

Research on the Application of Virtual Animation Interaction Technology in Product Model Construction and Design

Xiaocheng Zhou^{1,a,*}

¹Computer Engineering College, Anhui Wenda University of Information Engineering, Hefei, Anhui, China

^a729334333@qq.com

*Corresponding author

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Abstract: 3D animation and interactive design are important key technologies and realization ways in the field of virtual reality. In the field of product design, the diversity and flexibility of product modeling and decoration design can be realized through interactive design of virtual animation, and the dynamic change process of product modeling can be realized by using 3D animation technology. Using virtual interactive technology, we can realize the dynamic change process of product decorative texture and pattern. The application of virtual animation interactive technology in the field of product design can make up for and improve the singleness of hand drawing's visual angle and the fixity of traditional animation display. With the help of new computer application technology and subject development, it can provide some reference for opening up new methods and approaches in the field of product design.

1. Introduction

Product design is a comprehensive conception and design process that combines elements of art, function, and science and technology. It creates products that meet the aesthetic needs of the public and are economically practical, considering factors such as product form and structure, decoration and texture, style, and pattern. In the design process, the comprehensive use of product design methodology, engineering, behavioral psychology, and scientific disciplines plays a crucial role in determining the final form and effect of the product [1].

Product design is not only a creative coordination process based on human-machine engineering and product semantics between form and function, but also a sublimation and feedback from culture in the process of inheritance and development. The organic integration and innovative development of product design disciplines with other related interdisciplinary fields can explore and excavate more logically connected and realistic design works based on market rules and demand expectations, thereby better reflecting the essential relationship between products and humans. By analyzing user feedback, we can identify the core values and behavioral concepts of user needs, helping developers, designers, and sales personnel effectively predict and analyze during market monitoring. With the

help of new scientific technologies and the spread of new media, companies can design better products with core competitiveness that meet the diverse needs of customers [2].

The product research and development design process aims to shorten the product development and design cycle through a planned, researched, designed, integrated, and improved process. It aims to address the shortcomings and deficiencies in the product development design process by targeting, planning, and redesigning workflows and data analysis processes. Through the continuous maturity and improvement of information technology and data management technology, product design processes and methods become more efficient and practical [3].

Product design has undergone a long development process, with many research institutions around the world making significant achievements. For example, the MIT "Product Development Innovation Center" conducts preemptive research on product development theory and practice; Stanford University's Design Research Center strives to reduce industrial manufacturing pressure, optimize team design processes, develop advanced tools and methods, improve industrial product design and manufacturing levels, focus on conceptualizing design thinking techniques, promote research on engineering design innovation, and design education; Cambridge University's Institute of Manufacturing mainly collaborates with industry to guide product design strategies and operational technologies through specific technical solutions. Through research on human-machine engineering, product semantics, and the relationship between form and function in product design, it actively promotes the development of product design art in the process of exploring, designing, and developing new products [4].

In the product design process, although there are mature ideas and systems for design methods and system management, in specific design aspects, plans are usually designed using hand-drawn or computer-aided drafting methods in the early stages. During the display phase, three-dimensional effects may be used for comprehensive display. In the later stages, there are also broad media channels for promotion. However, during the design process, how to establish dynamic associations between the diversity and variability of design plans and user requirements during post-use is an important issue. Through human-machine interaction, screening and integration of design plans can be achieved by running database or quantitative product design methods for qualitative and quantitative analysis to maximize display of operability of product design plans. Further exploration and analysis are warranted [5].

With the continuous advancement of technology, traditional product design methods and processes also need to keep pace with the times. By introducing new scientific and interdisciplinary fields such as virtual three-dimensional animation technology and product human-machine interaction technology, how to organically integrate these into product form and decoration is a constant exploration and accumulation of experience. How to take the audience as the center, take design symbols as the form, use creative techniques as a means, and meet needs as the goal while enhancing product usability, aesthetics, and emotional design is worth further pondering and delving into [6].

1.1. Product Plan Design and Modeling

Product form determines function, and product functionality helps to design a better form. Therefore, product design should follow the people-oriented design concept. On the basis of focusing on product functionality and practicality, emotional factors and artistic interest should be added to enhance the product's form. Therefore, at the stage of product scheme design, target audience groups and market demand should be considered. Based on research data analysis, relevant product design processes should be standardized using related design methods. A general framework and positioning should be established for sketch design and conception through

comprehensive communication and exchange among relevant designers. The initial embryonic form and basic structure of the product should have a detailed product design proposal with feasibility and market value. Then, a hand-drawn or basic model production method should be used to determine CAD plane drawings and size charts to prepare for three-dimensional mapping and scheme preparation in the later stage [7].

