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Research on Humanized Design and Implementation of Computer Software User Interface Based on Visual Data Mining

Yang Luo, Quan Huang*, Hao Liu

Department of Information Science and Engineering, Hunan University of Humanities, Science and Technology, Loudi, 417000, China
hnldhq@126.com
**Corresponding author*

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Abstract: With the rapid development of the Internet and the continuous increase of users, computer software increasingly needs to consider humanized design when designing. Previous User Interface (UI) had issues such as insufficient consistency and slow response time in humanized design. This article applied visual Data Mining (DM) to the user-friendly design of computer software UI. The article compared the UI humanization design effects of neural network method and decision tree method. The experimental results showed that the average consistency of UI humanization design based on neural network method and decision tree method was 95.2% and 88.4%, respectively, for data after one month of UI upgrade. Based on the data from two months after the UI upgrade, the average consistency of UI humanization design based on neural network method and decision tree method was 96.3% and 92.0%, respectively. From this, it could be concluded that applying neural network method to humanized design of UI could effectively improve the consistency of humanized design of UI.

1. Introduction

The UI is the soul and core of a software, and how to design it attractively is crucial. Many researchers have conducted in-depth thinking on the optimization of UI design. Among them, Fisher Stuart developed a web-based UI framework called Daiquiri, which was used for control system monitoring and data acquisition. It provided a simple, intuitive, and responsive interface for controlling and monitoring hardware, thus initiating collection sequences and managing related metadata [1]. Osorio-Olvera, Luis designed a software package called NicheToolBox (ntbox). It allowed users to carry out all processing steps involved in ecological niche modeling: download and management of occurrence data; acquisition and conversion of environmental data layer; selection of environmental variables; exploration of the relationship between geography and environmental space; calibration and selection of ellipsoid model; the use of binomial and partial Receiver Operating Characteristic Curve test evaluation models; the assessment of extrapolation risks; the execution of geographic information system operations through graphical UI [2]. Fadzlah explored usability guidelines and investigated the importance of these guidelines in designing UI for mobile game applications for children aged 1 to 3. As a result, he found that 87 guidelines were highly correlated with 17 usability features when designing usable mobile game interfaces for such users [3]. Shi, Xiaohong introduced a search engine based on the description, graphical view, and source code of UI components in mobile applications. A density based maximum intra cluster distance clustering algorithm was proposed to automatically recommend samples. The comparison between the recommended examples using this method and existing summary examples showed that in 83.33% of the summary examples, there were complete/partial matching examples in the recommended results [4]. Although the above methods were indeed feasible for optimizing UI, there was a lack of design research on humanization.

By utilizing visual DM tools and techniques, analysts can quickly and easily retrieve information from a new perspective to solve common business problems. Visual DM makes DM simple, and non-technical business managers can use it to better understand the market and make wise decisions. Many people have conducted research and analysis on the application of visual DM technology. Among them, Sunhare made it possible to accumulate a large amount of data from the heterogeneous environment and transformed it into valuable knowledge using DM techniques. These generated knowledge would play a role in optimizing resource and service management [5]. Yu Bowen designed Flow Sense. It used the most advanced natural language processing technology to assist in the construction of data flow graph. Using Flow Sense, users could easily expand and adjust data flow diagrams in simple English [6]. Cui, Zhe introduced Data Site, which was an active visual analysis system. The system was validated through user research and compared with recent visual recommendation systems, thus resulting in significant improvements, especially for complex analyses that cannot be well supported by existing analysis systems [7]. Salih Sinan Q explored a new machine learning model (namely DM), including the Secure Sockets Layer attribute selection classifier (AS M5P), M5Rule (M5R) and K Star (KS) models used for forecasting at Trenton Weather Station on the Delaware River in the United States. Overall, the applied DM model achieved excellent prediction of the Secure Sockets Layer process [8]. The above results indicated that visual DM had certain effectiveness in multiple fields, but there were still some shortcomings and a lack of its application in user-friendly interface design.

The UI is the soul and core of a software. If it cannot be designed more user-friendly, then this software would be phased out sooner or later. Here, this article used visual DM technology to conduct humanized design and research on the UI of computer software, and analyzed its differences and uniqueness from the previous UI in five aspects: consistency, accuracy, layout rationalization, system operation rationality, and system response time.

