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The Evolution of Art Design: Digital Modeling and Computer-Aided Techniques

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ABSTRACT: Art design includes a wide range of fields including industrial design, environment design, advertising design, web design, fashion design, and animation design, etc.; the digital model of art design also faces the transition from plane to space and differential analyses. With the continuous update and development of computer technology, the role of computer-aided design in the field of art has become more and more obvious, and its position has become more and more important. Based on the summary and analysis of previous research results, this paper expounded the current status and significance of the digital model of art design, elaborated the development background, current status, and future challenges of computer-aided technology, proposed the digital model of computer-aided graphic art design including art design strategy and digital model structure, analyzed the digital model of computer-aided spatial art design including art design system and digital model optimization, and discussed the interactive range interaction between design and calculation and the association between the graphic and spatial digital model. The analytical results show that, in the process of introducing computer applications, the digital model of computer-aided art design can also introduce the professional knowledge of art design in more detail so that designers can understand the principles and patterns of art design and can apply them to computer-aided designs, having greatly improved the efficiency and quality of art design, extended designers' thinking, and then developed a digital model from plane to space. The study results of this paper provided a reference for further research on the digital model of computer-aided art design.

KEYWORDS: Art design; Digital Model; Computer Aided

I. INTRODUCTION

Art design is a broad field, which includes industrial design, architectural environment design, advertising design, web design, fashion design, animation design, and many other aspects. With the continuous update and development of computer technology, the role of computer-aided design in the field of art has become more and more obvious, and its position has become more and more important. The application of computers in the field of art design has included all art design content, from graphic art design to spatial art design to animation art design, and all of these design activities are inseparable from the assistance of computers. Mayvan et al. pointed out that two-dimensional accurate drawing, three-dimensional modeling, virtual reality experience, geographic information system support, and other computer-aided technologies represent computer-aided art design. Especially in recent years, new computer-aided design technologies such as virtual reality technology and geographic information system technology have been combined with planning and design more and more in-depth, making the integration of science and aesthetics in the application of art design. Zhao et al. suggested that in-depth study of the application and development status of computer-aided art design is of great significance for expanding the application field of computer-aided design, shortening the time of art design, and improving the quality of art design.

The purpose of computer-aided art design is to better serve the needs of human art design, and the humanization and intelligence of the digital model of art design is the most ideal embodiment of service quality. At present, computer-aided art design simply combines the existing intelligent technology with related software technology, and combining computer technology with artificial intelligence to improve the auxiliary function of computer technology in art design is the inevitable development of computer-aided art design in the future trend. Liu et al. suggested that the communication between customers and designers will be more convenient and faster. Designers can establish initial digital models according to customer needs in the early stage, and then modify and adjust according to customer needs, which greatly saves design time and shortens the design process. Designers can use their imagination to the fullest according to their own needs and directly generate various highly creative visual images in font design or graphic processing. Qin et al.

concluded that the digital model can also record the drawn graphics into the computer through various technologies and then apply a variety of methods to perform various special processing, so as to produce a unique creative and breathtaking picture effect.

Based on the summary and analysis of previous research results, this paper expounded the current status and significance of the digital model of art design, elaborated the development background, current status, and future challenges of computer-aided technology, proposed the digital model of computer-aided graphic art design including art design strategy and digital model structure, analyzed the digital model of computer-aided spatial art design including art design system and digital model optimization, and discussed the interactive range interaction between design and calculation and the association between the graphic and spatial digital model. The study results of this paper provided a reference for further research on the digital model of computer-aided art design. The detailed chapters are arranged as follows: Section 2 proposes the digital model of computer-aided graphic art design, including art design strategy and digital model structure; Section 3 analyzes the digital model of computer-aided spatial art design, including art design system and digital model optimization; Section 4 discusses the interactive range interaction between design and calculation and the association between the graphic and spatial digital model; Section 5 is the conclusion.

