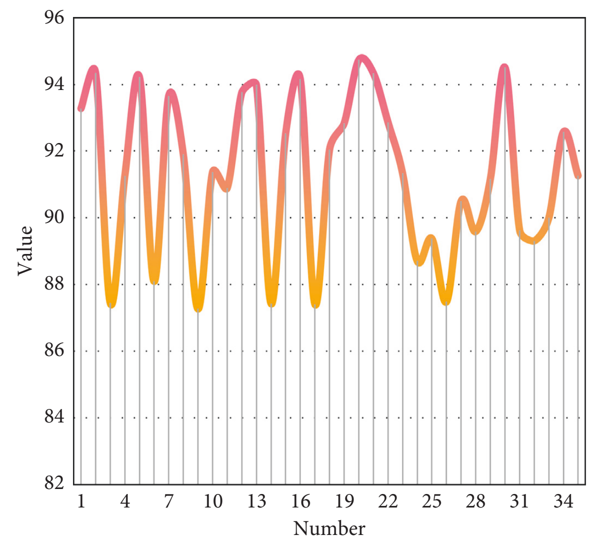

Figure 8: Statistical diagram of system user experience.

Table 1: Evaluation of system use effect.

No	User experience
1	93.28
2	94.34
3	87.44
4	91.25
5	94.22
6	88.09
7	93.65
8	91.90
9	87.27
10	91.37
11	90.89
12	93.76
13	93.98
14	87.43
15	92.52
16	94.16
17	87.40
18	92.04
19	92.83
20	94.73
21	94.34
22	92.87
23	91.33
24	88.70
25	89.37
26	87.48
27	90.50
28	89.59
29	91.17
30	94.50
31	89.62
32	89.31
33	90.00
34	92.58
35	91.26
36	90.31

Table 2: Analysis of the application effect of environmentally friendly materials in the design of children's furniture.

No	Evaluation
1	87.54
2	85.69
3	85.64
4	83.00
5	90.17
6	82.23
7	91.12
8	90.60
9	81.36
10	91.05
11	87.49
12	89.53
13	90.37
14	84.90
15	84.47
16	81.43
17	82.54
18	82.82
19	90.56
20	86.64
21	85.64
22	81.30
23	91.54
24	89.33
25	89.69
26	91.35
27	90.56
28	84.21
29	86.18
30	91.80
31	82.63
32	88.98
33	87.72
34	90.80
35	87.52
36	82.93

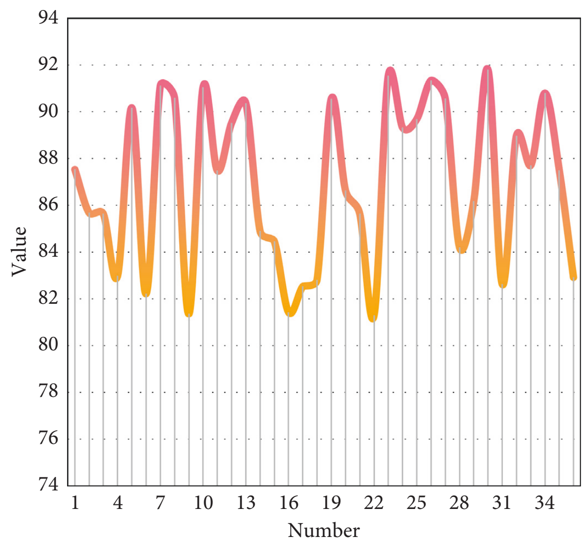

Figure 9: Statistical diagram of the application effect of environmentally friendly materials in the design of children's furniture.

design of children's furniture. This article analyzes by doing simulation experiments, counts widely used environmental protection materials, merges this article's fuzzy technology for data processing, and performs experiments in the system architecture created in this article. First of all, this article counts the evaluation effect of the use of this system, as shown in Table 1 and Figure 8.

It can be seen from Table 1 and Figure 8 that the children's furniture design system based on fuzzy technology proposed in this paper has a good user experience. On this basis, this article studies the application of environmentally friendly materials in children's furniture, and the results shown in Table 2 and Figure 9 are obtained.

From the above analysis, it can be seen that the system designed in this paper can play an important role in the application of environmentally friendly materials in the design of children's furniture.

5. Conclusion

The health of their kid is the most important thing to parents. As children get bigger, they must interact with preschool furnishings. As a consequence, every parent will evaluate and choose a practical design, environmentally friendly materials, as well as safety and thoughtful issues. Furthermore, every parent takes every attempt to establish a better learning and living environment for their children. This article focuses on the use of environmentally friendly materials in the field of children's furniture design, combining fuzzy technology with structured design technology to create a fuzzy technology-based children's furniture design system, as well as two intelligent systems for children's furniture design. Finally, this research presents tests to evaluate the suggested system's performance. The experimental research results show that the children's furniture design system based on fuzzy technology proposed in this paper has a good user experience and can play an important role in the application of environmentally friendly materials in the design of children's furniture.

Data Availability

The numerical dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest to disclose in relation to this work.

References

[1] N. A. Ahmad Sayuti and O. Abdulwahhab Khalaf, "Nurturing biophilic design and nature-inspired design in furniture design projects," *International Journal of Advanced Science and Technology*, vol. 28, no. 13, pp. 483–497, 2019.