2. Humanized UI Design Method

2.1 Computer Software UI

UI realizes the transformation between the internal form of information and the acceptable form for humans. The purpose is to enable users to easily and efficiently operate hardware to achieve bidirectional interaction and complete the desired tasks with hardware. The definition of UI is broad, including human-machine interaction and graphical UI. UI exist in all fields involved in information exchange between humans and machinery [9]. A UI generally consists of four elements: browsing, querying, printing, and library files, as shown in Figure 1.

Software interface design, like industrial design in industrial products, is an important selling point of the product. Interface design is not just art painting. It needs to locate the user, the environment and the way, so as to design it for the end user, which is purely scientific art design [10]. The standard for testing an interface is the feelings of the end user. Interface design should be closely integrated with user research, which is a continuous process of designing satisfactory visual effects for end users. The UI of a certain exam software is shown in Figure 2.

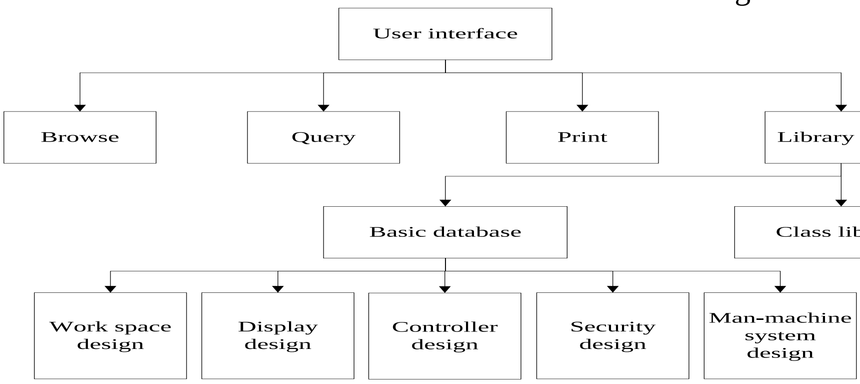

Figure 1: UI system structure diagram

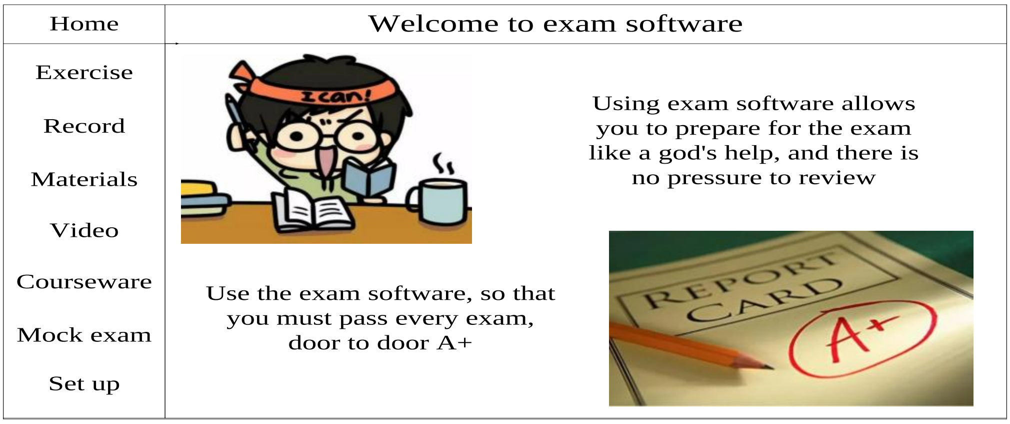

Figure 2: UI of a certain exam software

The starting point of humanized design is to make every effort to facilitate users, and the design should start with aesthetics and ergonomics. By taking the human heart as the center of a circle with a radius of the human body, a perfect relationship between humans and objects can be constructed. The humanized design is aimed at making users more comfortable to use, without hurting their eyes or burning their brains, thus fully tapping into their potential abilities and ultimately achieving the goal of “integrating people and things, and improving work efficiency” [11]. It is not about aimlessly studying how to make programs more flashy and complex, nor about how to maximize software functionality and have a colorful visual impact. Instead, it requires standing from the perspective of users and carefully analyzing their needs, psychological characteristics, and ways of thinking. Only by examining and developing software from the perspective of users can users be satisfied [12]. What principles need to be adhered to in designing UI to achieve humanized standards?

