




Connecting the Past and the Future: Digital Restoration Technology of Ancient Ceramics and Its Impact on the Cultural Heritage Industry

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ABSTRACT

In order to explore the problem of digital restoration of ancient ceramics and dig deeper into the archaeological value of ancient ceramics, this paper takes three ancient ceramics from the Ming Dynasty (AC 1368~1644) as the research objects, and uses Sony 230 4K electron microscope and Vinda 400 3D scanning equipment to reproduce ancient ceramics. First, observe the fracture location of the ceramic with a microscope and calculate the diameter between the cracks. Then, a 3D scanner is used to digitize and plan the restoration accordingly. Finally, the impact of ancient ceramics on the cultural heritage industry is shared by combining restoration techniques and results. The results show that the location of the fracture can be determined more accurately by microscopic observation. After 3D scanning, the ancient ceramics can be virtually repaired, avoiding ceramic damage and improving the accuracy of the restoration. Therefore, digital restoration technology and modern scientific and technological means can excavate the value of ancient ceramics, realize the connection between the future and the past, and tap the deep cultural heritage value.

Keywords: Ancient Ceramics, Digital Restoration Technology, Cultural Heritage Industry, Past and Future, Microscopic Observation, 3D Scanning.

INTRODUCTION

Ancient ceramics are one of the cultural relics of ancient China, and at the same time, they can also influence the entire cultural heritage industry. Based on this, after an in-depth study of the digital restoration technology of ancient ceramics, this paper concludes that archaeologists will complete the effective restoration and in-depth restoration of the original ancient cultural relics by applying the digital restoration technology of ancient ceramics. Therefore, this will be conducive to the long-distance appreciation of the audience and enhance the influence of ancient ceramic relics. At the same time, it will also affect the future cultural heritage industry and promote the further development of the cultural heritage industry in the future (Amicone et al., 2023). At the same time, it can also innovate the business model of the cultural heritage industry. All in all, the restoration quality of ancient ceramic cultural relics and the subsequent protection effect need to be further improved (Avramovska et al., 2023), and the effective application of digital restoration technology of ancient ceramics will undoubtedly provide a strong guarantee for this. Therefore, this paper studies the mathematical restoration of ancient ceramics from the following aspects (Di Angelo, Di Stefano, Guardiani, & Morabito, 2023). Firstly, the role and significance of the restoration of ancient ceramics and the restoration process of ancient ceramics are expounded. Then, the restoration of three ancient ceramics of the Ming Dynasty (AC 1368~1644) was studied, and the simulation analysis was carried out to verify the restoration effect. Finally, the restoration role of ancient ceramics and the impact on cultural heritage are elaborated. The main purpose of this paper is to explore the restoration value of ancient ceramics. There is an obvious gap between domestic and foreign countries for the restoration of ancient ceramics, and foreign countries pay more attention to the application of research technology and research

equipment in the field of restoration, and analyze the material of porcelain before restoration. According to the nature of porcelain, materials such as gypsum clay are selected to minimize the damage to ancient ceramics during the restoration process. The restoration of ancient ceramics in China mainly stays at the theoretical level, focusing on practical protection, using modern equipment to analyze the data on ancient ceramics, and reducing the restoration of ceramics. The shape and pattern of the ancient ceramics themselves are only completed through the splicing of images, and the overall appearance of the ancient ceramics cannot be displayed as a whole. Under the influence of 3D simulation technology and high-definition video technology, 3D simulation repair is tried in China, and 3D models are built through the analysis and construction of pictures and graphics, and the fusion of data is carried out to find the fusion point of repair. Finally, a high-definition microscope was used to determine the results of data fusion. It can be seen that there are great differences in data restoration and ancient ceramic simulation between domestic and foreign countries in terms of restoration technology, and more practical cases are needed as support. On this basis, the contents of ancient ceramics are restored, and the corresponding scanning and restoration work is completed with the help of simulation technology and high-definition microscope technology, so as to explore the cultural connotation of ancient ceramics. In this paper, we should first collect the data of ancient ceramics, complete the overall analysis of ancient ceramic data, and use high-definition microscope technology to collect the texture curves of repaired ceramics and the corresponding fusion points. Then, the 3D simulation technology was used to simulate the docking and fusion of the ancient ceramic pieces, and the high-definition microscope was used to count the picture porcelain pieces in the 3D microscope for restoration, and the final results of the restoration were verified to be verified. Therefore, this paper mainly uses 4K microscope counting and 3D scanning technology to discover the texture patterns and coupling points of ancient ceramics, and carry out non-destructive simulation to repair them, in order to reduce the damage to ancient ceramics in the repair process.

ANCIENT CERAMICS AND THE PROTECTION OF CULTURAL HERITAGE

The Practical Application Value of Ancient Ceramics

Ancient ceramics are porcelain made by ancient archaeologists with rich cultural connotations and aesthetic value. These ancient ceramics generally have a long history and carry a vision of cultural inheritance. It is clear that as a kind of artwork, ancient ceramics can continue to be inherited and preserved, the main reason is that ancient ceramics carry the memory of human history and culture (Dong et al., 2023), and are a precious heritage worthy of protection. These ancient ceramics can not only reflect the development level of society, science and technology, economy, art and other aspects in different periods of ancient times, but also reflect a certain value of historical and cultural inheritance, which has great cultural significance (Gao, Zhu, Zhang, Wu, & Zheng, 2023).

