The organic form of Thai plants: ceramic creation based on 3D printing technology

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Abstract

This article investigates the organic forms of Thai plants based on 3D ceramic printing technology. Using Thai plants as samples, the article explores the artistic characteristics of organic forms using the tools of 3D ceramic printing technology combined with manual creation and studies the application characteristics of the technology. The article summarises the artistic characteristics based on organic forms with vessel modelling characteristics and parametric features through practice combined with theory. The article summarises the advantages and technical limitations regarding the industrial reproduction of 3D ceramic printing technology and proposes corresponding solutions.

Keywords: The Organic Form of Thai Plants; Ceramic Creation; 3D Printing Technology

Introduction

1. Plants of Thailand

Thailand is located in the south-central part of the Central South Peninsula, bordering the Gulf of Thailand in the southeast, the Andaman Sea in the southwest, Cambodia in the southeast, Myanmar in the northwest, Laos in the northeast, Malaysia in the south, and China's Yunnan Province in the north, the northern border is only about 150km away. Thailand is located in the tropics, and the climate can be roughly divided into two types, the Chumphon Province north of the tropical monsoon climate, the whole year can be divided into the dry season, the rainy season, and obviously, the cool season. The peninsular area south of Chumphon Province has a tropical rainforest climate, with no distinction between rainy and dry seasons and relatively uniform rainfall throughout the year (Ximu, 1995: 115). The favourable natural conditions have given birth to the vast forests and rich plant species in Thailand. When the author was studying in Thailand, field trips were made to various plants and gardens in Thailand, and the feeling was profound, so the author used Thai plants as inspiration for his creations.

Thailand has a species-rich and complex biodiversity that differs in various parts of the country. Based on the forest inventory projects and the specimens from the Forest Herbarium there were all together 5048 occurrence records of 733 species from 90 families and 323 genera (Yongyut, 2002: 1109). Considering the scope of this study, the author visited the Queen's Garden Plants of Chiang Mai, which is rich in species and types, concentrating more than 700 species of plants from Thailand and around the world. Most of them originated from within tropical families and genera, which is in line with the local natural ecological environment. Broad-leaved evergreen species are dominant, with fewer coniferous species, in line with the local natural vegetation type. Among them, there are more plants of Palmaceae, Asparagaceae,

* Received: November 27 2023; Revised: December 27 2023; Accepted: December 28 2023

Mulberry, Agave, and Euphorbiaceae. Cultivated and horticultural species such as hibiscus, foliage flowers, lobelia and fuchsia are included (Jun and Guoyong, 2012 : 60).

The traditional definition of phytolandscaping is: "The use of trees, shrubs, vines, and herbs to create a landscape that mimics the structure and characteristics of the native natural plant community and to create a rational artificial plant community. In natural plant communities, trees, shrubs and herbs are not scattered in a jumble but are arranged and combined according to their own specific patterns, showing certain characteristics of community morphology. In Thailand, you can find gardening designs with palms, coloured flowers and lawns everywhere. The flowers and foliage of plants are often used as decorative motifs in works of art. As shown in Figure 1, the chrysanthemum petal pattern in Thai ceramics of the 15th and 16th centuries is often centred on the heart of the flower, surrounded by curvilinear petals, with the chrysanthemum as a whole in the form of a spiral. The whole chrysanthemum flower is shown in a spiral shape, which is a representation of sensual beauty full of vitality and dynamism. In contrast to the Chinese chrysanthemum pattern of the same period, which is concerned with straight-line geometric rules, rationality and regularity, it presents different characteristics, forming a unique feature of Thailand (Wenke and Yan, 2021: 94).