(1) Principle of consistency

By adhering to the principle of user experience centered design, the interface is intuitive. Users can easily understand the corresponding functions on the interface after touching the software.

(2) Accuracy principle

By using consistent markings, standard abbreviations, and colors, the meaning of the displayed information should be very clear.

(3) The principle of rational layout

When designing the UI, it is necessary to fully consider the rationalization of the layout, so as to avoid the problem of scattered arrangement of commonly used business function buttons, which can cause the user to move the mouse too far. It is necessary to hide unused functional blocks to maintain a concise interface, thus allowing users to focus on the main business operation processes.

(4) The principle of system operation rationality

It is necessary to try to ensure that users can smoothly complete some commonly used business operations without using the mouse (only the keyboard), and switch between various controls through the Tab key, so as to select all editable text for processing.

(5) System response time principle

The system response time should be moderate. If the response time is too long, users would feel uneasy and frustrated. If it is too fast, it can also affect the user's operating rhythm and may lead to errors.

2.2 Visual DM

2.2.1 Concept

The main purpose of visual data is to use graphical means to clearly and effectively convey and communicate information. To effectively convey ideological concepts, aesthetic form and function need to go hand in hand. By intuitively conveying key aspects and features, in-depth insights into quite sparse and complex datasets are achieved [13]. However, designers often fail to grasp the balance between design and functionality, thus creating flashy visual data forms that cannot achieve their main goal of conveying and communicating information.

Currently, visualization data is an extremely active and critical aspect in the fields of research, teaching, and development. The term "visual data" realizes the unification of the mature scientific visualization field and the younger information visualization field [14].

DM is divided into guided DM and unsupervised DM [15]. Guided DM is the use of available data to establish a model. Unsupervised DM is searching for a certain relationship among all attributes. Specifically, classification, valuation, and prediction belong to guided DM; association rules and clustering belong to unsupervised DM. Figure 3 shows a DM model.

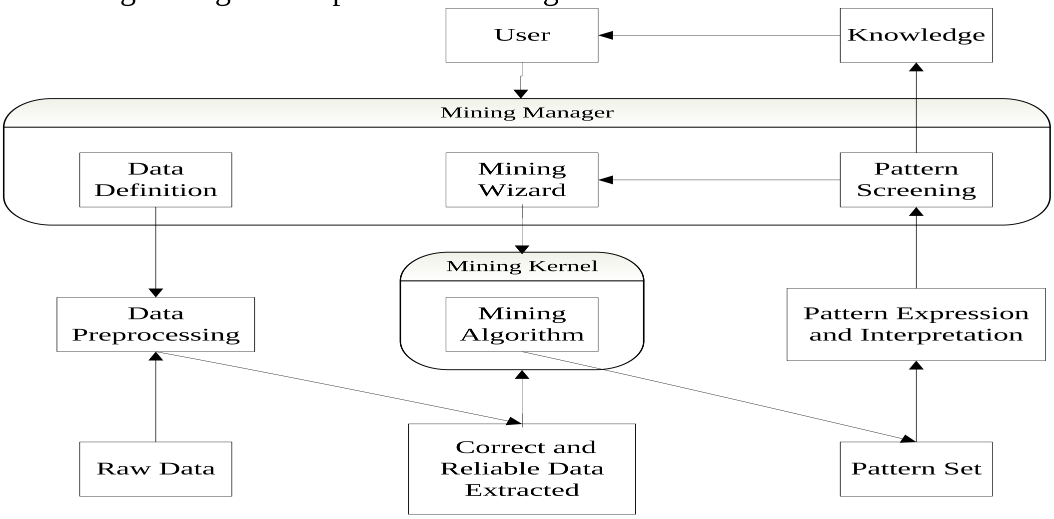

Figure 3: DM model

In Figure 3, a basic DM model is described, which consists of 11 steps such as data definition, data preprocessing, mining algorithms, and a mining manager and mining kernel. The algorithms for DM mainly include neural network method, decision tree method, genetic algorithm, rough set method, fuzzy set method, association rule method, etc. The experiment would be conducted using a comparative analysis of neural network method and decision tree method.