There is a strong connection between ancient ceramics and traditional techniques, and at the same time, their existence will also illustrate the creativity and wisdom of the ancients. The carvings of these ancient ceramics are very delicate and artistic, which also shows that the archaeologists of the time were constantly pursuing beauty and were able to enrich their aesthetics for this purpose. It is worth mentioning that the effective preservation and protection of these ancient ceramics will also show the unique aesthetic concepts and technical styles of various periods and regions in ancient times (Gu & Xing, 2023).

Ancient ceramics reflect the social life of the ancients, business and trade exchanges, religious beliefs and other information. This can provide important value for the study of history, sociology and archaeology for future generations. As one of the cultural heritages, ancient ceramics are also irreplaceable and non-renewable. Therefore, after a long period of history, these ancient ceramics have become extremely precious and unique (Jin, Wang, & Xue, 2023). To this end, archaeologists should be aware that the protection and inheritance of ancient ceramics will promote the integration of human culture and promote common cultural progress. In addition, it will also play a positive role in the preservation and protection of ancient cultural heritage. Based on this, archaeologists must strengthen the protection of ancient ceramics to better promote related historical and cultural research, so as to truly connect the past and the future.

Current Problems Faced by the Cultural Heritage Industry

With the progress of science and technology and the development of society, the protection of cultural heritage is facing more and more severe challenges. The details are as follows: 1) The dilemma of cultural poverty. Because of the impact of social development, many areas are currently facing the problem of cultural poverty, which is a cultural dilemma, which is manifested in the extreme lack of resources related to the protection and inheritance of local cultural relics. Therefore, the relevant parties should make positive improvements in this regard, and it is best to take some corresponding measures to improve the level of local cultural development. 2) Natural disasters or man-made damage are the key to the damage or destruction of various cultural relics. Natural

disasters and man-made destruction are undoubtedly the two main threats to the protection of cultural heritage. Earthquakes, floods, fires, etc., these natural disasters will cause the damage and loss of important cultural relics. At the same time, because many cultural relics in cultural heritage protection have high economic value, this also leads some people will take risks, theft, excavation, illegal trade, etc., will have a devastating impact on cultural heritage protection (Liu, Gong, & Yan, 2023). 3) problems arising from transnational trafficking and illegal trade. Ancient ceramics are an important cultural heritage of Chinese civilization, carrying the historical and cultural memories of various periods of ancient China, and at the same time, they are also a key part of ancient Chinese cultural heritage (Maltsev et al., 2023). The in-depth archaeological excavation activities, the active economic activities, and the protection and attention of archaeologists to the cultural heritage and ancient cultural relics have made the value of ancient cultural relics continue to increase. Because of the increasing cultural heritage value of ancient ceramics, ancient ceramics are often the target of illegal trafficking and underground trade. According to relevant investigations, there are many precious and high-value ancient ceramics in China, which are illegally sold to other countries. In doing so, the Chinese will be deprived of the right to inherit their own cultural heritage. Therefore, this has become a serious challenge for the protection of cultural heritage.

Scientific and technological progress can improve the archaeological value excavation ability of ancient ceramics and make up for the problem of dynastic disconnection in traditional archaeology. Modern technology has replaced the original technology, and many traditional industries and ancient ceramic production techniques have been lost, which has an inhibiting effect on the protection and promotion of Chinese culture. By-technologies may upset the balance between the preservation of traditional skills and the needs of modern production, and improve the value of archaeology. In view of the above points, the archaeological community must take strict measures to protect and restore Chinese cultural heritage such as ancient ceramics. This paper will focus on the digital restoration technology of ancient ceramics and its impact on the cultural heritage industry, and hope to use the innovative means of digital restoration technology to provide effective solutions for the solution of cultural heritage protection. In order to effectively protect the cultural heritage industry and allow ancient ceramics to be comprehensively restored, archaeologists must first understand what digital restoration technology is and apply it to the protection and restoration of ancient ceramics, so as to promote the further development of the cultural heritage industry.

Digital Restoration Technology of Ancient Ceramics

In recent years, digital technology has begun to be valued and applied by archaeologists. Influenced by the way of thinking, digital technology has long been invested in many fields in the museum, so, from the current situation, the digital restoration technology of ancient ceramics has begun to replace the traditional manual operation and process technology, forming a new application and development situation. As we all know, ancient ceramics are a very valuable cultural heritage, and they are often destroyed for various reasons. Therefore, the restoration of ancient ceramics has become an important work at present. In order to improve the restoration effect of ancient ceramics, archaeologists also realize that some new technologies and means need to be used to achieve twice the result with half the effort. At the same time, traditional crafts still have some value and, therefore, need to be kept basically. Therefore, from the perspective of connecting the past and the future, archaeologists should apply digital restoration technology in an extended way while maintaining the advantages of traditional handicrafts, so as to improve the overall restoration level of ancient ceramics.

Basic Repair Mode

In the restoration of ancient ceramics, some advanced restoration techniques need to be applied in order to maintain effective restoration. Therefore, the application of digital restoration technology of ancient ceramics is extremely crucial. At present, the application of digital technology in the restoration of ancient ceramics will improve the restoration quality of ancient ceramics, and can shorten the operation time and ensure the safety of operation. First of all, the effective application of digital restoration technology of ancient ceramics will effectively improve the basic mode of this work, so that the subsequent restoration work can be guaranteed. To this end, archaeologists should first deal with the restored part of the foundation in place and restore the ancient ceramics of the damaged part.