Figure 1 Underglaze black bowl with chrysanthemum
Source: From Southeast Asian Ceramics Museum

2. Ceramics Exchange between China and Thailand

Thailand introduced Chinese ceramics in large quantities during the Tang and Song dynasties in China. Thailand's local ceramic artisans, with the help of Chinese artisans, set up kilns in Thailand's Sukhothai and Songkhlaos regions, in Thailand to promote the traditional Chinese ceramic culture, not only to promote the development of Thailand's ceramics but also to deepen the cultural exchanges between the two countries. Thai ceramics in the 14th century, the rapid development of ceramics, ceramic styles and decorative varieties are very rich. In the

absence of Chinese ceramics in the 15th century, to meet the demand for ceramics in Southeast Asia. Thai ceramics during this period in Southeast Asia in a leading position.

3. Ware modelling in ceramics

Ceramics have both practical and decorative attributes, and vessels are the functional use of ceramics. Looking back at the development of traditional ceramic vessels, their shapes range from simple to complex, from meaningless to symbolic, reflecting the material life and spiritual world of the ancient people. Traditional Chinese figurines have also had a great influence on Thai ceramic vessels. In ancient China, ceramic vessels were created by simulating plants, people, animals or other natural scenes (Song et al., 2023: 108). As shown in Figure 2, in ceramics production, the traditional handmade methods such as "billeting", "panning clay strips", and "moulding clay slabs" are also in line with the laws of object modelling. That is, large-scale conforms to the whole, regular, hollow, upward modelling trend. Given the way ceramic 3D printing is characterised, the author's creation draws fully on the characteristics of this type of ware modelling.

Figure 2 Ceramics made with panning clay strips and 3D printing
Source: From the author

4. The use of plant bionics in the design of daily-use ceramics

There is a wide variety of ancient pottery, which appeared with the settlement of the Neolithic period. Primitive porcelain appeared during the Shang and Zhou Dynasties, with a long history of cultural inheritance, followed by the Qin, Han, Sui, and Tang dynasties, and then by the Song Dynasty, when the porcelain atmosphere became increasingly sophisticated. There is also no lack of works that approximate some of the natural forms of the bionic works, take Ru Kiln, the first of the five famous kilns in the north of the Song Dynasty, as an example. The Ru kilns, like the Ding kilns and the Jun kilns, were made for the Song court, but very few of them have survived, so they are especially rare. The Ru kilns were heavily influenced by the Yue kilns and the Yaozhou kilns, and some of the decoration was inherited from their ticked and engraved lotus petal motifs. The glazes of the Ru Kiln come in a variety of colours, including sky blue, moonlight white, azure, pea green, and so on. The Ru Kiln Lotus Warming

Bowl is a wine-warming vessel that takes its name from the lotus flower's symbolism of purity and purity from sludge and mud. As shown in Figure 3, the bowl is carved in the form of a lotus flower, which appears to be in full bloom and wrapped around and is used as a wine holder for warming wine, with smooth and gentle lines and a fresh and elegant glaze (Xueyan and Jianmin, 2022: 107).