2.2.2 Neural Network Method

The structure of a neural network consists of an input layer, several intermediate hidden layers, and an output layer. The neural network analysis method can discover patterns from a large amount of complex data of unknown patterns through continuous learning. It overcomes the complexity of traditional analysis processes and the difficulty of selecting appropriate model function forms.

The general steps of using neural network method for humanized UI design are as follows: obtaining UI design data, including UI design drawings and operational status of the UI, training and learning UI design data, error feedback, adjusting network structure, and humanizing UI design.

It is assumed that the UI design dataset obtained using DM technology is $Y=(y_1,y_2,\cdots,y_n)$, and the connection weight between each data and the neural network is $X=(x_1,x_2,\cdots,x_n)$. The results of analyzing UI design data using the neural network method are as follows:

$$g=\sum_{i=1}^{n} x_i y_i \tag{1}$$

According to the comparison between the predicted analysis results and the actual results, the error obtained is as follows:

$$Q=\frac{1}{2}\sum_{k}(\lambda_k^1-\lambda_k^2)^2 \tag{2}$$

In Formula 2, Q represents the error of the neural network method, and λ_k^1 and λ_k^2 represent the actual output and expected output of analyzing UI design data, respectively.

According to the size of the error, the network structure is adjusted in a timely manner:

$$x_{ij}(a+b)=x_{ij}(a)+\Delta x_{ij} \tag{3}$$

In Formula 3, $x_{ij}(a+b)$ represents the connection weight between neuron a and neuron b at time a+b. Δx_{ij} represents the amount of change in the connection weight between neuron a and neuron b.

The criterion for judging whether the neural network method can be used for user-friendly interface design is that the error generated by the system is within an acceptable range. The formula is expressed as follows:

$$Q \le Q_0 \tag{4}$$

2.2.3 Decision Tree Method

Decision tree analysis is a risk based decision-making method that uses probability and graph theory trees to compare different options in a decision and obtain the optimal solution. In graph theory, a tree is a connected and acyclic directed graph. The point with an in degree of 0 is called the root of the tree, the point with an out degree of 0 is called the leaf, and the point outside the leaf is called the inner point. The decision tree is composed of tree roots (decision nodes), other interior points (scheme nodes and state nodes), leaves (endpoints), branches (scheme branches and probability branches), probability values, and profit and loss values. The specific operating steps are shown in Formulas (5) to (7).

$$x(S,S')=\sqrt{(a-a')^2+(b-b')^2+(c-c')^2+(d-d')^2} \tag{5}$$

In the formula, quaternions (a, b, c, d) are used to define the rectangular space of node S. a and b are the horizontal and vertical coordinates of rectangular space, respectively, while c and d are the width and height. For the rectangular node S (a, b, c, d), if the coordinates change to $S'(a',b',c',d')$ after the data update, it would become as shown in Formula (5). It can be seen that if $x(S,S')$ is larger, the amount of change would be greater, and the visualization effect would be more unstable, resulting in higher cognitive complexity for users; on the contrary, if $x(S,S')$ is zero, it indicates that there has been no change. After determining the matrix, it is necessary to perform an identity check on it. The specific steps are shown in Formula (6).

$$HE=\frac{(\eta_{\max}-m)}{(m-1)} \tag{6}$$

In the formula, $\eta_{\max}$ is the maximum eigenvalue of the matrix. Obviously, when the matrix has complete identity, HE is 0. The larger the $\eta_{\max}-m$, the greater the HE, and the worse the homogeneity.

Finally, due to the different orders of magnitude of each indicator in the original data and the lack of comparability, it is necessary to apply the maximum minimum normalization method to the value of the same indicator at different values. The method is shown in Formula (7).

$$Q_i'=(Q_i-Q_{i\min})/(Q_{i\max}-Q_{i\min}) \tag{7}$$

In the formula, Q_i' is the standardized value of indicator i; Q_i is the original value; $Q_{i\max}$ is the maximum value; $Q_{i\min}$ is the minimum value. Due to insufficient space for visualization and limitations in the data set, further experiments are needed.