Repair with Photosensitive Adhesive Material

The operator will use photosensitive composite resin to realize the bonding of the broken parts, or will use putty materials to complete the repair of damaged parts. Second, during the operation, archaeologists need to input relevant data information into the digital system, and use high-definition digital scanning equipment and digital cameras to record the location of the restoration target in detail. In addition, it is necessary to enter texture data and color sample data information. The operation process of this process is basically the same as that of cultural relics photography. That is to say, it is necessary to fully grasp the color temperature state and clarity of the place to be repaired, so as to facilitate the subsequent part of the restoration work; thirdly, after completing

the above operations, the archaeologists should also input all the collected data information into the computer system, and then, use the system to repair the damaged parts to achieve the purpose of restoration. Immediately afterwards, archaeologists will continue to carry out various processing work, such as completing splicing operations, synthesis operations, deformation operations, color correction operations, etc. At the same time, it is necessary to make the necessary processing of the background color and texture part to better realize the restoration, and fourth, after the formal entry of the data information, it is necessary to invest in the image processing process. In the process of output printing, archaeologists should be able to ensure that the color of the restored parts is basically the same as the original color through color tracking processing; fifth, archaeologists should use high-definition printing technology to achieve transfer printing processing, and complete the spraying operation of polyester materials on it, and complete the processing of reinforcement and removal of traces. According to the actual development of pigment technology in printing equipment in China, it can be seen that in the complete digital restoration of ancient ceramics, the color of the entire restoration will be maintained for more than 100 years. Therefore, this shows that after digital restoration, ancient ceramics can reach a better standard of restoration application.

Repair by 3D modelling

In the digital restoration of ancient ceramics, archaeologists should be able to build a 3D model of ancient ceramics, and then use Max's method to build a complete main body shape for it. In this regard, archaeologists need to ensure that the corresponding modelling measures and technical methods can be selected according to the type of ancient ceramics. The personnel concerned should first grasp their characteristics. For example, ancient ceramics in the form of cups or bottles tend to have very simple bodies, and most of them are objects with symmetrical structures. Therefore, archaeologists need to use the latest digital max technology to turn this two-dimensional body into a 3D model (Stamatopoulos & Anagnostopoulos, 2023; Kravari et al., 2022). Then, archaeologists have to accurately depict their shapes. After the contouring of ancient ceramics such as cups and bottles, they are also "turned". In the "turning" process, the archaeologist should compile a winding rotating bus bar or 3D object, in which the shape of the bus bar will define the overall shape of the ancient ceramic. Then, based on the endpoints, you can adjust its specific shape and use effective control of the end cranks to delineate the busbar. For example, it is possible to depict the busbar as convex and sleek, and to use the "turning method" of the contoured busbar to reflect the thickness of the ancient ceramic in the 3D model created, so that an accurate model can be obtained during subsequent restoration. In addition, at present, archaeologists can also use the MAX method to complete the accurate input of ancient ceramic model information. At the same time, in this process, archaeologists can also use smooth subdivisions and point capture to achieve the details of ancient ceramics and restore its lines. It can be seen that the "turning process" link in the digital restoration technology of ancient ceramics will make the overall and local treatment of the restoration of ancient ceramics more refined. In addition, the use of digital restoration technology of ancient ceramics will better achieve the effective creation and preservation of 3D model bodies, and improve the overall efficiency and accuracy of this process. The digital restoration technology of ancient ceramics can also be used in the modeling of sculptural ceramics. Moreover, when applied to the restoration of sculptural ancient ceramics, archaeologists basically use polygonal modeling. Specifically, multiple triangles need to be effectively combined to create a 3D object, and then the triangles need to be arranged and complex. In addition, before modeling the ancient ceramics of sculptures, archaeologists should also understand the characteristics of the modeling structure clearly and fully grasp it. At the same time, it is necessary to accurately set the size and direction of the triangle according to the actual shape of the sculpture's ancient ceramics, so as to ensure that it can be consistent with the overall modeling and structural characteristics of the ancient ceramics. In short, for the sculpture of ancient ceramics, only through the polygonal modeling method can its decorations be completely depicted and the details can be enhanced. In addition, archaeologists can use computer technology and related high-configuration software to ensure the effectiveness of 3D modeling and improve the final accuracy.

The Role and Significance of Digital Technology in the Restoration of Ancient Ceramics

Digital technology is the use of digital simulation technology to carry out non-destructive data analysis of ancient ceramics, in the process of data analysis, you can discover the hardness, strength and material of ancient ceramics, and identify the internal structure and crystallization of ancient ceramics, so digital technology is to dig deeper into the archaeological value of ancient ceramics in the case of non-destruction, in the process of digital restoration, through the simulation of the construction of each fragment, you can carry out more accurate fragment fusion, fragment point combination, in order to improve the accuracy of repair, compared with digital technology, the traditional artificial repair technology will cause the wrong fusion of different materials or the repair of different proportions of fragments, reduce and affect the accuracy of restoration, and at the same time, traditional restoration for archaeology. In addition, due to long-term weathering, its texture is relatively fragile, and artificial restoration will cause secondary damage to archaeological restoration, causing irreversible damage

to archaeological restoration, so digital restoration technology can reduce the impact and intervention of artificial on archaeological materials, improve the accuracy of ancient ceramic restoration, and provide accurate support for the excavation and archaeological confirmation of ancient culture in the later period.

