

Application of 3D printing technology in the production of modern complex structure sculpture¹

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Abstract. The development of the information age has brought the digital technology to the artistic creation. 3D printing is usually achieved by the use of digital technology printer, often used in mold manufacturing, industrial design and other fields to be used in the manufacture of models. In view of this, the music teaching mode based on the computer platform was studied and analyzed in this paper. Firstly, the sequential methods and fuzzy comprehensive evaluation methods in the production of modern complex structure sculpture based on 3D printing technology were analyzed. Then the 3D printing was compared with the traditional printing, and the sculpture production process of 3D technology was analyzed. The results show that the 3D printing technology is helpful to the sculpture creation writer who can design the sculpture which is more in line with the modern aesthetics.

Key words. 3D printing technology, modern complex structure, sculpture, production.

1. Introduction

In the history of mankind, the development and progress of science and technology will always affect and even change the field of art. Since modern times, the rapid development of science and technology and the expression of the forms and creative means of art are also constantly enriched and improved. A series of industrial revolutions in modern history have promoted the rapid development of computer and network communication technology, and the computer and the network have become an indispensable part of human life [1]. Computer technology has been involved in almost all areas of human production and life, which has brought great changes to not only the society, but also the field of art, and it has also brought new art forms and creative means to the field of art. Digital art is a new art form that is produced by the application of computer technology in the field of art [2].

Digital art has been integrated into and even replaced some of the traditional art design techniques. Among them, applications of the three-dimensional modeling

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design in three-dimensional video effects, three-dimensional games and animation show a wealth of artistic expression, which has brought opportunities for the sculpture art to enter a virtual space [3]. Art creators use 3D printing technology to realize the reproduction and simulation of the sculpture material, texture and space in the virtual space [4]. In addition, by increasing the contrasts of backgrounds, space environments, sounds, animations and other effects, the digital technology brings us new visual experiences and feelings, which cannot be achieved if we only depend on the traditional technology [5].

The remainder of this paper is organized as follows. In the second chapter, the author briefly introduced the requirement analysis and the related content of the 3D printing technology in the creation of the modern complex structure sculpture. The third chapter introduced the research method, sequence analysis and fuzzy comprehensive evaluation of the 3D printing technology in the production and application of modern complex structures. In the fourth chapter, the 3D printing technology and the traditional printing technology were compared, and then the production process of modern complex structure sculpture based on 3D printing technology was analyzed. Finally, the fuzzy comprehensive evaluation and analysis of the modern complex structure sculpture products based on 3D printing technology were made. The fifth chapter was the conclusion.

2. State of the art

2.1. The demand analysis of 3D printing technology in the creation of modern complex structure sculptures

From the rigorous mathematical logic of the computer, human beings have calculated the points, lines and surfaces that conform to the human aesthetics, which is changed actively, and it can change them within the scope of their ability too [6]. For example, scientists have invented three-dimensional digital software based on mathematical principles [7], so the most complex computing programs have been become the most basic visual elements, so as to meet their own aesthetic rules. The digital technology based on computer can achieve the traditional aesthetic principles in the virtual space [8].

The needs of sculpture creations of 3D printing technology are shown in the following two aspects: firstly, in the usual practice of sculpture creation. By using the three-dimensional model of computer sculpture, it can be marked at any time on the model, so as to get a clear structural analysis, and it can continue to withdraw and move forward at the same time, which is the function that the traditional sculpture cannot achieve [9]. Secondly, in some large-scale sculpture creations, it needs to enlarge the model according to the small draft [10]. In the real world, there are some errors in the data of the scanning model, which cannot reach the precision requirement of large-scale projects. But in the model of the software, its data is very accurate, which can be guaranteed by the proportion of size, so as to enlarge the accuracy of the size [11].

2.2. The creation method of 3D printing technology in the creation of modern complex structure sculptures

In the digital age, the virtual space of the computer is more likely to be appreciated by people. Under normal circumstances, due to the environments, spaces, locations and other restrictions, people cannot be based on their own needs to make specific multi-angle observations. Virtual simulation technology based on the computer can solve this problem, and in this virtual space, people can experience the visual experience they want [12]. The performance of virtual creations means that we can use three-dimensional computer software to easily simulate the objective world in the virtual world, which even can not only reproduce the complex structure of the ancient Greek, but also present the simple structure of the industrial structure. Computer has opened the window with special significance for art, which makes the art form enter another space level, showing the true reproduction of material of the space [13], see Fig. 1.