3. UI Humanization Design Experiment

The UI of a computer is a carrier for browsing information and an important medium. Through this medium, users can engage in work, learning, and daily life. People go online every day and use software. Beautiful software has many customers browsing, while others are rarely visited. The experiment first conducted a survey and analysis of 200 professionals, and asked them about their views on the UI, drivers, process management, and kernel of computer software. They identified which of them they valued the most. The survey results shown in Table 1 are obtained.

Table 1: Computer software system survey form

Object	Index	Number of people	Percentage
Computer software	UI	67	33.5%
	Drivers	49	24.5%
	Process management	28	14%
	Kernel	56	28%

In Table 1, it showed that the majority of people believed that the UI was quite important, with 67 people accounting for 33.5%. The UI was the core of computer software. Therefore, if the UI of a software was not pleasing, it was difficult to make people interested in the software. The second ranked kernel had 56 people, accounting for 28%. The number of process management personnel was 28, accounting for only 14%, which was the lowest. Although the survey results for these four were uneven, it was still necessary to upgrade them all. After all, all four were components of a computer software system, and it was important to focus on upgrading the UI.

To verify the effectiveness of visual DM in upgrading UI user-friendly design, this article conducted a satisfaction survey on the UI of a certain computer software from four perspectives: layout, wording, check, and operability. The survey results are shown in Table 2.

Table 2: UI satisfaction survey form

Evaluation criteria	Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied
Layout	19%	23%	31%	14%	13%
Wording	17%	20%	35%	16%	12%
Check	15%	20%	36%	13%	16%
Operation	16%	23%	32%	15%	14%

The satisfaction questionnaire for the UI of a certain computer software was described in Table 2. From the perspective of layout, the proportion of very satisfied people was 19%, and the proportion of satisfied people was 23%. The proportion of ordinary people was 31%. The proportion of dissatisfied people was 14%, and the proportion of very dissatisfied people was 13%. Regarding the wording, the proportion of satisfied people was 20%, and the proportion of check of the satisfied people was 20%. The proportion of people who were satisfied with operability was 23%. It could be concluded that although there were many shortcomings in the current UI. However, for the four indicators of layout, wording, check, and operability, the majority of people were satisfied.

Finally, this article conducted a survey questionnaire on 300 professionals in visual DM, and identified the indicators they believed could represent visual DM, as shown in Table 3.

The key indicators of visual DM were described in Table 3, with a total of 5 types. Among them, the proportion of consistency was the highest. There were 83 people, accounting for 28%. Accuracy was second. The number of people was 75, accounting for 25%. The response time was the lowest. There were 38 people, accounting for 13%.

Table 3: Visual DM survey questionnaire

Object	Index	Number of people	Percentage
Visual DM	Consistency	83	28%
	Accuracy	75	25%
	Layout rationalization	49	16%
	Operational rationality	55	18%
	Response time	38	13%

4. Experimental Results of User-friendly Interface Design

4.1 Consistency

The consistency of the UI of computer software systems includes consistency in font and color, alignment-maintaining consistency in the alignment of elements within the page, switching mouse gestures to hand shapes for clickable buttons and links, maintaining consistency in function and content descriptions, and consistency in form entry. This article compared the consistency between UI humanization design based on neural network method and decision tree method, as shown in

Figure 4.

In Figure 4, the left image described the consistency comparison of five computer software designs after one month using two visual DM methods to design UI. Among them, the consistency of user-friendly design for software 2 based on neural network method was the highest at 97.7%, while software 3 had the lowest at 93.5%. The average consistency was 95.2%. The consistency of user-friendly design for software 2 based on decision tree method was the highest at 92.2%, while software 5 had the lowest at 85.4%. The average consistency was 88.4%. The figure on the right described the consistency comparison of five computer software designs after two months using two visual DM methods to design UI. Among them, the consistency of user-friendly design for software 1 based on neural network method was the highest at 98.0%, while software 2 had the lowest at 95.2%. The average consistency was 96.3%. The consistency of user-friendly design for software 5 based on decision tree method was the highest at 92.9%, while software 2 had the lowest at 90.9%. The average consistency was 92.0%. Therefore, the consistency of UI humanization design based on neural network method was higher than that of UI humanization design based on decision tree method.