RESEARCH TECHNIQUES AND METHODS

Research Technology

In this paper, three ancient ceramics from the Ming Dynasty (AC 1368~1644) were taken as the research objects, and the Sony 230 4K electron microscope and Vinda 3D scanning equipment were used to restore the ancient ceramics. The research indicators are mainly the texture, repair degree and consistency of ancient ceramics, as well as the construction of 3D models. Among them, the 4K electron microscope is mainly the texture and material of the ancient ceramics in the square, as well as the link effect at the cracks, which provides data support for the later restoration and grain coupling, and enhances the accuracy of ceramic restoration. The function of the 3D scanner is mainly to restore ceramic pictures, compare different restoration schemes, and verify the repair materials and repair effects, so as to reduce the number of repairs and minimize the damage of ancient porcelain. Using a 4K microscope, archaeologists only need to observe whether the lines are consistent between the different fragments, and whether the wear lines are consistent. Through 1.2x or 3.0x microscopic observation, the material wear pattern in the excavated archaeological porcelain is in the same direction, so as to verify the relationship between the archaeological fragments. By comparing the feasibility of the fragments and repairing the fragments of the 3D simulation model, it is theoretically verified whether they belong to the same fragment. The repaired porcelain tiles were observed under a microscope to verify whether the wear direction of the grain and the depth of wear were consistent.

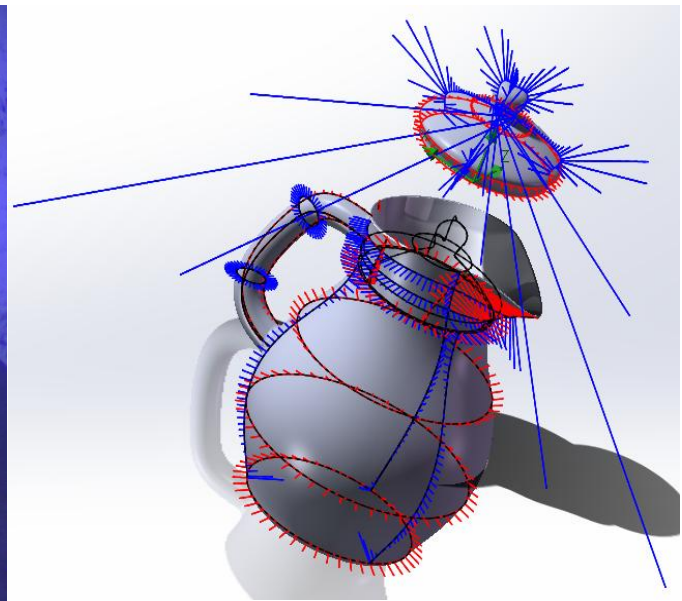
Research Findings

Tests and Measures for Textures

In the digital restoration of ancient ceramics, archaeologists should use microscopes to complete light processing and observe the fragments of ancient ceramics. For example, lighting information can be added to the 3D model to improve the realism of the restored parts and make the restoration of ancient ceramics more effective. In addition, this will also make the restored parts closer to the original state of the ancient ceramics, so as to improve the realism after restoration. In order to make the final state of the ancient ceramics closer to its original appearance, the grain is measured. Archaeologists can also improve the effect of light and shadow settings, and combine the material of ancient ceramics and the set lighting characteristics to compile the corresponding model lighting scheme in the 4K microscope, and maintain the stability of the lines. Directional light, flood light, spot light, etc. can be used for texture observation. Among them, the light source of the spotlight often has obvious edges in the process of projection, and the shape of the range of the light is similar to that of a rectangle, a circle, etc. Flood light sources, on the other hand, are unique in that they are point sources that can be used to simulate the effect of indoor light bulbs. So, it has a more pronounced shadow effect. In addition, there is a collimated light source. This type of light tends to have soft shadow areas and will show a soft-border state within its illumination range. In the grain measurement operation, archaeologists can select targeted light combinations based on the specific reality and characteristics of ancient ceramics, so as to improve the overall pattern measurement effect, as shown in [Figure 1](#).



Measurement of ceramic particles



Radian calculations are performed in combination

Figure 1. Comparison of the Radius of Ancient Ceramic Grains

After the implementation of the digital modeling work, there is a very critical step, which is to simulate the material and appearance texture of ancient ceramics. Archaeologists need to take advantage of leading MAX digitization technology to complete the modulation work, or they can also take advantage of the advanced manipulation measures in the VRAY rendering engine to achieve effective simulations. In Figure 1, the texture of the ceramic is observed with the help of a microscope, and the circumference of the radius on the left side is 4.99 mm, and the circumference on the right side is 7.74 mm, which is relatively close, so it can be determined that this is the connection point of the ceramic. In this way, archaeologists were able to simulate and modulate universal ceramic materials. From the comparative analysis of the contour line in Figure 1, it can be seen that the contour arc between the two is in the same direction, indicating that the porcelain piece has been damaged in a circle, and the crack appears in the damaged position, resulting in the fragment breaking, the characteristics of the contour line can effectively distinguish the damaged position and damage characteristics of the porcelain tile, and provide characteristic support for repair, and at the same time, the direction of wear and the position of the contour line maintain the same angle, which further indicates that the porcelain tile is the same broken fragment.

Determination of Crack Color and Gloss

In order to further verify the crack location, the gloss and color of the crack at different locations were compared, and the results are shown in Table 1.