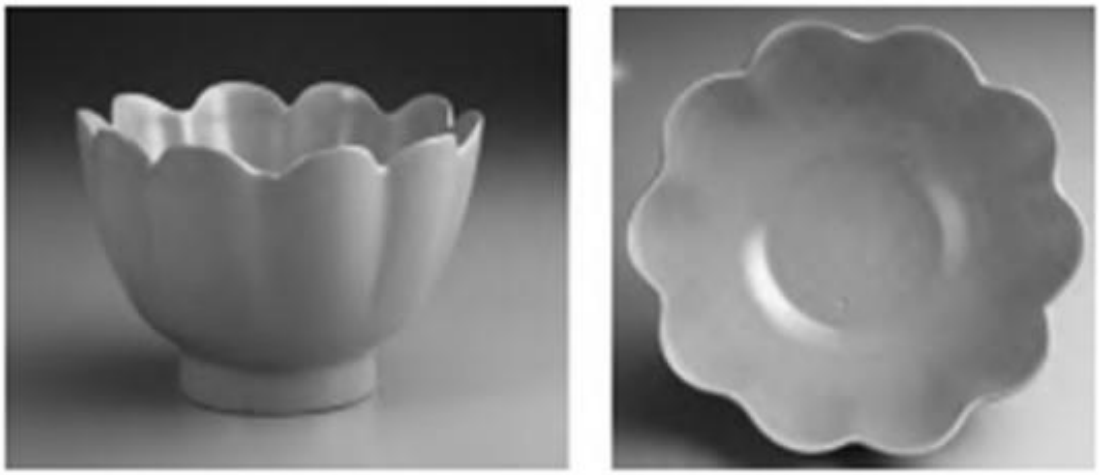

Figure 3 The Lotus Warming Bowl
Source: From Bionic Design by Nina Sun

5. Status of ceramic 3D printing

3D printing technology, also known as "additive manufacturing technology", different technologies corresponding to the production process are more or less the same. Ceramic 3D printing has been deeply applied in the medical and architectural industries. At this stage, the type of technology has been industrialized light curing moulding technology (SLA, Stereolithography Apparatus), selective laser sintering powder bed layup SLS (Powder-based SLS), three-dimensional printing moulding (three-dimensional printing, 3DP), Laminated Object Manufacturing (LOM) (also known as layered solid manufacturing technology), etc. (Cao et al., 2022: 82). Mainstream 3D printing has advantages such as high precision, large size, and ease of operation. Hospitals and, the transportation industry of high precision materials need to use some advanced instruments, for commercial use, which require safety and other necessary high standards. As far as ceramic art is concerned, advanced instruments are not needed, but rather constraints. According to the author's creative ideas and ceramic process characteristics, choose the extrusion type 3D printing equipment for creation, also known as direct ink writing DIW. The advantage is that the process and equipment are simple and easy to realize; do not need laser and other high-energy output consumption, so less energy consumption, low cost; the disadvantage is that the moulding accuracy is low, the paste is not easy to save and other issues remain to be resolved. In the field of ceramic design, ceramic 3D printing has been a lot of commercialization cases, mostly some mass production of small and medium-sized vessels, such as vases daily decorative necessities. Ceramic 3D printing technology in the traditional industry chain, reducing the opening of moulds and other processes, can be more strict control of manual errors, in the subsequent firing process is also more stable, in terms of efficiency and yield rate has been greatly improved, with greater

capacity. The disadvantages are limitations in style, product accuracy, and size, and the need to transfer reduced labor to routine machine operation and maintenance.

Research Objective

1. What are organic forms?

An organic form is a three-dimensional form in space that is animated. It can also be seen as a further development of bionic design. Bionic design is to imitate the structure and growth of natural objects, and so is the natural form of organic form. Plants as organic life forms, their growth form, texture and colour, movement changes, habit function, etc. are organic, vital forms [8].

2. Ceramic arts and organic forms

Ceramics is a collective term for pottery and porcelain. Ceramics, due to their materials and the process of firing and moulding, many excellent examples of organic forms exist. The sensory perception of organic form, visually speaking, focuses on form, space, reality, material, colour, texture, etc., which is no different from traditional ceramic production.

3. Extrusion 3D ceramic printing

In this study, an extrusion-based 3D ceramic printing device was used for the research. For ceramic art creators, the clay direct writing forming technology is more controllable and can be manually intervened at any time during the printing stage, and the choice and preparation of the printing material also has more free space. It can be relatively free to realize the combination of 3D printing and manual processing. Combined with 3D printing and other digital production technology, this organic extends to a combination of mechanical digitization and life organic, called a digital organic form. This study, in the context of the author's specific creative process, will reveal the concepts, methods of creation and artistic characteristics of this organic form, as well as the advantages and limitations of the application of the technique of direct clay writing into shape in the creative process. Based on the results, the value and future of the research will be affirmed.

Research Methodology

1. Research methodology

As shown in Figure 4, the research framework is divided into four main phases: data research, design, experimental and outputs. Population and sampling, data collecting and analysis were used in the research process.