II. DIGITAL MODEL OF COMPUTER-AIDED GRAPHIC ART DESIGN

A. Graphic Art Design Strategy

The application of computers in the field of art design has included all art design content, from graphic art design to spatial art design to animation art design; all design activities are inseparable from the assistance of computers. In the process of introducing computer applications, the digital model of art design also introduces the professional knowledge of art design in more detail, so that designers can understand the principles of art design and the laws of design art, and apply them to computer-aided design (Figure 1). Not only can computer applications be applied, but also the application of artistic design and production is important. The digital model of artistic design pays attention to readability, practicality, and maneuverability, and most of the content is written based on the designer's own design experience. The purpose is to enable the designer to apply the most practical computer-aided graphic design method. Oladumiye suggested that the digital model involves the case is more practical and representative of art design and production, and it is more about the experience of actual art design work. The content of the art design digital model is comprehensive and accurate, the case is rich and diverse, the operation is explained in detail, the steps are complete, and the key points are highlighted.

After the art design digital model plan is completed, it is necessary to think in detail about how to better express the functional relationship between the various parts of the design plan, how to make the designer's design concept and design idea better show to the audience, and how to be understood by the audience. This requires a detailed analysis of the plane structure in the model, such as functional structure analysis, traffic structure analysis, landscape structure analysis, etc. The purpose of computer-assisted analysis is to make an overall plan for the model road, evaluate whether the artistic design plan is reasonable, identify problems, and prepare backup solutions. Specifically, the computer-aided design software used in the art design digital model can be divided into two types: vector software and bitmap software. The advantage of vector graphics is that they can be infinitely enlarged or reduced without affecting the image quality. The disadvantage is that the color level is not rich enough, and the overall look and feel is worse than that of bitmaps. Graphic analysis plays a very important role in planning and design and is an important embodiment of designers expressing their thoughts and ideas.

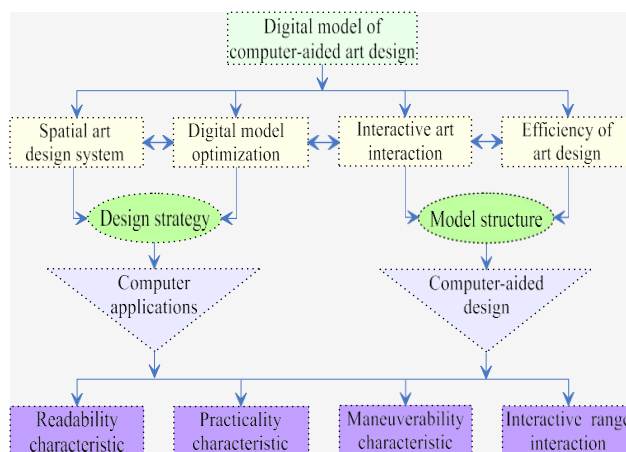


Fig1: Digital model framework of computer-aided graphic and spatial art design.

The digital model of artistic design is a mathematical model created based on the principle of binocular stereo vision. Different scenes require different binocular stereo vision models to achieve the expected stereo effect. The parallel binocular model simulates the situation where both eyes observe an object in parallel, while the convergent binocular model simulates the situation of viewing the object when both eyes intersect. The object coordinate system is also called the model coordinate system, which is used for the computer-aided description of the basic shape of the space model. The projection plane coordinate system is a plane coordinate system, referring to the coordinates on a projection plane, that is, when viewing the space model. The digital model of art design is projected to the projection plane to generate a plane image, which describes the coordinate system of the image. When performing computer-aided art design, the most critical step is to obtain a flat image, and the objects that can be displayed by the left and right eye images must be consistent in the corresponding positions, which require consistent image design. Based on this problem, an auxiliary viewpoint is set in the space scene, and the viewpoint design space model obtains an image that includes the binocular field of view, which lays the foundation for subsequent stereoscopic display.

B. Plane Digital Model Structure

The purpose of computer-aided art design is to better serve the needs of human art design, and the humanization and intelligence of the digital model of art design is the most ideal embodiment of service quality. At present, computer-aided art design simply combines the existing intelligent technology with related software technology, and combining computer technology with artificial intelligence to improve the auxiliary function of computer technology in art design is the inevitable development of computer-aided art design in the future trend. Art design is the intersection of disciplines and aesthetics in various fields. In the future, the areas covered by digital models of art design will become wider and wider with the continuous improvement of the level of science and technology (Figure 2). This requires designers not only to be professional in artistic skills but also to have knowledge of more disciplines, such as ecology, materials science, architecture, psychology, etc. For example, if designers need to use computer-aided software to create a virtual ecosystem, they must understand the science of mutual concern between organisms and the surrounding environment, that is, ecology. Therefore, the integration of multidisciplinary knowledge from plane to space is one of the future development trends of computer-aided art design digital models.