Table 1. White Restoration Modulation of Ancient Ceramics

Material	Fresnel	Refect	Diffuse
White antique ceramics	Check	230	220

As shown in Table 1, the white modulation table for ancient ceramic restoration, can complete a reasonable modulation for white ancient ceramics. In the table, diffusion is very important, and when operating, it is necessary to select a fixed connection point and make a color contrast, and the value of the color should reach 220 color wheels. Although the color is white, it is grayish white, so it does not affect the result of ceramic restoration. In addition, a crack indicates the reflectivity of the material. In the case of restoration, it should have a value of 230 color wheels, which is very close to white and can indicate a higher degree of reflection. Finally, Fresnel stands for the "Fresnel reflex", which is a special form of physical reflection. When the light hits the junction of the material, it is easy to form part of the reflection and part of the refraction of the light. If you look at it vertically, archaeologists will find that it has a relatively low degree of reflection. However, if archaeologists look at it from a non-vertical perspective, they will find that the degree of reflection will continue to increase as the angle continues to decrease. Therefore, this is more suitable for glazed ancient ceramics. The reason for this is that glazed ancient ceramics are more prone to the phenomenon of "Frenier reflection", so the repair points in Figure 1 can be repaired using the materials in Table 1. From the contents of Table 1, it can be seen that before restoration, archaeologists should analyze the texture and light perception of ancient ceramics. VRAY is a rendering engine.

Judgment of the Contour Line of the Repair Position

The contour line is an important line segment in the restoration of ancient ceramics, which mainly reflects the overall position of ancient ceramics and the cracks of ancient ceramics, so it is necessary to 3D scan the position of ancient ceramics and fill in simulated materials to verify the restoration of ancient ceramics, and the specific results are shown in Figure 2.

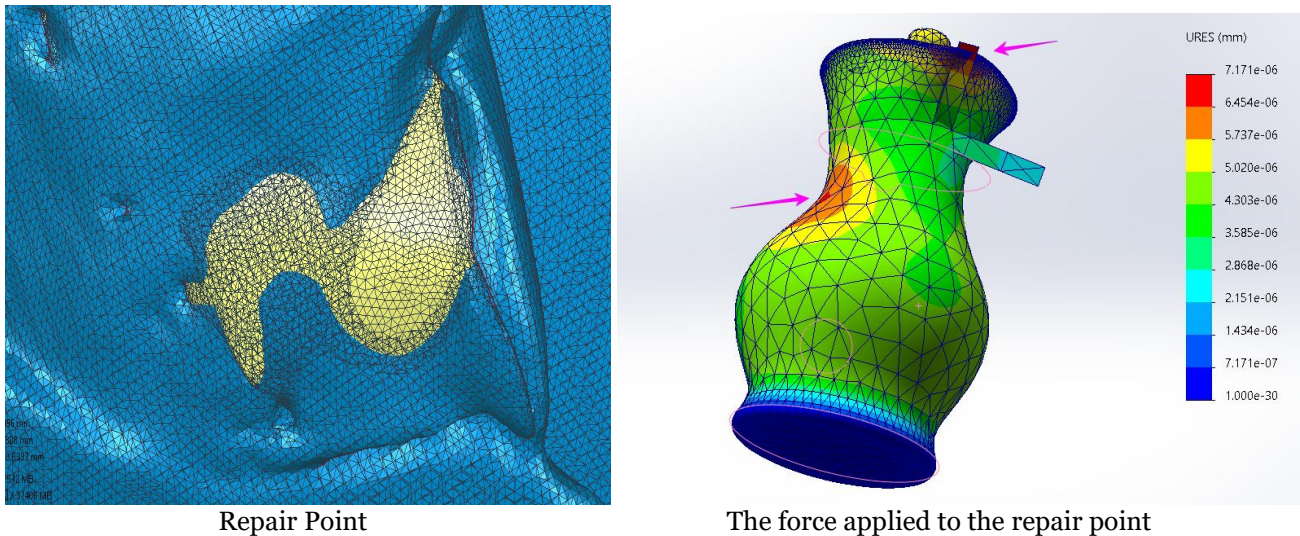
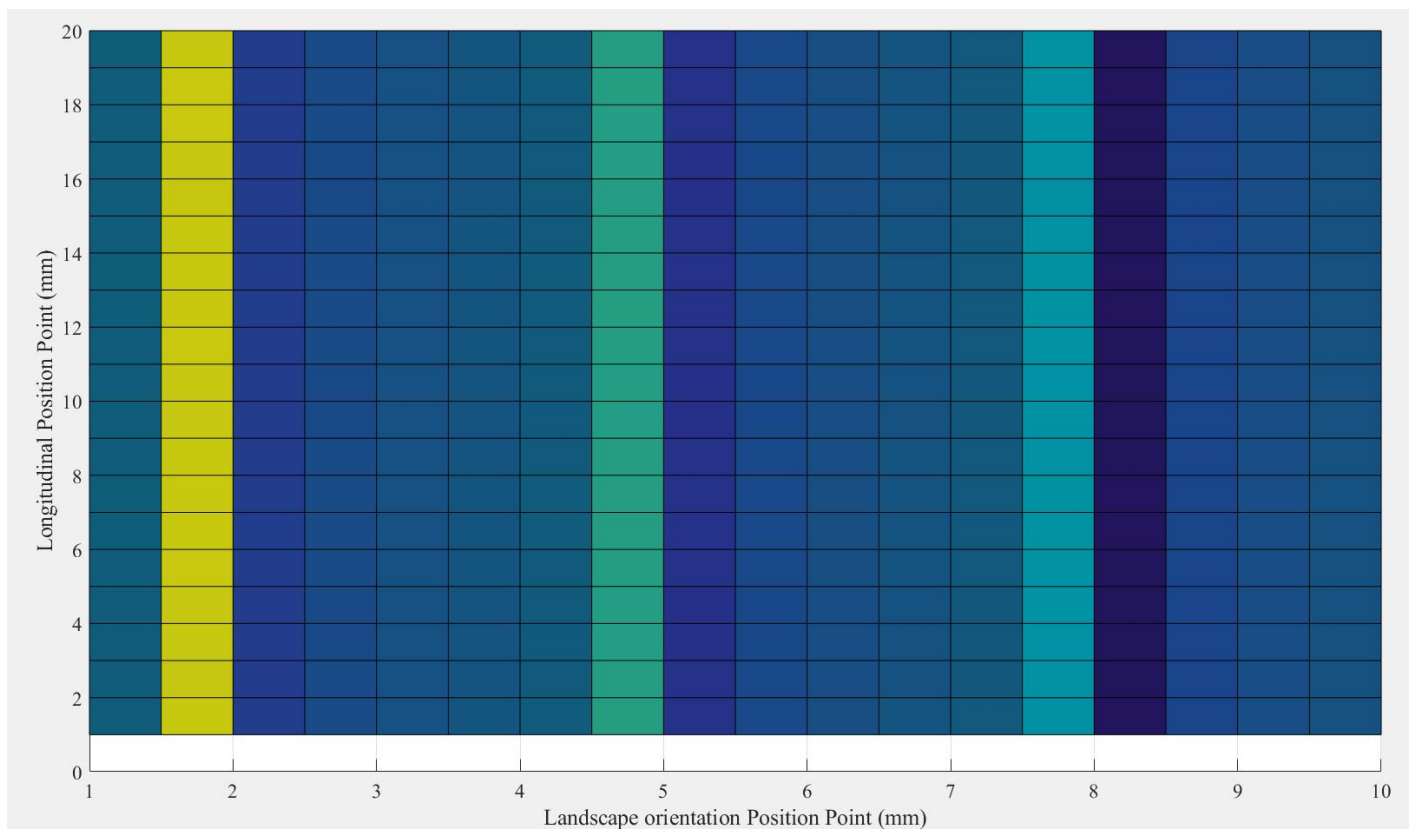