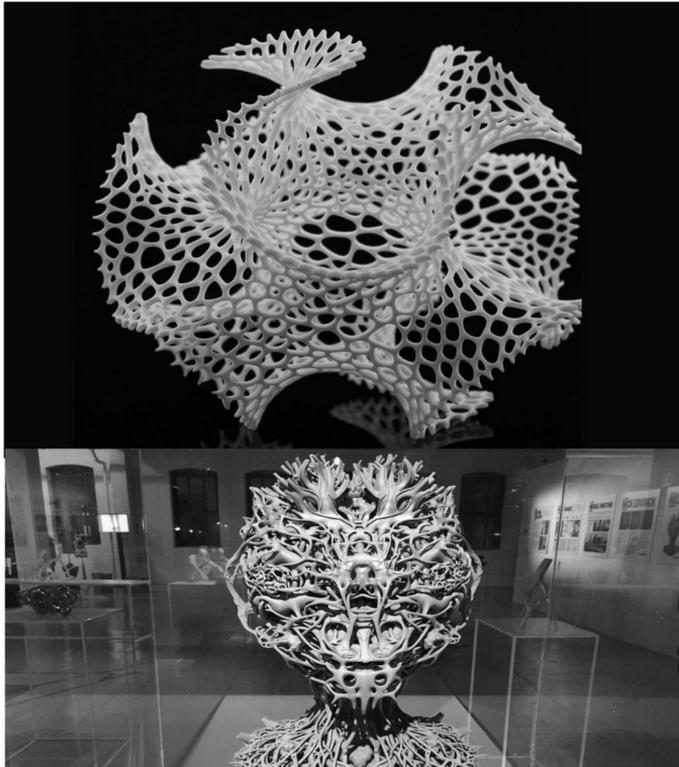


Fig. 1. Creation of the modern complex structure using 3D printing technology

The creative thinking and the thinking of software influence each other, so that the artistic creation activities can get a higher level [14]. The efficient performance means that in order to preserve the authentic social life of ancient times, the artists use reproduction to obtain the preservation of works of art, which is the earliest

way to implement a simple and unaffected hand copy. Hand-copied things will be different from the original object, which is caused by the manual labor error and the shape and material of the object.

3. Methodology

3D digital sculpture is regarded as a new discipline with science and art, and it has a broad space for development. At present, with the rapid development of science and technology, the plastic material and equipment have been improved, so the sculpture community has been formed from three-dimensional engraving software to 3D fast-printing equipment, which is a complete industrial chain. The production processes of the modern complex structure sculpture of 3D printing technology are: firstly, the design of the modern complex structure sculpture will obtain the unity and change, the symmetry and balance, the contrast and harmony, the proportion and scale, the rhythm and cadence and other design knowledge. According to their different structure forms, they will be put in different knowledge bases, and the basic information database of the complex structure will be perfected, and according to the type of the product structure, we will search its corresponding structure design styles. Then the design style is combined with 3D printing technology, and then according to the characteristics of sculptures we will make fine adjustments. Therefore, the design block diagram of the modern complex structure of the 3D printing technology is as follows (see Fig. 2):

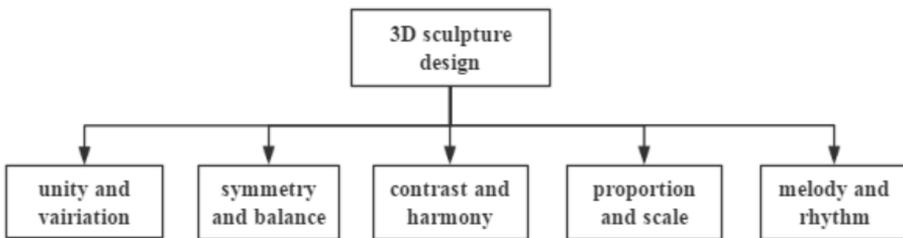


Fig. 2. Design block diagram of the modern complex structure of the 3D printing technology

Due to the design of modern complex structure sculpture works, we start from the production business requirements to determine the elements and contents of the sculpture structure design. Therefore, the design sequences of the modern complex structure sculpture works have certain influences on the effects of the finished products. Sculpture works of modern complex structure are divided into a number of design patterns. First of all, we will finish the results of the design of the color of the complex structure and the three-dimensional structure, then based on the results of the analysis, each color and space structure have their own corresponding conveying effects. According to the requirements of the design goal of the sculpture, we can obtain the visual effects of the image, colors, structures and other sequences, so as to get the corresponding designs and carry out the 3D print tasks.

Digital technology has been introduced into the process of sculpture by some artists; however, most of the researches and attempts at present are to combine the 3D scanning technology with the 3D printing technology or the digital engraving technology and 3D printing technology. And the studies on the comprehensive utilization of the three are still relatively rare, especially in the recreation of the sculpture digital model. In order to combine the three kinds of digital technologies, the key lies in how to convert the 3D model data acquired by 3D scanning to the model data that can be used to meet the needs of digital engraving technology.