Compared with traditional art design, computer-aided designers can directly see the design effect model at the beginning of the design, allowing multiple design schemes to be selected, greatly increasing selectivity, and allowing the design scheme to be edited again at any time.

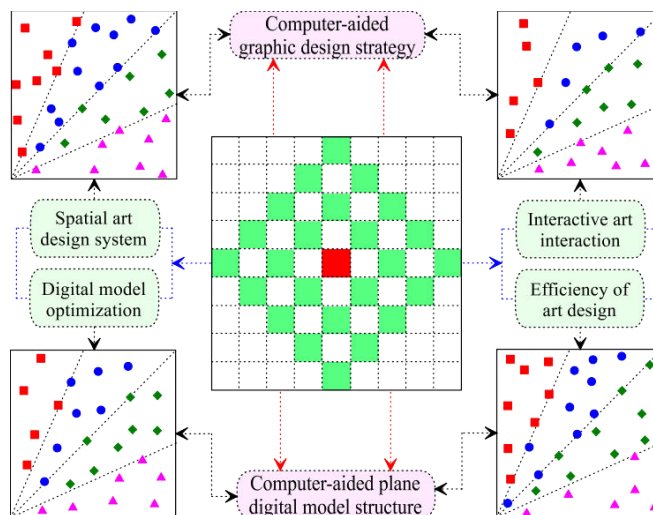


Fig 2: Plane digital model structure of computer-aided graphic art design.

Designers can establish initial digital models according to customer needs in the early stage, and then modify and adjust according to customer needs, greatly saving design time and shortening the design process. Compared with the plane digital model of a photo, computer-aided design technology can show objects that can be directly observed more realistically and can also reflect the digital model imagined by the designer to the greatest extent. Computer-aided design can be created in both plane and space at the same time, more vividly and beyond the objects that people have ever imagined. Designers can use their imagination to the fullest according to their own needs and directly generate various highly creative visual images in font design or graphic processing. The digital model can also record the drawn graphics into the computer through various technologies and then apply a variety of methods to perform various special processing, so as to produce unique creative and breathtaking picture effects. Computer-aided design also provides a wealth of expression techniques in drawing graphics. It can imitate the effects of oil painting, watercolor painting, mural painting, and it can also imitate other painting techniques that cannot express and cannot exist in the real world. The manifestation creates a mythical realm that combines reality and fantasy, often creating effects that photography cannot achieve. In art design, text is an important carrier of transmitting information and the most basic medium of art design. The designer often spent a lot of time on the training of writing fonts, and ultimately often failed to express the creative content of the design work. The application of computer-aided design in art design in terms of text, graphic objects, painting, color, etc., has broken through the limitations of previous art design techniques, design methods, and design thinking. The rapid development of computer hardware in recent years and the continuous improvement of related software have provided designers with unprecedented convenience and speed. Coupled with the popularization and development of supporting equipment such as laser scanning, color printing, and digital imaging, computer-aided design has become more widely used in art design.

III. DIGITAL MODEL OF COMPUTER-AIDED SPATIAL ART DESIGN

A. Spatial Art Design System

The real-space digital model of artistic design is to construct a real digital model of artistic design space according to the actual spatial geographic coordinates of the object. The real-space digital model of artistic design can accurately measure the spatial and spatial coordinates of the structure according to the large-scale computer-aided digital method. The structure model of the object is automatically generated by the software, and the corresponding texture is attached to it. Then the result is converted to the next level of computer-assisted matching, centering on the matched point pair, and the points in its neighborhood are matched (Figure 3). Computer-assisted processing advances to the first layer, selects another point in the neighborhood of the matched point in this layer, performs matching, converts the result to the original computer-assisted stage, and repeats the previous process until the first matching point of the first layer has processed all the points in the neighborhood. From the perspective of computer assistance, without affecting the visual effect, only considering that the light emitted by the light source is white light and the object is an opaque body, the designer proposes an illumination model, and the color of the object surface is determined by the reflected light.