Figure 2. Material Filling at the Location of Ancient Ceramics

According to the analysis of the contour line, the construction of the 3D scan image is mainly to judge the position of the contour line and the direction of the contour line, and the accurate fusion of the contour line between the fragments has been realized. As can be seen from the yellow data in Figure 2, the ancient ceramics were filled with materials and the materials showed irregular shapes. The upper part of the material is filled deeply, so it is necessary to take a depth measurement and calculate the smoothness and fusion of the material after the middle of the day. Under the analysis of the grid data in Figure 2, the relevant material filling tests meet the requirements, and the specific filling results are shown in Figure 3.





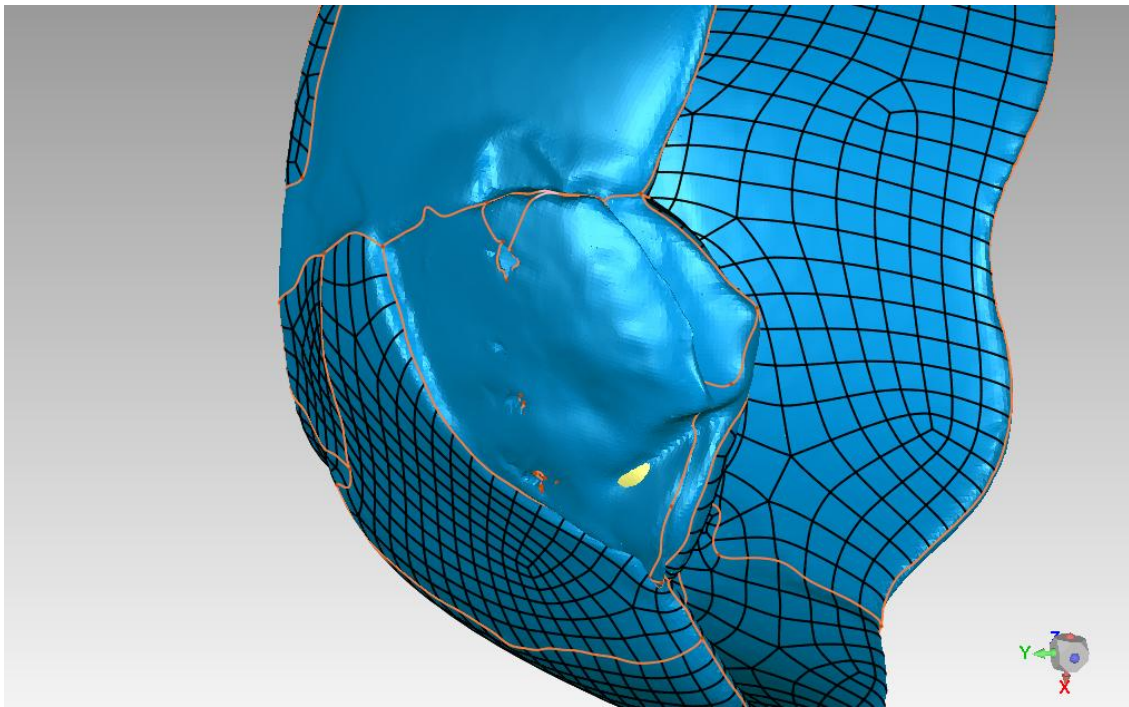
Fixed the rate of change of the dot connection