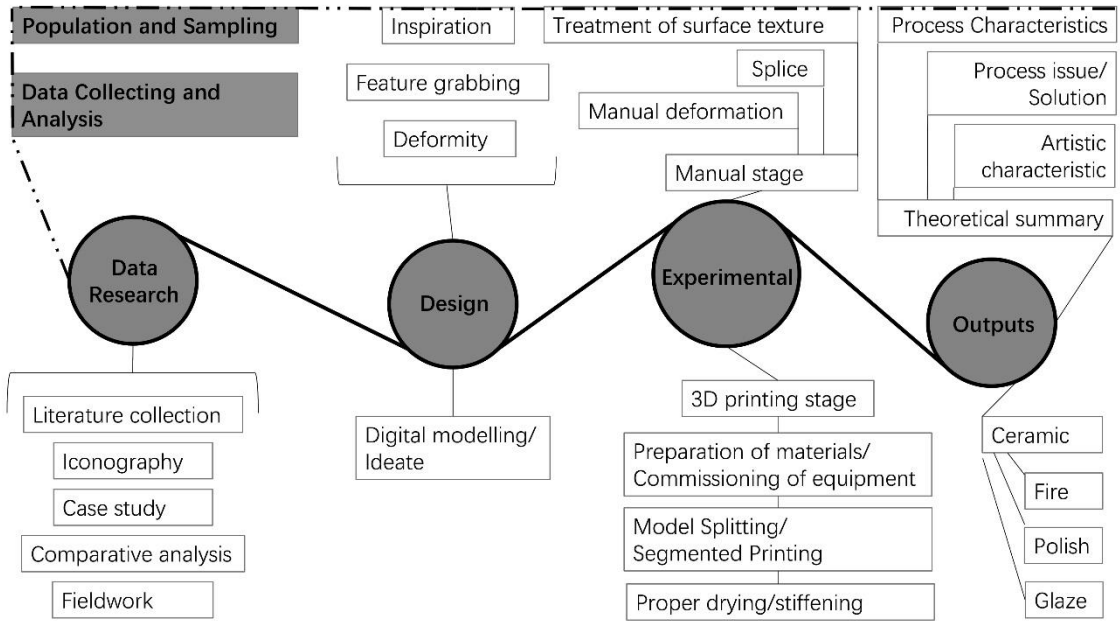

Figure 4 Methodology frameworks
Source: From the author

2. Source of data

The author uses Thai plants as the origin of his work. Fieldwork is used, literature is collated, and the method of iconography is used for research. Meanwhile, in the actual creation, 3D printing and handmade data are recorded.

3. Population and sampling

After getting a large amount of data, the author applied the method of population and sampling. Combined with the geographical and climatic characteristics of Thailand, to study its plant morphology. Mainly, the common cactus family in Thailand, flowers and leaves, etc. are taken as the overall research objects. Through the specific sampling morphological examination, the general characteristics of its plant morphology were summarised. In order to get inspiration and capture important features.

4. Data collecting and analysis

The author has used data collecting and analysis. Suitable data were collected and selected. The available data on plant forms are broadly classified into three types: the first is plant forms with more holistic shapes, which are more suitable for three-dimensional spatial modelling, such as cacti and succulents. The second type is the contour lines of flowers and leaves with vitalised and rich forms. The third is the unique characteristics of the plant, such as colour and textural features.

5. Design

After data collection and analysis, the author combined previous methods of creating organic form sculptures, such as deformation, repetition and other techniques, to make artistic treatment and conceive sketches. Finally, it was modelled in the computer to get the visual digital sculpture, as shown in Figure 5.