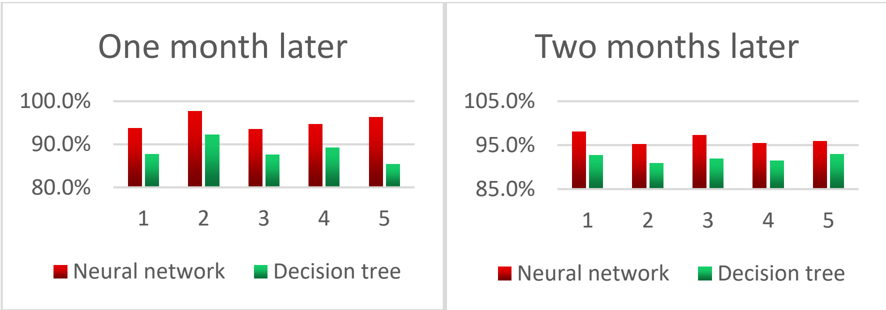

Figure 4: Consistency comparison results

4.2 Accuracy

The use of consistency as a means of analyzing the humanized design of UI is not comprehensive enough, and it is also necessary to analyze the accuracy of humanized design of UI. The accuracy comparison between UI humanization design based on neural network method and decision tree method was shown in Figure 5.

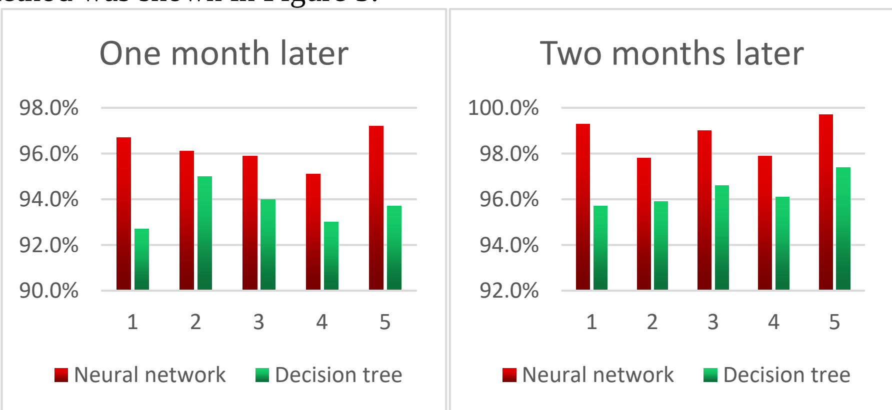

Figure 5: Accuracy comparison results

In Figure 5, the left image described the accuracy comparison of five computer software designs after one month using two visual DM methods to design UI. Among them, the highest accuracy of user-friendly design for software 5 based on neural network method was 97.2%, while software 4 had the lowest accuracy of 95.1%. The average accuracy was 96.2%. The highest accuracy of user-friendly design for software 2 based on decision tree method was 95.0%, while software 1 had the lowest accuracy of 92.7%. The average accuracy was 93.7%. The figure on the right depicted a comparison of the accuracy of five computer software designs after two months using two visual DM methods to design UI. Among them, the highest accuracy of user-friendly design for software 5 based on neural network method was 99.7%, while software 2 had the lowest accuracy of 97.8%. The average accuracy was 98.7%. The highest accuracy of user-friendly design for software 5 based on decision tree method was 97.4%, while software 1 had the lowest accuracy of 95.7%. The average accuracy was 96.3%. Therefore, the accuracy of UI humanization design based on neural network method was higher than that of UI humanization design based on decision tree method.

4.3 Rationalization of Layout

In the humanized design of the UI, it is also necessary to pay attention to layout rationalization. If the layout is too messy, it can easily lead to user loss. The comparison of layout rationalization between UI humanization design based on neural network method and decision tree method was shown in Figure 6.