1.2. Three-dimensional Modeling and Material Design of Products

After the product plan is established and the product CAD production is completed, the next step is to convert the flat structural diagram into a visual three-dimensional view. Therefore, it is necessary to use relevant three-dimensional design software for production, such as 3ds Max, Maya, SolidWorks, Rhino, ZBrush, etc. Three-dimensional mapping has been well utilized in the product design industry, but considering the need for virtual interaction presentation of models in later stages, attention should be paid to issues such as modeling and material performance as shown in Table 1 below.

Table 1: Precautions in three-dimensional modeling and material design of products

Precautions	Design Methods
Pay attention to the topology of the model during modeling to avoid errors or unreasonable structures.	Before modeling, carefully analyze the structure and function of the product, determine the relationship and connection between each part, and then model it according to the correct topology. You can use the automatic wiring function in CAD software to assist with modeling.
The material mapping should be accurate and free from duplicate or missing situations.	Before creating material maps, prepare the corresponding texture image materials and process and edit them as needed. Then apply them to the corresponding materials to ensure that each part has the corresponding mappings. You can use image processing software such as Photoshop to make and manage the map tiles.

The material design of a product is mainly aimed at creating a three-dimensional mapping representation of the texture attributes and characteristics of the product's surface. The production process and performance technology of this design are fundamentally different from traditional product rendering. Typically, when rendering a product, the material attribute parameters need to be adjusted to the most realistic state, and it takes a lot of time and many render plugins to render a beautiful rendering. In contrast, for the material and mapping of the post-production virtual interactive display product model, it is not as complex as traditional product rendering. Only the basic texture attributes of the material need to be demonstrated. Later in the interaction engine, because there are better real-time material properties and dynamic display light and shadow effects, it can also achieve the most authentic display effect. Typically, a standard material is added with a texture map in the diffuse channel, and the format of the map generally supports file formats such as JPG, BMP, TGA, PNG, and DDS [8].

The design of product material mapping first needs to determine the product's material attributes and categories. Use the material design system and program textures to specify diffuse color. If the object has a translucent attribute, a black-and-white bitmap mask needs to be added in the opaque channel of the material. After assigning the material, adjust the UVW mapping coordinates of the product model. Using the UVW mapping coordinate modifier, select appropriate mapping

coordinate methods based on the model's sculptural characteristics. If there are some complex product models, you may need to split the product UV maps further. Re-split the UV coordinates of the model through the UVW mapping coordinate system and UV unfolding map editing modifier, render the UV planar map to Photoshop software for texture drawing, and then assign it to the product model in the scene. For objects with special highlights and reflection attributes, fine adjustments can be made in post-interaction design software [9, 10].

1.3. Virtual Scene Lighting and Camera Design

Lighting design is mainly about simulating and designing the light effects in a scene, aiming to let products receive influence from virtual lighting effects in all directions. By using different light source attributes and lighting colors, enhance and render the theme tone and atmosphere of the scene. The quality of a rendering largely depends on lighting design. Without light and shadow, there will be no color or texture expression. Therefore, lighting performance in traditional product rendering has high requirements. Although design software can simulate various complex lighting effects to the maximum extent, some excellent renderers such as Vray, Final Render, Brazil have preset lighting effects that can create a very realistic lighting scene. However, it still takes a long time to wait for results during rendering processes. As a product in a VR scene, lighting performance is indeed very important. How can we run it smoothly and freely in later stages of development while still retaining lighting atmosphere and details? This is a problem that needs to be solved before importing it into later software for further design. During software design, software developers have taken this into consideration. They only need to perform scene lighting according to normal lighting design, save lighting information and light shadows in a way of mapping images, bake map production and rendering to use bitmap forms to save lighting information, and then restore light in later interaction software. Of course, light can also be designed and adjusted in real-time in later interaction engines to achieve optimal lighting effects [11].

Product scene lighting generally uses a three-point lighting design method. That is to say, combine the main light source, auxiliary light source, and background light source through different brightness and cool/warm light source effects to illuminate the scene. Try to use as few lights as possible to achieve optimal lighting effects. Where lighting is insufficient, local illumination and global illumination can be combined for supplementary illumination. Further adjustments can also be made in later stages of development. After completing product light source design, in order to obtain a better viewing angle, a camera needs to be created to position the product's viewing angle. There are two purposes for creating a camera in the scene: one is to fix the viewer's perspective so as to reflect the product's sculptural features; the other is to provide a panoramic view through the creation of camera animations for later interactive animation display. The feature of virtual scene implementation is that it can simulate animations and interactions. Therefore, cameras in scenes can be adjusted by changing parameters such as field of view and focal length to an appropriate viewing angle for later human-computer interaction and virtual display to provide a third-person perspective view location [12].