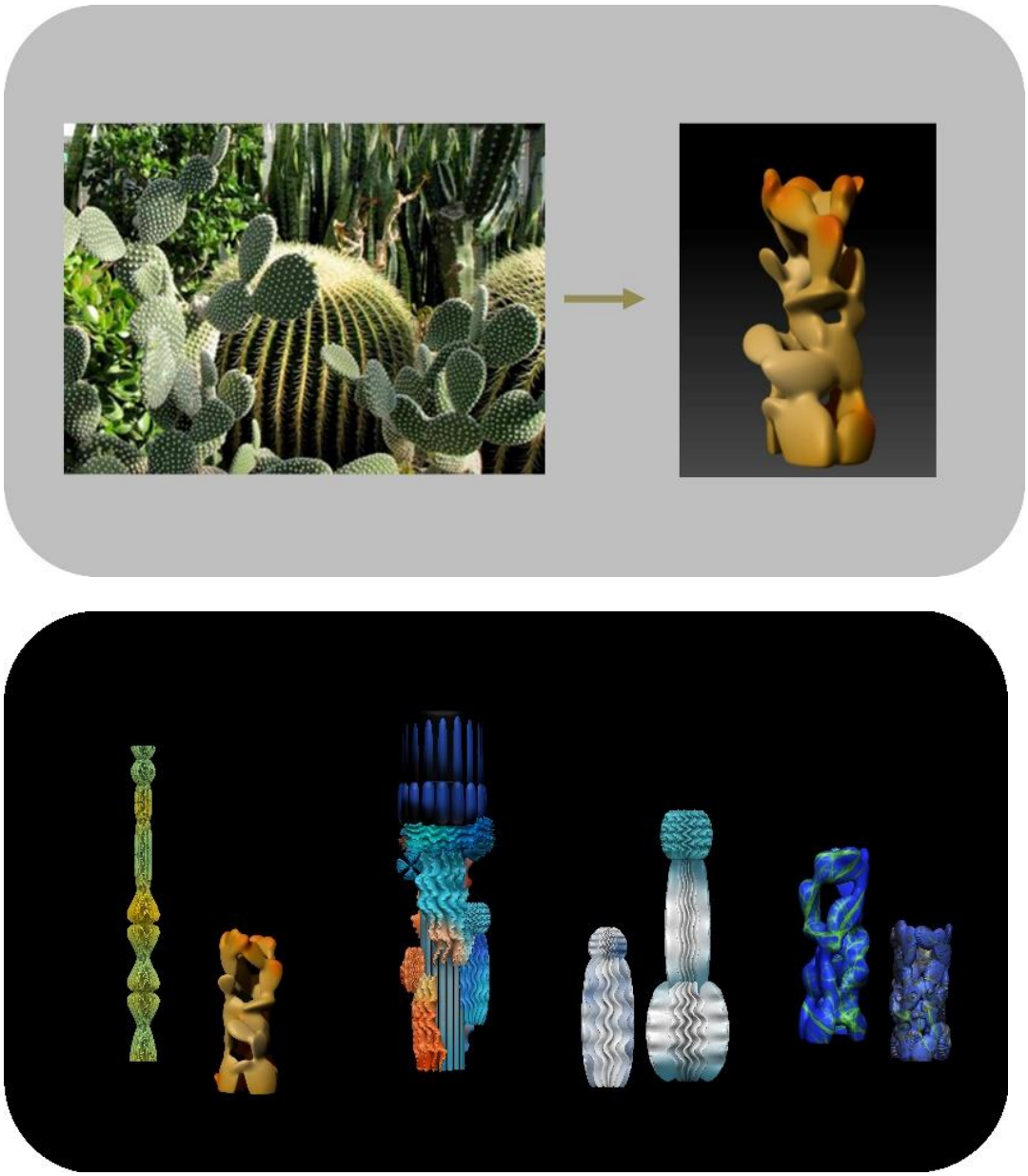

Figure 5 Design stage of artwork
Source: From the author

6. Experimental phase

The creation enters into an experimental phase where, unlike traditional handmade ceramics, 3D printing dominates the actual creation as the main production method. In the 3D printing stage, equipment commissioning and clay preparation are needed first. Then the digital model is sliced on the software, in order to obtain a file recognizable by the printer. As shown in Fig. 6, at this stage care should be taken to match the size of the printer, the support of the printed shape and other important issues. After 3D printing, the ceramic is properly dried to increase its hardness for manual processing. Ceramic treatment at this point is no different from the traditional handmade method. The main processing of some splicing, surface texture, and appropriate deformation, is shown in Figure 7. In general, 3D printing and hand processing are alternated. After the final drying and polishing, plain firing, and glaze firing, the final ceramic work is obtained.