In addition, this paper applies the method of fuzzy comprehensive evaluation to make quantitative evaluations on the comprehensive factors (unity and change, symmetry and balance, contrast and harmony, proportion and scale, rhythm and cadence) that are involved in the modern sculpture works of 3D printing. In order to obtain the accurate evaluation information of the modern complex structure sculpture of 3D printing. Here, we can use a set to show the representation, and then we carry out the quantitative analysis: (r means every factor of 3D printing technology)

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{pmatrix}. \quad (1)$$

Among them, the most representative is 3D printing technology, which extends the creation means of sculptures to the three-dimensional virtual space of the computer. So the creation of sculptures and the sculpture art break away from the limits of materials, and the 3D modeling in virtual space enters the real world, which is shown by the solid material. Among them, the modern digital graphic design is based on the visual communication can be expressed by the decomposition of the logic function, and each decomposition is determined by a set of sub function factors. In this way, as long as the sub function is known, the logical function can be determined. The sub function and decomposition of the logical function are defined as follows: (x means the evaluation factor)

$$f_c = f(x_1, x_2, \cdots, x_{i-1}, c, x_{i+1}, \cdots, x_n). \quad (2)$$

4. Result analysis and discussion

4.1. Comparison of 3D printing technology and traditional printing technology

In this experiment, the sculpture manufacturer in Guangdong Province was taken as the study sample, and the comparative study on the design of the complex structure of the three-dimensional space of the traditional print design and 3D printing technology was made. The contents of the score included the color, the balance, the symmetry of the structure and the novelty, and the color and balance had 20 points, the symmetry and novelty of the structure had 40 points, and the results are shown in Table 1.

Table 1. Comparison of 3D printing technology and traditional printing technology

	Sub item	Total score	Grade
Sculpture design of 3D printing technology	Color and balance	40	34.7
	Symmetry of structure	30	24.9
	Novelty	30	23.6
	Total score	100	83.8
Graphic design of traditional printing technology	Color and balance	40	31.3
	Symmetry of structure	30	24.6
	Novelty	30	22.5
	Total score	100	78.4

Through the above table, the comprehensive score of 3D printing technology products was higher than the graphic design products of traditional print technology. This showed that compared with the traditional plane printing technology, 3D printing technology had better display effects, and the combination of 3D technology and digital art included not only the visual and auditory art, static and dynamic model art, but also the 3D art and graphic art, and the 3D printing technology included the points of traditional plane printing technology. More and more artists begin to use the computer to make virtual sculpture, and the sculptor can not only design the shape of sculpture by using the computer software, but also simulate the space environment of the sculptures, so as to get better display effects.

4.2. Production of modern complex structure sculpture based on 3D printing technology

The first step of 3D printing process is to use the 3D modeling software, such as AutoCAD, ProE and other computer vector modeling software or reverse engineering reconstruction software to make digital editing on the targeted products, so as to print the "original manuscript". Subsequent use of the same 3D printer driver which is regarded as the layered slice software will be built into a number of 3D digital models with the thin layer, and the thickness of each layer depends on the properties of the spraying materials and 3D printing precision, which usually is in ten micrometers to hundreds of micrometers. After the completion of the preparation work, it will enter the printing process, and according to the different characteristics of the printing products, it can choose different printings. After the completion of the printing, it also needs to print out the 3D model for post processing. The production processes of modern complex structure sculpture based on 3D printing technology are shown in Table 2.

This is what we call the software thinking, which affects the creative thinking of

the artist in a certain extent. This effect produces two interactive processes: the active exploration of the creator; the new thinking of the creator brought by the software. The performance of interactive creations is to generate a variety of other shapes by using the digital computing of the software, and the sculptor will refer to this style, which can bring inspiration to the creators and stimulate the creative and active creations. Secondly, in the use of computers for sculpture creations, it will produce many unexpected and good art forms, and these form are usually in the scopes of thinking that are unimaginable for the sculptor.

Table 2. Production process of modern complex structure sculpture based on 3D printing technology

Data acquisition and processing of the sculpture model	Scanning sculpture model
	Point data processing
Processing 3D model scan data	Using 3D technology to obtain low modulus
	Mapping model
	Two sculpture creation
3D technology will produce sculpture works	Model slice
	Print model

4.3. Fuzzy evaluation of the modern complex structure sculpture products of 3D printing technology

In this experiment, we took the modern complex structure sculpture products in Guangdong Province as the research sample, and the effects of complex structure sculpture were divided into five levels. At this time, the evaluation factors and the fuzzy relations between the set of comments can be represented by using the evaluation matrix, and the evaluation factors set = (unity and change, symmetry and balance, contrast and harmony, proportion and scale, rhythm and cadence). The evaluation grade set = (the ultimate expression of the modern digital theme, the better expression of the modern digital theme, a part of the expression of the modern digital theme, less expression of the modern digital theme, far away from the modern digital theme), and the fuzzy evaluation form of the modern complex structure sculpture products of 3D printing technology is shown in Table 3.