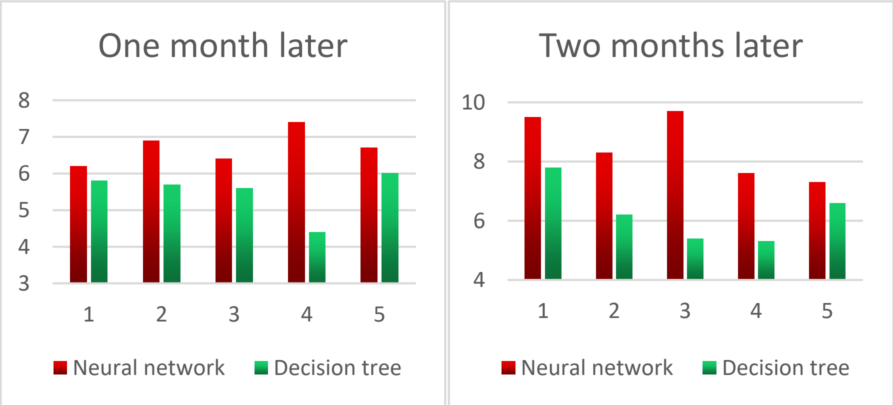

Figure 6: Comparison results of layout rationalization

In Figure 6, the left image depicted a comparison of the layout rationalization of five computer software after using two visual DM methods to design UI for one month. Among them, the layout rationalization of the user-friendly design of software 4 based on neural network method had a maximum score of 7.4 points, while software 1 had a minimum score of 6.2 points. The average rationalization of layout was 6.72 points. The layout rationalization of the user-friendly design of software 5 based on decision tree method had a maximum score of 6 points, while software 4 had a minimum score of 4.4 points. The average rationalization of layout was 5.5 points. The figure on the right described the layout rationalization comparison of five computer software after two months of designing UI using two visual DM methods. Among them, the layout rationalization of the user-friendly design of software 3 based on neural network method was highest at 9.7 points, while software 5 was lowest at 7.3 points. The average rationalization of layout was 8.48 points. The layout rationalization of the user-friendly design of software 1 based on decision tree method had a maximum score of 7.8 points, while software 4 had a minimum score of 5.3 points. The average rationalization of layout was 6.26 points. Therefore, the layout rationalization of UI humanization design based on neural network method was higher than that of UI humanization design based on decision tree method.

4.4 Operation Rationality

In addition to rationalizing the layout, the operation should also maintain a certain level of rationality. If the operation is complex, it can also lead to user loss, which is something no software company wants to see. The comparison of operational rationality between UI humanization design based on neural network method and decision tree method was shown in Figure 7.

In Figure 7, the left figure described the comparison of the rationality of five computer software operations after using two visual DM methods to design UI for one month. Among them, the humanized UI design of software 4 based on neural network method had the highest operational rationality score of 7.4, while software 3 had the lowest score of 6.1, with an average operational rationality score of 6.88. The humanized design of the UI for software 5 based on decision tree method had a maximum operational rationality score of 6.3 points, while software 2 had a minimum score of 5.1 points, with an average operational rationality score of 5.68 points. The figure on the right depicted a comparison of the rationality of five computer software operations after two months of designing UI using two visual DM methods. Among them, the humanized UI design of software 1 based on neural network method had the highest operational rationality score of 9.6 points, while software 4 had the lowest score of 7.3 points, with an average operational rationality score of 8.54 points. The humanized design of the UI for software 1 based on decision tree method had a highest operational rationality score of 8.1 points, while software 4 had a lowest score of 5.2 points, with an average operational rationality score of 6.42 points. Therefore, the operational rationality of UI humanization design based on neural network method was higher than that of UI humanization design based on decision tree method.