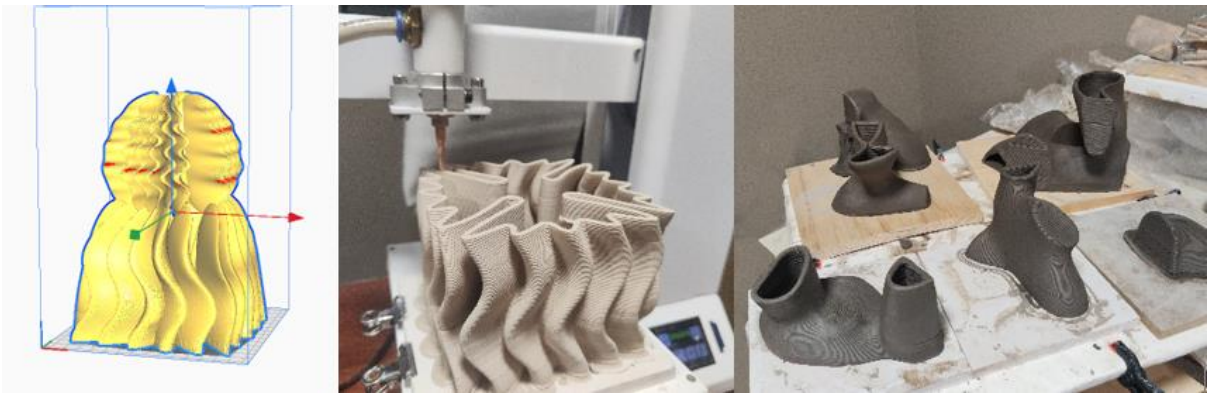

Figure 6 Experimental stage of artworks
Source: From the author

Figure 7 Artistic process
Source: From the author

Research Results

Results: 3D Printed Ceramics Creative Works

1. As shown in Figure 8, the ceramic work *Iris* is based on the theme of Thai flowers, 3D ceramic printing combined with hand processing, using the techniques of "copying" and "collage". The work takes the form of traditional Chinese " vessel " modelling, with cross-cultural regional significance.

2. As shown in Figure 9, the ceramic work *Cactus*, inspired by the characteristics of the Thai cactus, embodies a new interest in subtropical plant modelling. The work uses abstract lines to express the vitality of the plant.

Figure 8 Final ceramic artwork *Iris*
Source: From the author

Figure 9 Final ceramic artwork *Cactus*
Source: From the author

Discussion

Combined with previous literature and experimental creations, the organic form of Thai botanical ceramics based on 3D technology has the artistic characteristics of cross-cultural region, parametric, digital and mechanical reproduction. Its artistic characteristics and aesthetic value inherit the excellent artworks of the previous generation and create a new look. Compared with traditional handmade ceramics production, 3D printing ceramic technology has certain advantages and limitations. Based on this, the author summarises the advantages and limitations of the process and puts forward different theories and insights.

1. Artistic heritage: The creation of Thai plant organic form ceramics based on 3D printing technology has the artistic characteristics of cross-cultural geography and mechanised reproduction. This study combines Thai plant forms and traditional Chinese "artefact" ceramic modelling features. It reflects a new interest in subtropical plant modelling. From the point of view of art history, this work is a contemporary continuation of Dada art and surrealism. "Collage" and "reproduction" are the main creative techniques of Dada and other art genres. 3D technology has the characteristics and advantages of mechanized reproduction. The works come from the real world of nature and plants, after digital technology processing, to transcend reality.