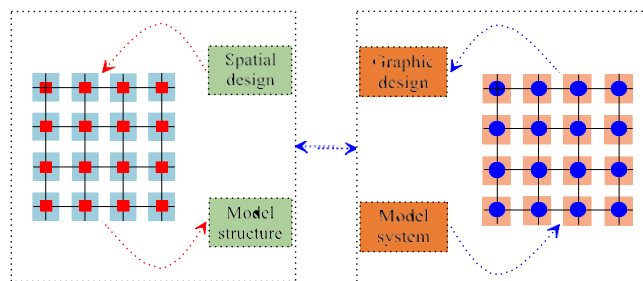


Fig 3: Spatial art design system of computer-aided spatial art design.

The existing digital model of space is mainly obtained through scanning by space scanning equipment and artistic design using spatial art design software. Scanning the digital model of space in reality through space scanning equipment involves complicated operations and low precision. Additionally, spatial art design software is vast, with complex functions requiring professional knowledge to generate high-quality models. These factors make it difficult to obtain computer-assisted digital models, resulting in a limited number of models and a lack of diversity in digital models generated based on spatial digital models (Figure 4). Despite advances in computer-assisted modeling, both space-scanning equipment and software have their limitations. Space scanning equipment can capture data from real sculptures, but the accuracy may be insufficient, particularly for large models. Similarly, digital modeling software offers high functionality but requires skilled professionals to operate it effectively. Therefore, digital model generation based on space models is often restricted by the limitations of the space model itself and may not always meet user-specific requirements. Furthermore, the operation of space models is typically more complex and time-consuming than plane-based models.

B. Spatial Digital Model Optimization

From a computer-aided perspective, establishing the application of digital models for studying art design in visual communication design is crucial. This means moving beyond the purely two-dimensional form of art design to explore spatial forms with multiple perspectives, rich connotations, and diverse presentation methods. Such an approach enhances the application of spatial forms of art design in visual communication, providing viewers with stronger visual impact and enriching design methodologies. Due to the rapid evolution of art design, designers have often overlooked the development and utilization of digital models, focusing solely on two-dimensional forms while neglecting three-dimensional and immersive representations. The use of computer assistance can address this gap by enhancing spatial design, leveraging the beauty of both positive and negative space, and creating profound visual communication effects. The broad application of spatial digital models has expanded artistic expression, allowing designers to transcend traditional planar limitations.

As a fundamental aspect of artistic design, computer-aided composition plays a pivotal role in integrating creativity with technical execution. Designers inject cultural essence into their work while leveraging technology to enhance content and structure. The fusion of art and digital models has significantly influenced cultural and creative industries, bringing artistic design closer to everyday life (Figure 5). Contemporary trends indicate that integrating regional cultural characteristics into digital modeling—through extraction, decomposition, reorganization, and reconstruction of abstract elements—can create compelling visual representations. This approach blends traditional cultural heritage with modern digital advancements, enhancing the aesthetic and conceptual depth of artistic designs.

In digital modeling, colors cannot exist in isolation; they must be harmonized with shape, space, location, and texture. Digital models incorporate color composition into various designs, enhancing visual appeal and making products more distinctive. Text, graphics, and colors are fundamental

elements in graphic art design. When processed effectively, they interact dynamically, reinforcing each other's impact. Graphic and image software enables seamless text integration into artistic compositions, allowing for artistic manipulations that enhance visual appeal.

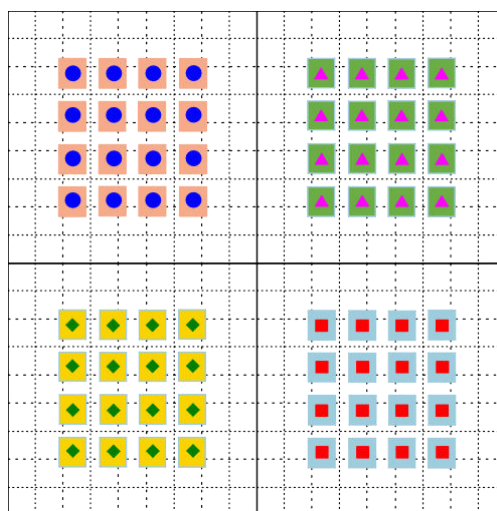


Fig 4: Spatial digital model optimization of computer-aided spatial art design.