Since we knew that it is the kind of duplication precisely that makes the ancient art become more primitive and unique. Because the digital technology itself has the function of data storage and saving, so it is convenient for the creators to observe the previous model in the creation of the similar art works, and through the adjustment and modification, people can accelerate the work efficiency of the creator. The following figure is the creation of the modern complex structure of 3D printing technology. So digital sculpture and traditional sculpture follow the principle of common aesthetics, and it is very important to introduce the former to the latter [15]. In the information age, the computer technology gives infinite possibilities to

the art and makes its creation and expression forms have diversified tends. In the art of sculpture, the three-dimensional digital software technology is involved, so that the sculpture with a new face is shown in front of everyone

Table 3. fuzzy evaluation form of the modern complex structure sculpture products of 3D printing technology

Evaluation factors			Evaluation level				
			Ultimate expression of the modern digital theme	Better expression of the modern digital theme	Part of the expression of the modern digital theme	Less expression of the modern digital theme	Far away from the modern digital theme
Unification and change	0.11	0.5	0.2	0.2	0.1	0	
Symmetry and equilibrium	0.13	0.5	0.2	0.1	0.2	0	
Contrast and harmony	0.16	0.3	0.2	0.4	0.2	0	
Proportion and scale	0.18	0.4	0.3	0.2	0.1	0	
Rhymes and rhythms	0.20	0.4	0.3	0.1	0.2	0.1	

From Fig. 3, in the fuzzy evaluation results of the modern complex structure sculpture product of the 3D printing technology, the ratio of the ultimate expression of the theme of the modern digital reached 50%, especially in the unity and change and the symmetry and balance. In contrast and harmony and scale and scale evaluation, the ultimate expression of the theme of the modern digital reached more than 30%. Overall, in modern complex structure sculpture products of 3D printing technology, 70% of the 3D printing products in the symmetry and balance, unity and change had the ultimate expression of modern digital theme, and the design that can express the theme of modern digital theme was more than 80%, and only 10% of the modern digital graphic design in the scale and rhythm deviated from the modern digital theme. Thus, 3D printing technology was helpful to improve the unity and change, symmetry and balance, contrast and harmony, scale and rhythm of the modern digital complex structure sculpture products.

5. Conclusion

The sculpture is the use of different plastic materials through the method of carving, so as to create the artistic image that has a sense of volume, and it also can be seen and touched, which can map some social phenomenon or express the aesthetic and emotion of individual artists. Digital sculpture is a small branch of digital art.

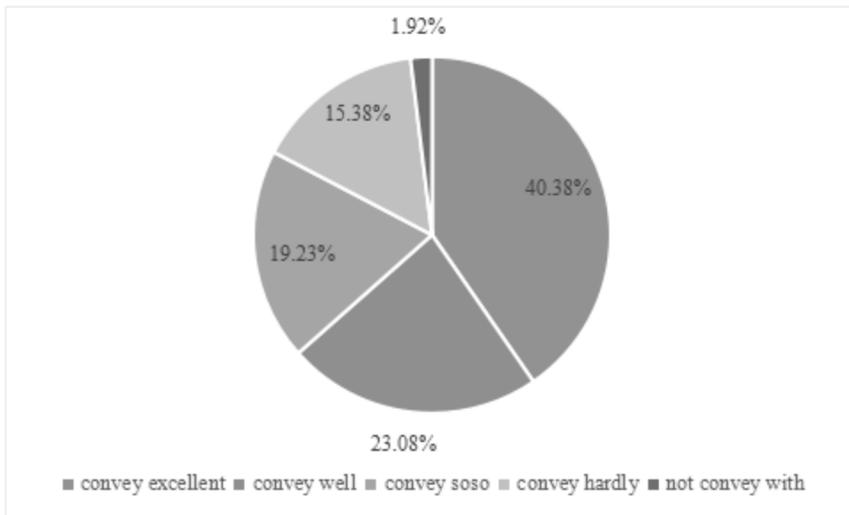


Fig. 3. Effect statistics of the modern complex structure sculpture product of 3D printing technology

Digital sculpture is the combination of 3D printing technology and traditional engraving art, which uses computers for artistic creation. Digital sculpture, as a newly emerging subject of art and science, has wide development spaces and application fields.

The research on the application of 3D printing technology in the production of modern complex structure sculpture was divided into three steps. Firstly, the sequential methods and fuzzy comprehensive evaluation methods in the production of modern complex structure sculpture based on 3D printing technology were analyzed. Then the 3D printing was compared with the traditional printing, and the sculpture production process of 3D technology was analyzed. From the experiment what can be obtained was that the 3D printing technology fitted the actual characteristics of the modern digital technology, which was conducive to bringing new thinking inspirations for complex sculpture designs, and it could inspire the creation of the sculptor.

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