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Technical Research on Computer-Aided furniture design Based on Human-Computer Interaction

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In accordance with the fundamental principles and methods of Human-Computer Interaction (HCI), this paper has explored the design process and methods on modeling technique of furniture equipment through studying the computer-aided modeling design of modern furniture products; and builds up a complete set of 2D and 3D sketch design system through demonstrating the transformation of furniture product modeling design from 2D to 3D, namely from freehand sketching, CAD to CATIA, which proved by experiments to have greatly shortened and increased the time and efficiency of product development from concept proposal to computer-aided modeling design, and to be significant for promoting the design and development of other products and equipment.

1. Introduction

Along with the development of modern computer technology, Human-Computer Interaction (HCI) plays an important role in driving designers to convert 2D creative design to 3D virtual simulation and manufacture, and optimizes gradually the processing mode for information input and output between the designer and the computer (Park, JS , Kim, JH (2015)). As the information technology develops, the modern furniture equipment is upgraded very rapidly, which is more obvious and prominent than that of other light industrial products and equipment. Therefore, in the process of product design and development, the designer is required to express accurately, rigorously and effectively his/her design creativity and idea through the way of drawing with computer-aided software, thus shortening the time from the overall idea (sketch design), design expression (2D, 3D computer simulation), craft processing (material and texture) and component mounting to product sales (Sendin, M, Lopez-Gil, JM, Lopez-Jaquero, V, (2014)). In this process of product development, the strict consistency and precision between the designer's early design creativity expression and the simulation of computer software condition the late series of crafts and processes. The computer-supported sketch design technology, bridging the freehand creative sketches by the designer and the computer-aided detail design, is an important research field of the modern interaction design, and an improvement and important development of the traditional CAD technology, as well as a key technology of computer-aided industrial design (CAID). This paper explores the design process and methods on modeling technique of furniture equipment based on interaction design through studying the computer-aided modeling design of modern furniture products; and builds up a complete set of 2D and 3D furniture equipment development system through taking advantage of HCI in computer-aided design and studying the transformation of design modes from 2D to 3D, namely from freehand sketching by the designer, CAD to CATIA; and proposes the research method and process of computer-aided HCI through the analysis from 4 aspects of sketch-supporting user interface design, preliminary 2D processing, high-level 3D modeling and post rendering, which provides important reference for other equipment in design and development .

2. Human-Computer Interaction (HCI)

Human-Computer Interaction refers to an information exchange process between human and computer in order to complete certain tasks using a sort of conversational language and in a certain interactive way [4]. It includes providing the user with massive information about hints, fees and fault tolerance, etc. by the

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computer via output or display device, and inputting information, hints and question answering to the computer by the user via input device. Interaction design presents correctly the information to the user and its focus will influence the options and sequence that users perform and fulfill tasks. Maybe this sounds very mysterious, but it's not all about technical problems. Figure 1 is the process of product modeling interaction design (Demir, Onder; Yilmaz Camurcu, Ali, (2015)) .

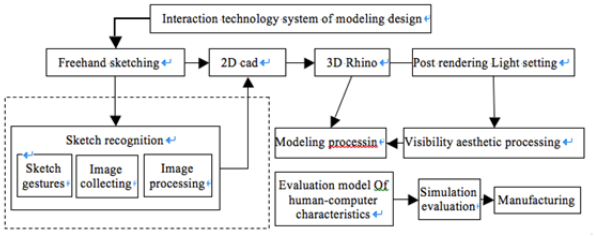


Figure 1: Process of interaction technology system of modeling design

3. Advantages of Human-Computer interaction in Computer-Aided Design

The HCI functions are achieved mainly via external input and output equipment as well as the relevant software. Equipment available for HCI mainly includes keyboard, mouse, stylus and other patterns of recognition devices. The main function of HCI in computer-aided design is to control the operation and management of the related software in computer-aided design, and to execute the related commands and requests from the HCI equipment, through which the human and the computer can be perfectly combined, and the operator will be facilitated to conduct substantive manipulation. In computer-aided design, HCI is beneficial to exploiting optimally the product performance and increasing the production efficiency (Maia, Ajalmar, (2013)). It can fully express designers' creative thinking, experiential knowledge, synthetic judgment and the best thinking characteristic, combine the aesthetic creativity with computer's strong information retrieval ability, processing ability of high-speed computing for massive information, prominence of virtual reality and processing of artistic infection, thus improving the speed and efficiency in designing, greatly shortening the design cycle, guaranteeing the design quality and reducing the design cost [9]. HCI technology must adhere to user-oriented purpose, no matter how it develops. Taking advantage of the extensive application of HCI in design, we shall emphasize customer-centered design, strengthen the originality of the product, develop HCI to maximum extent in industry, meet the humanized needs of customers, bring favorable experience for customers and increase the efficiency of design and manufacture. If the above-mentioned factors can be fully performed, the product's creativity, design and quality will be better than other like products, its market competitiveness will be enhanced, and the enterprise will also remain invincible in the process of business competition.