IV. DISCUSSIONS

A. Accuracy of AI-Powered Assistants

Since art design is a graphic design process, designers only rely on the horizontal, vertical, and depth-related design data of the digital model to evaluate the rationality of the model. However, this approach is not intuitive and makes it difficult to compare different digital model design plans quickly. From the cross-section data, the horizontal distance and height difference of each feature point on the cross-section relative to the midpoint of the model are calculated. Once the coordinates and elevation of the center point of the model are determined, they form the feature point data of the section of the road models. When a structure needs to be added to the computer-aided space scene, the system will directly load the corresponding model from the model library and set the model position, zoom ratio, and other attributes according to the parameters in the design data to realize an integrated structure model (Figure 6). The visualization of spatial model data is key to practical applications. In a visualized environment, designers can analyze the surrounding environment of the digital model, both holistically and in detail, enabling a better grasp of model design quality and improving operational efficiency. After processing by simplification, data scheduling, perspective transformation, blanking processing, lighting simulation, and texture mapping, the space visualization scene of the artistic design digital model is created.

Computer-aided design is the process of applying computer software to draw and simulate physical objects, enabling designers to create, analyze, and visualize their work. The use of computer-aided design in art design enhances efficiency, accuracy, fault tolerance, and the extensibility of the digital model. Computer-aided design allows designers to store design drafts and samples at any time, facilitating easy retrieval and modification. For example, advertising and other art designs often require multiple revisions. Traditional hand-drawn methods are time-consuming and error-prone, as mistakes necessitate starting over. In contrast, computer-aided design software offers fault tolerance, allowing designers to restore previous steps, adjust colors and contrast, and make modifications as needed without losing prior work.

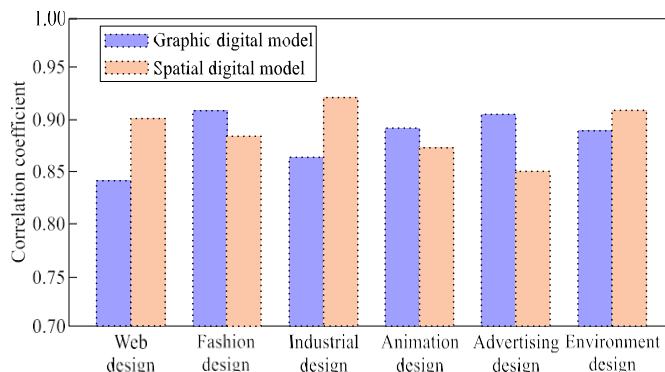


Fig 5: Interactive range interaction between design and calculation in six typical art design fields.

Computer-aided design empowers designers with unlimited creative possibilities. By leveraging graphic information databases, designers can access materials and create innovative designs through digital manipulation. The use of computer-aided tools in art design is primarily driven by design software, network resources, and art materials. Compared to traditional methods, computer-aided art design is better suited to modern needs, offering multimedia integration, high-speed processing, and unique effects that cannot be achieved manually. Additionally, digital tools minimize transmission errors in design execution, enhance creative freedom, and extend artistic possibilities beyond previous limitations. By simulating real-world modeling conditions, designers can make informed adjustments and optimize their work for better market adaptability and client satisfaction.

B. Association Between the Graphic and Spatial Digital Model

When a designer completes a task requiring computer assistance, the efficiency and effectiveness of the tool are critical to user experience. In modern software development, designers aim to balance learning difficulty with usability. Powerful software tools often require significant learning time due to their complexity. However, learning cost can be mitigated through user-centered design principles, making the interface intuitive while maintaining advanced functionalities. The practicality of digital models is evident in their ability to cater to contemporary design needs. Unlike traditional hand-drawn techniques, digital models integrate multiple layers of data, enhancing the visual representation of artistic concepts. The complexity of digital modeling operations includes both the number of required steps and the fluidity of user interactions. Research has shown that increased functionality often correlates with higher learning costs. This challenge can be addressed in two ways: (1) by refining task-centered design methodologies that simplify operations based on user needs, and (2) by offering adaptive learning tools within the software to guide users efficiently. Traditional hand-drawn works require meticulous redrawing in case of errors, which is time-consuming. In contrast, computer-aided design enables quick modifications and iterative enhancements, significantly improving workflow efficiency.