2. A new look: The creation of ceramics of organic forms of Thai plants based on 3D printing technology with a new look of parameterisation and digitisation. In the context of sculptural modelling, it is characterized by vitality, abstraction, and parametric spatial modelling. From the visual intuition of the work, we can see the origin of the plant bionic modelling. Its abstraction is specifically shown in the organic form of the shape reflects the overall geometric outline. The author deliberately retained the characteristics of 3D digital

modelling, so the work has parametric characteristics. This is the most prominent artistic feature of the creation, which has important aesthetic significance. In the context of ceramic art, it is important to compare traditional handmade ceramic works. The creation retains the scale of the " ware " and continues the tradition of handmade ceramic vessels with upward and hollow features. This work expands the landscape of ceramic art by showing a more digitized texture and sense of order. The work therefore has a certain disciplinary significance. This study also expands a new look at ceramic art.

3. Industrialised production values: Compared with traditional ceramic handmade art, the process is characterized by strong reproducibility, high efficiency and stability. It has a high reference value for ceramic product design, industrialized production and so on.

4. Acceptable print accuracy error: About printing accuracy. If the precision of the 3D printing preparation is high enough, the creator can almost print out the digital model perfectly. The author used a device with an accuracy of 0.4mm, and its 3D printing error was kept in the range of 1~5%. After manual repair and other processing, the error is within a completely acceptable range.

5. 3D printing size limitations: The 3D print size is an important condition for this process due to the limitations of the machine. The author's machine print size is 15x15x24cm. After experimentation, we know that the optimal creation size range of this process is within 0~3 times the print size. Theoretically, the human-computer combination creation process in this article is not limited by the size of the 3D printer. However, in the context of actual creation, a larger-sized 3D printer should be used for larger-sized works in order to create them most efficiently while minimizing errors. Similarly, this research has very strong theoretical and practical support for the creation of ceramics of larger sizes.

6. Solving skeleton modelling and load-bearing problems: Based on the moulding characteristics of an extrusion 3D clay printer, its skeleton shape and load-bearing are the place that needs to be focused on when designing 3D modelling. The extrusion path of the 3D printer's nozzle, which needs vertical support, can not be large overhangs. The situation in the digital model slicing can be directly processed into a print file with internal filling support. However, ceramic firing needs to be hollow, too much internal filling has the risk of blowing up the kiln. The internal supports produced automatically by the slicing software are not fully controllable and are only suitable for simple ceramic forms. When it comes to complex and large-sized ceramic models, I prefer to use 3D print files with no internal support. Therefore, the author summarizes three solutions in the process of creative practice. First, when 3D modelling, the skeleton structure is reasonably handled, and the skeleton shape at the details is reasonably handled as an internal concave shape. The author does not recommend manually adding the support structure directly in 3D modelling, because the internal support structure will interfere with the print path and affect the moulding effect. Secondly, when slicing the model, deal with the skeletonized part separately, for example, the horizontal overhanging shape, and adjust the orientation to vertical printing. After printing, these skeletonized parts are then spliced and processed manually. Third, during printing, observe the printing progress in real-time, and pause the printer to add support manually when printing to the overhanging structure. The combined use of the above 3 methods is sufficient to solve most of the skeletonization problems.

Suggestion

Thailand's plant species and forms have a large volume and high research value. The study of the plants of Thailand should go deeper into the Thai land with more field surveys and more in-depth literature studies. The creation of a Thai plant ceramic organic form based on 3D printing technology, using cacti, flowers and so on from Thai plants as the main body, combined with digital technology, presents a new organic form and explores a new human-machine combination process. However, due to the limitations of the equipment, the process can only address the author's current creative needs to a certain extent. This study solves some specific process problems by means of manual processing. The study enriches the creative outlook and direction of ceramic art and is a path worthy of continued research.

Further Research Work

In the future, deeper geographic and cultural backgrounds should be included in the study of plant forms and digital ceramics creation in both China and Thailand. In this way, the research will not be limited to the realm of art and the 3D printing process but will have a broader connotation. However, iterative digital technologies, such as multi-axis robotic arms and AI technology, are emerging one after the other. Continuous iteration, a variety of 3D ceramic printing equipment and technology will help artists and designers to create a higher precision, larger size, and more complex shape of the 3D printed ceramic works. Based on the present, always embracing the development of technology, ceramic art can go further.

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