4. System of Computer-Aided furniture equipment design technology

4.1 Sketch design

Figure 2: Freehand sketch schemes of the furniture

Sketch, as the start of design, is a key factor in the process of early concept design. At the beginning of product design, a designer would rather record quickly the creative inspiration in his/her mind by using paper and pencil; and in the post detail design stage, he/she might turn to use the computer. Figure 2 shows the designer's freehand sketches of the furniture.

4.1.1 Sketch-supporting design interface

Sketch-supporting design interface allows users to delineate directly and freely the entire or partial sketch using pen or mouse in design environment, which is convenient for designers to express their design

inspiration quickly. Igarashi and Zeleznik, etc. all apply such design interface in their design systems. However, although the sketch interface allows designers to express their design inspiration quickly and freely, free sketching is always accompanied by understanding difficulties. For example, it is hard to accurately recognize the graphics of freehand sketches, and the gesture commands are not as obvious and catchy as menu buttons.

4.1.2 WIMP and sketch combined interface

Although WIMP-based interface is not so suitable for the early design stage, it can give some advantages to sketch design if the interface tools such as menu item and toolbar buttons are designed simply and with smaller quantity. For example, it is suitable to design some simple 2D primitive buttons such as lines, circles and arcs, etc. Most sketching systems apply such interface to promote the quick expression of design ideas. When an error occurs in sketch recognition, users can correct it through clicking the corresponding button. Figure 3 shows the Cintiq 24HD.

Figure 3: Cintiq 24HD

4.1.3 Sketch processing

Freehand sketching in the system interface via pen or mouse produces a series of discrete coordinate data points where noise and interference exist. Therefore, the system needs to process these data points with stroke segmentation, strokes classification, sketch recognition and sketch normalization, and finally recognize the geometric figure of the sketch.

4.1.4 Semantic understanding of sketches

Semantic understanding of sketches is to understand the specific meaning that the figure expresses according to the recognized geometric figures. It needs to be combined with the knowledge of specific domain, for example, an arrow signifies force in Physics, while it signifies direction of movement in sketching. The user inputs expediently the stroke information on tablet and the computer can pick up the input information in real time; with the sense of pressure, the tablet can simulate the pressure produced from the touch of pen and paper and simulate the generation of artistic effect with physical pen and paper. The view provided by the procedure can be transformed freely in real time, which adapts to the different hobbies of designers; it can also be zoomed and rotated in real time, which facilitates designers to sketch and give feedback. Figure 5 shows the presentation process of free-form modeling. As is shown in Figure 5a, because of the hand trembling in input process, the stroke produces a slight noise jitter. As a result, it requires mass space and computing information to save the information of data points. After a series of real-time processing by the computer, the line graph of morphological structure composed of stroke track curves can reflect clearly and correctly the current modeling. Figure 4 is the sketch recognition and drawing of furniture.

(a) Base recognition and sketching *(b) Main body recognition and sketching*

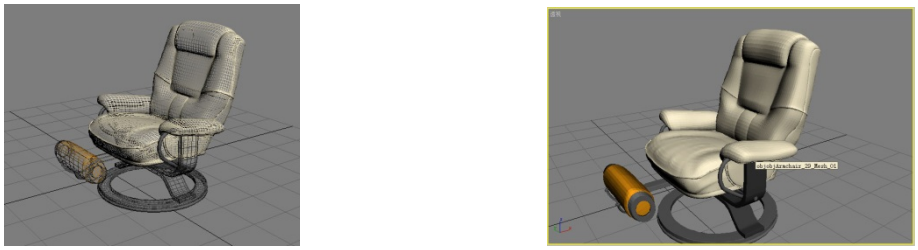
Figure 4: a, b Sketch recognition and drawing of the furniture

4.2 3D modeling

After finishing the 2D sketch, the application of 3D modeling technology will begin. 3D modeling can be achieved in lots of computer-aided design software which mainly includes engineering 3D modeling software such as UG, Pro/E, SoliWorks, 3DSMax, CATIA, Maya and Sketch, etc. 3D modeling provides the model with more visualization and strong operability, which can meet the requirements of modeling. For example, 3DSMax is powerful in triangle modeling and it is often applied in interior and architectural design. CATIA can achieve surface modeling with the features of accuracy, compatibility, high efficiency, usability and engineering, etc., and it can create any imaginary complex model. Therefore, it is widely applied in 3D modeling design of product design. This paper applies CATIA software to conduct 3D modeling for furniture equipment. Figure 5 and 6 are the view presentation of a furniture including the modeling process of the whole furniture as well as the perspective view. And the perspective view shows the overall effect of 3D model, which is ready for the next model rendering.