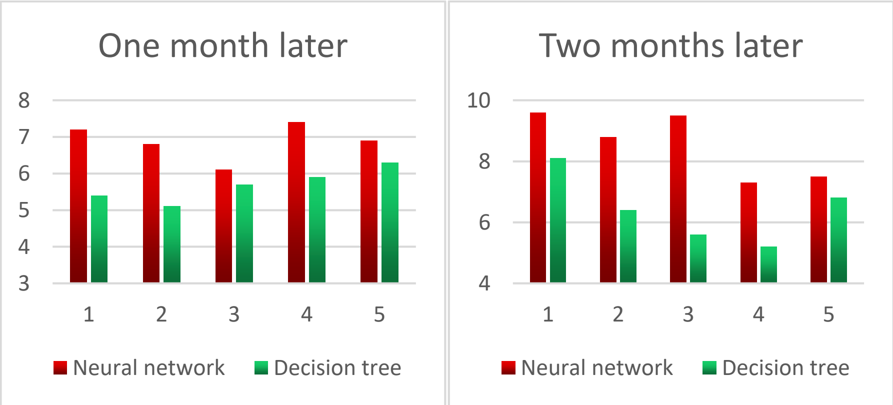

Figure 7: Comparison results of operation rationality

4.5 Response Time

In the user-friendly design of the UI, it is also necessary to consider the efficiency of system response and shorten the response time to effectively attract users. The comparison of response time between UI humanization design based on neural network method and decision tree method was shown in Figure 8.

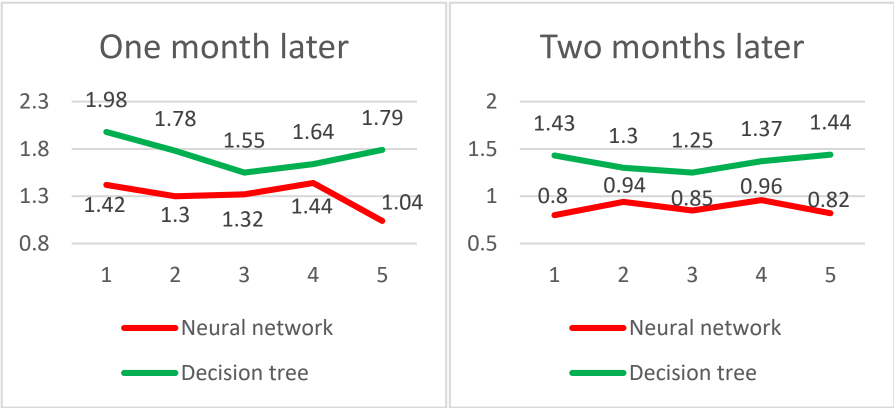

Figure 8: Response time comparison result graph

In Figure 8, the left image described the comparison of response time of five computer software designs using two visual DM methods to design UI after one month. Among them, the user-friendly design of software 5 based on neural network method had the fastest response time of 1.04S, while software 4 had the slowest response time of 1.44S, with an average response time of 1.30S. The response time of the user-friendly design of software 3 based on decision tree method was the fastest at 1.55S, while software 1 was the slowest at 1.98S. The average response time was 1.75S. The figure on the right depicted a comparison of the response time of five computer software designs after two months using two visual DM methods to design UI. Among them, the user-friendly design of software 1 based on neural network method had the fastest response time of 0.8S, while software 4 had the slowest response time of 0.96S, with an average response time of 0.87S. The response time of the user-friendly design of software 3 based on decision tree method was the fastest at 1.25S, while software 5 had the slowest at 1.44S. The average response time was 1.36S. Therefore, the response time of UI humanization design based on neural network method was faster than that of UI humanization design based on decision tree method.

5. Conclusions

With the continuous development of internet technology, the design of computer software is becoming increasingly labor-intensive. Many computer software is gradually phased out because it cannot meet the needs of users. Visual DM utilizes graphical means to clearly and effectively convey and communicate information. This article applied visual DM to the humanized design of UI, and analyzed the layout, wording, check, and operability of UI; the neural network method and decision tree method were applied to the humanized design of UI, and the two were compared. The results indicated that the humanized design of UI based on neural network method was better in terms of consistency and accuracy. The user-friendly design of UI based on neural network method could make the layout and operation more reasonable, and could also effectively shorten the response time of the system. However, when conducting research on humanized UI design in this article, the selected elements were not comprehensive enough. In future design research, more comprehensive elements would be considered.

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