[2] A. S. K. Ali, "Dynamic furniture design in contemporary house," *International Design Journal*, vol. 8, no. 1, pp. 167–176, 2018.

[3] G. M. F. Al-Muslimi, "The relationship between ancient Egyptian and African cultural heritage in contemporary furniture design," *International Design Journal*, vol. 11, no. 4, pp. 127–138, 2021.

[4] P. I. Braileanu, "Kitchen island furniture design for residential houses," *Journal of Industrial Design and Engineering Graphics*, vol. 12, no. 1, pp. 169–172, 2017.

[5] N. A. Can and A. Gürpinar, "The furniture design history OF Turkey, 1800-2000," *Turkish Online Journal of Design Art and Communication*, vol. 11, no. 3, pp. 1004–1018, 2001.

[6] M. Y. Chen and Z. F. Zhang, "Application of material characteristics in furniture design," *Packaging Engineering*, vol. 38, no. 2, pp. 141–145, 2017.

[7] Z. Chengmin, Y. Mengnan, and Z. Tao, "Experimental study on three-dimensional shape mapping of complex furniture," *EURASIP Journal on Image and Video Processing*, vol. 2018, no. 1, 9 pages, 2018.

[8] M. H. Chumiran, S. Z. Abidin, W. N. Rahim, and V. V. Vermol, "Cognitive ergonomics of formgiving as unstructured approaches in furniture design practice," *Environment-Behaviour Proceedings Journal*, vol. 6, pp. 27–32, 2021.

[9] O. P. Fidelis, B. Ogunlade, S. A. Adelakun, and O. Adukwu, "Ergonomic analysis of classroom furniture in a Nigerian university," *Nigerian Journal of Technology*, vol. 37, no. 4, pp. 1154–1161, 2018.

[10] S. W. Hwang, "A study on the combined custom furniture design for single person households (focused on the art furniture table)," *Journal of Digital Convergence*, vol. 16, no. 7, pp. 393–400, 2018.

[11] J. O. Igbokwe, G. O. Osueke, U. V. Opara, M. O. Ileagu, and K. U. Ezeakaibeya, "Considerations of anthropometrics in the design of lecture hall furniture," *International Journal of Regulation and Governance*, vol. 7, no. 8, pp. 374–386, 2019.

[12] C. O. Incekara, "Post-COVID-19 ergonomic school furniture design under fuzzy logic," *Work*, vol. 69, no. 4, pp. 1197–1208, 2021.

[13] T. K. Kapuria, M. Rahman, and D. A. Doss, "Users' satisfaction attributes analysis toward betterment of classroom furniture design for Bangladeshi university students," *Journal*

- *The Institution of Engineers: Series C*, vol. 101, no. 1, pp. 175–184, 2020.
[14] J. Kaufmann-Buhler, "If the chair fits: sexism in American office furniture design," *Journal of Design History*, vol. 32, no. 4, pp. 376–391, 2019.
[15] E. Nasir, "Identifying unspoken desires and demands: a collection of design ideas for living room furniture and zones," *Journal of Design Thinking*, vol. 2, no. 1, pp. 71–84, 2021.
[16] N. S. Osman, K. A. A. A. Rahman, A. R. A. Rahman, and M. F. Z. Ja'afar, "The effect of design capability characteristic on design performance for bumiputera furniture companies," *International Journal of Business and Management*, vol. 2, no. 3, pp. 30–35, 2018.
[17] R. P. Parvathy and S. Kapai, "Furniture design and sustainability-A design intervention with an approach for promoting and sustaining the craft of pattamadai grass mats," *International Journal of Modern Agriculture*, vol. 9, no. 3, pp. 1549–1563, 2020.
[18] D. Joseph, A. A. Boni, and D. Abremski, "A note on corporate open innovation: engagement with startups," *Journal of Commercial Biotechnology*, vol. 26, no. 2, 2021.
[19] I. W. Taifa and D. A. Desai, "Anthropometric measurements for ergonomic design of students' furniture in India," *Engineering science and technology, an international journal*, vol. 20, no. 1, pp. 232–239, 2017.
[20] X. Q. Xiong, W. J. Guo, L. Fang et al., "Current state and development trend of Chinese furniture industry," *Journal of Wood Science*, vol. 63, no. 5, pp. 433–444, 2017.
[21] J. Yao, D. M. Kaufman, Y. Gingold, and M. Agrawala, "Interactive design and stability analysis of decorative joinery for furniture," *ACM Transactions on Graphics*, vol. 36, no. 2, pp. 1–16, 2017.
[22] O. Zeleniuc and C. Mateiu, "Furniture design IN concept lego," *Pro Ligno*, vol. 15, no. 4, pp. 380–387, 2019.
[23] K. L. Wilson and A. Portes, "Immigrant enclaves: an analysis of the labor market experiences of Cubans in Miami," *American Journal of Sociology*, vol. 86, no. 2, pp. 295–319, 1980.
[24] Y. Rong, "Building technology enabled platform companies in Biopharma–a perspective on early-stage value creation from Millennium, Alnylam, Moderna, & Kymera," *Journal of Commercial Biotechnology*, vol. 26, no. 2, 2021.