Figure 3. Contour Line after Material Filling

Through the above analysis, it can be seen that the fusion of contour lines can provide accurate support for data analysis and 3D simulation modeling, and provide data and technical support for the fusion and adjustment of fragments. As can be seen from the contour line in Figure 3, the contour line of the concentrated part of the material is relatively chaotic, but the smoothness of the material is good. Since this paper only studies the restoration of ancient ceramics, the texture of ancient ceramic restoration materials can be ignored. In general, by default, 3D software should turn on the lighting effects of the global illumination environment. Only in this way can we restore the original color of ancient ceramics as truly as possible. In addition, archaeologists also need to set up lights in special booths based on actual needs to achieve better modulation effects. In the process of modulation, archaeologists should not only pay attention to the processing part of the material, but also pay great attention to it. In addition, archaeologists also use texture mapping techniques and texture mapping techniques in computer graphics to determine contour lines. The relationship between the contour and the texture is a coupling relationship, which is consistent with the texture line, indicating that the structure of the whole porcelain and the overall structure of the porcelain are complete. Otherwise, the fusion between the fragment and other fragments is not good, or it is a false fusion. The repairer deletes the porcelain tiles with large incorrect fusions, or selects the fragments with more fusion lines to complete the repair of the entire porcelain tiles. Therefore, the contour line plays an important role in the restoration of the whole ceramic, playing an indicative and guiding role. For porcelain with serious damage or many fragments in some damaged locations, it is necessary to scan each fragment with the help of 3D scanning technology to determine the combination position and direction of the fragments. As can be seen from the yellow curve in Figure 3, the position of the fragments presents a complex staggered relationship, and the previous manual observation methods cannot effectively judge the fragment direction and anastomosis position. With the assistance of 3D scanning technology and 3D scanning software, it is possible to judge the fusion relationship between fragments, determine the location of fragments, and realize small fragments by means of contour line fitting lines. At the same time, the higher the degree of fitting between the contour line and the correction line, the better the repair position and the better the contour repair.

Overall Repair of Ceramics

After determining the contour line and light, the ancient ceramics should be repaired as a whole and the key points in them should be extracted, so the overall outline of the ancient ceramics after the material is filled meets the requirements. The final renderings of the ancient ceramics are shown in Figure 4.