1.4. Product 3D Animation and Special Effects Design

Product 3D animation design is an important part of displaying in virtual interactive scenes in later stages, so in 3D animation design software, keyframe animation technology and related animation editing tools can be used for designing and creating animations. During the production process, the main information such as product shape, structure, material, texture, characteristics, function, and attribute are mainly displayed. In the performance of product 3D animation production, both keyframe animation and camera binding path can be used for panoramic display of

product modeling, and Morpher animator and skeleton animation can be used for dynamic quantification design of product structure. Particle system can be used to create realistic dynamic backgrounds, and animation controllers can be used for precise animation creation. After completing the production of 3D animation, it can be imported into later interactive software to run relevant UI interfaces and script programs for driving, allowing for non-linear display of product animation, and interactive display of different animation forms in the same virtual space at different times, achieving a comprehensive visual perception and dynamic experience. To enhance the richness of product animation display and the perfection of visual effects, special effect designs can be carried out specifically for the overall effect of the product, as shown in Table 2 below.

Table 2: Special Effects Design Methods for Overall Product Effect

Effect Design Method	Special Effect Form
HDR Mapping	Simulating a panoramic environment of the scene.
Volume Lighting and Fog Effects	Simulating the lighting levels of the scene.
Video Post Video Synthesizer	Rendering and compositing video effects.
Hair and Fur Functionality	Designing hair and fur.
Brightness Contrast and Color Balance	Performing color calibration design.
Depth of Field and Motion Blur	Simulating the motion effects of a camera.
Particle System	Producing complex atmosphere effects.

Through these special effects design, we can add many characteristics and atmosphere to the art of product modeling and decoration design. Once the properties such as models, materials, lights, cameras, animations, and special effects in the scene are set, you can save and export the scene. Generally, you need to bake the entire scene output and use lighting maps or complete maps to save and output the light and shadow information in the scene. The entire scene can be exported through related plugins or exported as a system file format that can be recognized by post-interaction software, such as OBJ, FBX, etc., preparing for the next step of designing the post-interaction scene.

1.5. Product UI Design and Interaction Design

Product UI design is a tool for human-machine interaction linkage and dialogue. After completing product modeling, material selection, lights, cameras, animations, and special effects in the current phase, you need to bake the scene and import it into post-interaction software for relevant UI design based on the scheme and purpose of product interaction design. In general, the principle of UI design can be summarized into three points: keeping UI control within users' grasp, maintaining consistency in UI interfaces, and reducing user memory burden. The principles of UI design mainly include user-centeredness, minimum information amount principle, help and prompt principle, and media best combination principle [13].

In product UI design, product interface analysis should be conducted first. Based on the characteristics and performance of the product, multimedia environments can be creatively used in combination with text, graphics, animations, video images, audio, gestures and actions. User psychology and cognitive science should be used to establish temporal correlations with modes that users understand from task information expression, UI control function, etc. In accordance with compatibility, adaptability, guidance, structured economy, etc. Through analysis of product UI design principles, there will be a macro grasp of the design process and interaction process. Since

UI design is a relatively complex system, it requires participation from multiple disciplines including psychology, linguistics, and design [14].

Interaction design originated earlier than the internet and was an extension of human-to-human interaction. Interaction design is essentially a real-time interactive display process through program interfaces between users and products. It belongs to one branch of art disciplines with core goals of enabling target audiences to perceive information transmission processes and symbol transformation processes in dynamic ways through interaction. For example, in product modeling and decoration design, functional and environmental interactions in post-virtual space need to be vividly processed for enhancing the aesthetics and interestingness of interaction design [15].

1.6. Program Script Design and Compilation Output

After establishing the process and method of product UI design and interaction design, computer script languages in interaction engines need to be programmed for programming design purposes to achieve human-machine interaction. Before programming design begins again, product model attributes need to be adjusted once more through simulation of environment reflections such as marble, wood grain, hair, jade, glass, metals, ceramics, porcelains, contour lines, cartoons, and normals to create more lifelike material effects. Model mapping display methods and characteristics in views can be modified in detail in property panels such as double-sided display of model mappings, color saturation of mappings, transparency properties of mappings, blending modes of mappings and reflection mappings; all according to project needs for design expression [16].