The continuous development of computer technology and digital modeling has revolutionized the art design industry. Compared to traditional hand-painted methods, digital tools offer speed, flexibility, and realism, providing designers with unparalleled creative potential. While computers enhance design capabilities, they should be used as a complementary tool rather than a replacement for human creativity. Successful designers integrate fundamental artistic principles such as composition, color theory, and aesthetics with digital tools to achieve the best results. Over-reliance on automated effects without a solid artistic foundation can lead to generic or uninspired designs. Computer-aided art design has numerous advantages over traditional methods, improving design quality and efficiency. By utilizing digital modeling software, designers can focus on the creative process rather than technical constraints. The ability to visualize and modify spatial designs in real-time allows for a more interactive and immersive experience. Unlike traditional methods, which rely on static two-dimensional representations, computer-aided design facilitates dynamic exploration of three-dimensional spaces.

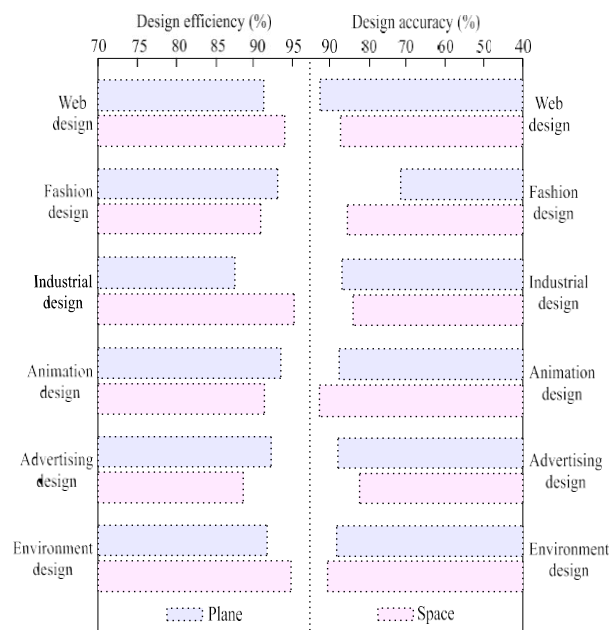


Fig 6: Association between the graphic and spatial digital model in six typical art design fields.

The development of space modeling has significantly advanced artistic design capabilities, allowing for real-scale virtual environments. With real-time visualization, designers can experiment with different configurations and instantly assess their impact. Furthermore, digital modeling promotes collaboration, enabling multiple designers to contribute to a shared workspace from different locations. This interconnected workflow enhances communication and accelerates the design iteration process. One of the most transformative aspects of computer-aided space design is the simulation of real-world environments. Advanced rendering techniques enable accurate light and shadow effects, providing designers with a true-to-life preview of their projects. Additionally, computer-assisted tools allow for precise scaling, ensuring that all design elements are proportionally accurate. The ability to test different lighting conditions, textures, and spatial arrangements enhances the overall quality of the design. In conclusion, the integration of digital modeling in art design offers unprecedented opportunities for creativity and efficiency. While traditional artistic skills remain invaluable, leveraging computer-aided design tools empowers designers to push the boundaries of their work, creating visually compelling and technically refined outcomes.

V. CONCLUSIONS

This paper proposed the digital model of computer-aided graphic art design including art design strategy and digital model structure, analyzed the digital model of computer-aided spatial art design including art design system and digital model optimization, and discussed the interactive range interaction between design and calculation and the association between the graphic and spatial digital model. The real-space digital model of artistic design can accurately measure the spatial and spatial coordinates of the structure according to the large-scale computer-aided digital method. The structure model of the object is automatically generated by the software and the corresponding texture is attached to it. Since art design is a graphic design process, designers only rely on the horizontal, vertical, and horizontal design data of the digital model to evaluate the rationality of the model, which is not intuitive to achieve rapid comparison of different digital model design plans. In the process of introducing computer applications, the digital model of art design also introduces the professional knowledge of art design in more detail, so that designers can understand the principles of art design and the laws of design art, and apply them to computer-aided design. The analytical results show that, in the process of introducing computer applications, the digital model of computer-aided art design can also introduce the professional knowledge of art design in more detail, so that designers can understand the principles and patterns of art design and can apply them to computer-aided designs, having greatly improved the efficiency and quality of art design, extended designers' thinking, and then developed a digital model from plane to space. The study results of this paper provided a reference for

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