(a) Curve modeling of the base *(b) Curve modeling of the main body*

Figure 5: a, b Modeling process of the furniture



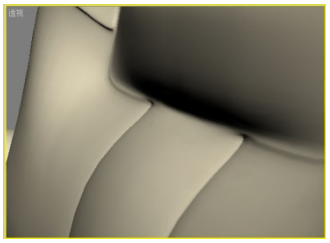
(a) Wire-frame model *(b) Basic model of the main body*

Figure 6: a, b Morphological model of the furniture

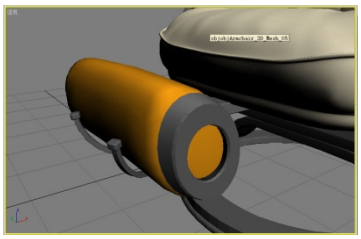
In CATIA design from parts to assembly, the relational structure is associated. We can also construct a part library of our own in CATIA to preserve as many reusable resources in design as possible such as products, parts, features and design rules, etc., and apply these data that have been verified through production to the design of other products, which can not only accelerate the design efficiency but also avoid repeated design. Read data from CATIA library and implement assembly design in DMU environment. This process realizes the thinking of design-production verification-design, and maximizes the application of our experience to the product design. Figure 7 and 8 are the effects of furniture parts after modeling, which can be stored and called in the post assembly of procedure.

(a) Base recognition and sketching *(b) Main body recognition and sketching*

Figure 7: a, b Sketch recognition and drawing of the furniture



(a) Model of volume buttons



(b) Model of function buttons such as tone and mode

Figure 8: Models of the furniture parts

4.3 3D rendering

Rendering the 3D model can produce a more verisimilar effect which provides the user with a final effect of the product. Through the verisimilar effect, the user can understand more intuitively the overall condition of the target product including elements such as material, color, overall dimension, etc. when he/she is interoperating. Therefore, a high quality rendering effect is an essential step in interaction design.

First of all, according to the model feature and the required rendering effect, import the output file in. obj format of the model from CATIA software to 3DSMax software. In order to get a better rendering effect, the surfaces must be optimized when the file is output. For example, reduce the number of surfaces and guarantee the surface features such as smoothness through adjusting the parameters. Secondly, according to the design requirements and through adjusting the parameters of multi-layer, add the materials and maps that have been set up to the multi-layer, and add them to the corresponding model units as required. Meanwhile, check whether the rendering effect is satisfactory through multi-pass partial rendering. Finally, as with the setting of environment, different locations in the scene can be lit to enhance the shading effect in different parts of the model. And with the cooperation of camera, namely observing the model from different perspectives, we can get visual effects from multiple views. After the above steps of rendering, the 3D model rendering can be able to represent a realistic product view, and under the influence of overall environment, the material and color of the model will fully exhibit the realistic feature of furniture model. Figure 9 is the final rendering of the furniture equipment.

Figure 9: The interactive exhibition of furniture renderings

5. Conclusions

Based on the design principle of Human-Computer Interaction, the paper explores the whole design process of the furniture equipment through the computer-aided virtual technology, and establishes a computer-aided design system for furniture equipment based on HCI, which fully demonstrates the design intent of designers and the creativity of conceptual design, and builds a bridge of visual communication between designers and users. Especially in the early sketch design process, through the research on design processes of sketch design interface, sketch 2D recognition, semantic understanding as well as the parametric and hybrid modeling in 3D modeling, and by applying the rendering technology of 3D visual interaction, a complete set of computer-aided design system from 2D to 3D is presented, which greatly shortens the process of design and manufacture, and vastly increases the efficiency of design and post modifications. What's more, computer modeling is conducted in CATIA software, and exhibitions and interactive applications are implemented in 3DMAX software. The above processes not only improve greatly the design speed and design quality, but also enhance the communication between designers and users, which conforms better to the needs of designers and users.

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