Program script designs are generally done in Unity, Unreal Engine, VR-Platform and other design software using C++ programming language and Java Script programming languages along with blueprint design systems and script editors to program language design for interaction process and method. Simulate dynamic holographic environments for human-computer interaction by utilizing UI interface objects and products in scenarios with virtual interaction related devices; virtual roaming presentation can be achieved through virtual characters or cameras; furthermore deeper human-machine interactions can be conducted for products themselves which rely on powerful computer programming languages as long as there are reasonable logic syntaxes and running sequences; program script designs can then be designed with targeted intent according to design ideas thereby providing a broader platform and space for virtual person-machine interaction product designs.

When programming finishes; suitable platforms such as Android, Apple iOS, Windows PC Mac Xbox360 Web etc can be selected for publishing standalone VR program scenarios; users and designers can install them on relevant third party clients either online or offline so as to fully conduct man-machine dialogue experience new functions new features of products offering new ideas and references for next step new product designs research development.

2. The Impact and Significance of Three-Dimensional Animation and Interaction Design on Product Form and Decoration

Combining three-dimensional animation technology with product form and decoration has a significant impact on displaying product structure and texture. Introducing the concept of interaction design into product form and decoration design affects the virtual interaction process and multisensory experience for human-computer interaction, as well as the design methods and ideas of products. It is mainly reflected in the following aspects [17]:

Firstly, three-dimensional animation technology can present the structural form and material properties of products more intuitively and vividly than traditional hand-drawn sketches or three-view diagrams. While these methods have played an important role in product creativity, they

have limitations in describing product functions and demonstrating usage methods through dynamic changes. With three-dimensional animation technology, users can better experience the form and function of products.

Secondly, virtual interaction technology allows for multiple design options and ideas to be presented in a human-machine dialogue format, better satisfying the needs of designers and users. By using parameterized indicators and ranges in the design process of product form and decoration, it provides new ideas and platforms for creative design methods.

Thirdly, virtual reality technology combines computer programming languages, hardware devices, and product interaction displays to achieve a comprehensive presentation of product form and decoration design. Using three-dimensional animation as the main display method, VR devices as the platform, interaction design as the presentation process, computer language as the program interface, visual, multisensory, and all-round dynamic demonstration and control, it realizes a new process and leap in product development design.

Finally, the combination of three-dimensional animation technology, interaction design, virtual reality, and product form and decoration design achieves multidisciplinary and cross-domain integration. Based on the basic methods and principles of product design, according to the latest research technologies and application fields of human-machine engineering and new media disciplines, with the help of new computer application technologies and the integration of art with disciplinary development, it provides reference and inspiration for exploring new methods and approaches in product design.

3. Innovative Application and Development of Virtual Reality Technology in Product Modeling and Decoration Design

Through the analysis of the key elements and processes of virtual 3D animation technology in product modeling and decoration design, the application research method of virtual animation interactive technology in product model construction design is obtained. Through the analysis of elements in product design process and the discussion of technical realization ways, the construction and simulation of virtual environment are carried out based on the 3D modeling platform. The use of relevant UI interface and programming methods has brought new development and changes to the content and presentation of products, and has certain reference significance for the promotion and design application of later technologies, as well as for the research of product modeling design methods and related theories. Virtual 3D animation technology has changed the method and process of traditional product design. Applying 3D animation, virtual reality technology, interactive design and ergonomics to the process of product modeling and decoration, 3D modeling and animation techniques are used to perform motion analysis, from planar to 3D, from static to dynamic, and from unidirectional to interactive, so that the product display can produce simulated effects. The application of virtual reality technology to the product design and interaction process can more vividly display the process of product digitization, and at the same time, the product's modeling and decoration, function and form display process can be more intuitive through visual symbols and sensory symbols to express and transmit the meaning, which plays a key role in the realization of human-computer interaction process. Through the innovative application of interdisciplinary, with the help of 3D interactive software and hardware platform, it has important innovative application value and market value for the methods and technologies of 3D product modeling and decoration in virtual roaming animation.

With the development and formation of the modern industrial chain, relying on cloud computing and big data technology as the platform, the application field of virtual reality technology has also expanded. Driven by the learning structure and internal connection of related interdisciplinary

disciplines, it provides a research platform for realizing previously bold and creative ideas that are difficult to realize. In the process of collaborative creation and application of virtual reality technology and interaction design, the content and method of product design will also develop towards diversification and visualization. Therefore, the development space of product design has been greatly improved. As a new technology application and presentation mode, virtual reality technology has been greatly improved. It can provide a real-time interactive process for the virtual construction in the process of product design, so as to improve the design efficiency and shorten the research and development cycle, which has an important role and significance, and provides a new media platform for product design and display, scheme selection and reconstruction.

Through the analysis and research of the principles and methods of virtual 3D animation technology in the process of product design and the realization process, it can be found that through the combination of design art and computer science, the operation of technical means to solve the problems in the process of artistic creation has a good promotion and help role. In the process of product design, three-dimensional animation technology is used for display and virtual reality technology for interaction, which can intuitively present the product shape structure and convey effective design information. At present, the hardware environment and design cost of virtual reality technology are relatively high, and the relevant technical application problems still need to be further explored and overcome. With the continuous progress of future science and technology and application innovation, it is believed that its application prospects will be more broad and prosperous. As a research field with comprehensive disciplinary characteristics, product design requires certain theoretical research foundation and design practical skills for designers themselves. In the process of product creation and development, the design concept of people-oriented should be adhered to, and innovative design ideas and methods should be implemented through the organic combination of emotional care and humanistic consciousness. Experience design and focus on the creative process. Under the background of both opportunities and challenges, the discipline of product design will be closely integrated and developed with other disciplines to provide innovation, creativity and creation space for new design and new ideas.

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References

- [1] Hu Zhiyi, Liu Liangfang. *Research on the application of virtual reality technology in 3D animation creation*. *Optik*, 2023, 272.
- [2] Li Zhiwei. *Task Image Setting of 3D Animation Based on Virtual Reality and Artificial Intelligence*. *Mobile Information Systems*, 2022.
- [3] Mao Jianxing. *Study the Differences and Similarities Between the Techniques of 3D Animation and Stop Motion Animation*. *Art and Design*, 2022, 5(2).
- [4] Sha Zhu. *Expression and Application of Watercolor Art in Computer 3D Animation Design System*. *Frontiers in Art Research*, 2022, 4.0(2.0).
- [5] Li Yongfeng and Zhu Liping. *Extracting knowledge for product form design by using multiobjective optimisation and rough sets*. *Journal of Advanced Mechanical Design, Systems, and Manufacturing*, 2020, 14(1).
- [6] Deng Cong, Kan Fengyan. *The visual expression of strength in product form design*. *IOP Conference Series: Materials Science and Engineering*, 2019, 573.
- [7] Jose A. Diego-Mas, Jorge Alcaide-Marzal. *Single users' affective responses models for product form design*.

International Journal of Industrial Ergonomics, 2016, 53.

[8] Lian Ding. *Research on the Application of Computer Virtual Simulation Technology in 3D Animation*. 2020 5th International Conference on Technologies in Manufacturing, Information and Computing, 2020.

[9] Chen Xiaoran, Gao Yu. *Application of Virtual Reality Technology in 3D Animation Teaching*. 2020 2nd Asia-Pacific Conference on Advance in Education, Learning and Teaching, 2020.

[10] Huang Li. *Research on Museum digital interactive display design based on AR technology*. Guangdong University of Technology, Guangzhou, 2022.

[11] Zhao Yanping. *Research on the Application of Auxiliary Graphics in Product Modeling Design*. Qilu University of Technology, Jinan, 2021.

[12] Zhou Lulu. *Application Research of Virtual Reality Technology in 3D Animation Creation*. Nanjing University of the Arts, Nanjing, 2021.

[13] Wang Fangjuan. *Research on Virtual Interactive Animation Creation based on Unity*. Lanzhou Jiaotong University, Lanzhou, 2021.

[14] Sun Mengyun. *Application research of Virtual Reality Technology in Interactive architectural animation*. Nanjing University of the Arts, Nanjing, 2018.

[15] Cui H. *Research and application of virtual simulation and interactive design in home display design*. Hunan Normal University, Changsha, 2016.

[16] Lv, Z., Li, X., & Li, W. *Virtual reality geographical interactive scene semantics research for immersive geography learning*. *Neurocomputing*, 2017, 254, 71-78.

[17] Jia, Q., Xie, R., Huang, T., Liu, J., & Liu, Y. *Caching Resource Sharing for Network Slicing in 5G Core Network: A Game Theoretic Approach*. *Journal of Organizational and End User Computing (JOEUC)*, 2019, 31(4), 1-18.