3D Scanning Restoration

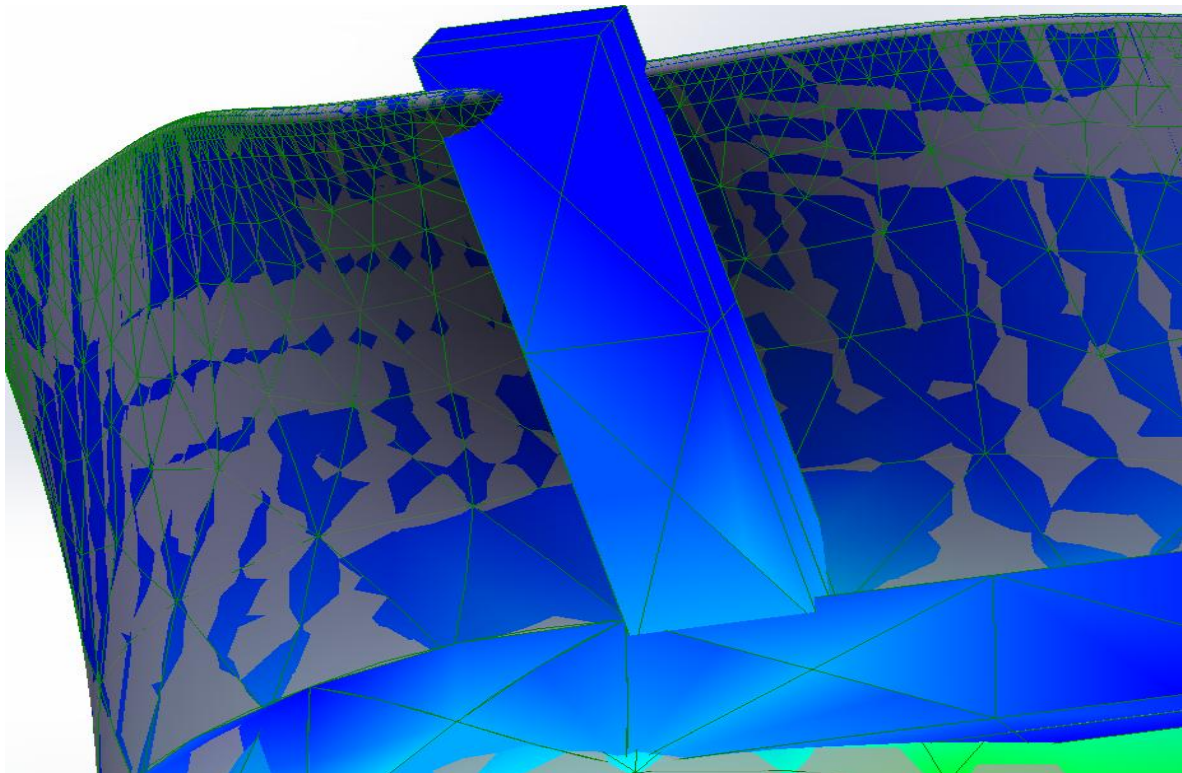


Physical Restoration

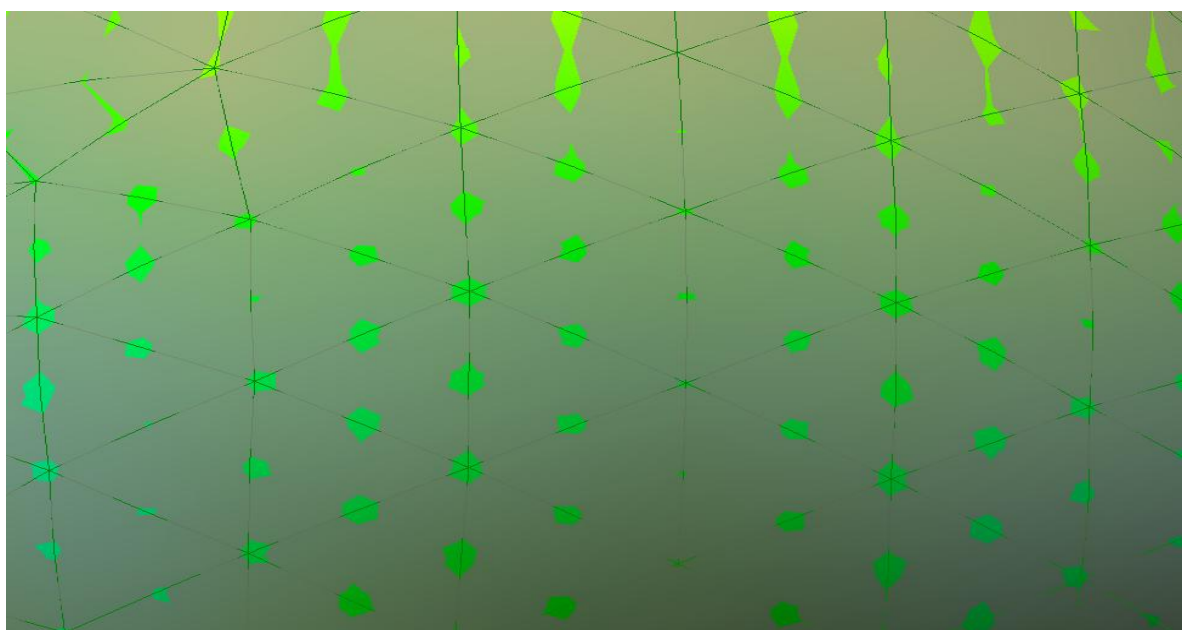
Figure 4. Final Renderings of Ancient Ceramics Restoration

As can be seen from the final restoration results in Figure 4, the use of texture mapping technology is to map the flat texture image to the established 3D model, so the restoration effect in Figure 4 is more reasonable in terms of light selection. In this regard, archaeologists need to use digital cameras to complete the shooting and collection of textured image materials, and then use 2D digital tools (static processing) to complete the reprocessing. Immediately afterwards, archaeologists will also stitch together the pictures to make and restore

them. It is worth mentioning that in the process of texture mapping, archaeologists should use various functions in computer software, such as image stitching and debugging tools, to color correct and enhance the texture of all photos, so as to improve their realism. At the same time, archaeologists also need to remove highlights from the photos and repair the textures and imperfections of the pictures. Once all of this is done, the archaeologists will place the photographs in the MAX digitization system and wrap them. Finally, you can get a 3D model of the image wrapping. As can be seen from the content in Figure 4, the physical restoration can be carried out according to the 3D scanning technology, and the repair results are relatively good, and the texture and lines can be adjusted through food repair, so that the restoration results are more in line with the actual requirements. In short, texture pictures are very important in the digital restoration of ancient ceramics. It is able to realistically present the details of ancient ceramics. Generally speaking, archaeologists need to apply digital scanning technology to obtain textured materials from the body of ancient ceramics (cultural relics). Then, archaeologists also have to restore the texture material according to the form of the ancient ceramic body, so that it can be changed back to the flat mode. In this way, it is possible to increase the ease of adjusting the scale and detail in the VRAY software. For the texture of the damaged parts of ancient ceramics, archaeologists can use advanced image processing technology to restore them and extend the image. Also, the texture material must be able to form a regular, clear texture image. The color blending of the sample was analyzed, as shown in Figure 5.



Color blending of borders



Overall color blending

Fig.5. Color blending after restoration

As can be seen from Figure 5, the color blending degree of the boundary and the whole is good, and there is no large color aberration. There are many boundary curves, so there is a large difference in color blending, and there is a large change in the image. The overall position is flat and easy to repair, so the color blend is high.

Physical Restoration of Ancient Ceramics

After calculating the cracks, contours, and corresponding 3D simulation models of ancient ceramics, it is necessary to carry out multi-angle measurements and analysis of ancient ceramics according to the test results. Archaeologists must use 3D software to fill the material to carry out baking technology on it. For example, use the texture form to attach its shadow parts, light parts, material information, etc., to its corresponding model. In addition, archaeologists also need to carry out roasting under the premise that the roasting index is extremely controlled. All in all, in order to ensure the digital restoration effect of ancient ceramics, archaeologists should try their best to refine the details of the previous steps. In addition, archaeologists should also ensure that after rendering, the shape, color, demeanor, and texture performance of ancient ceramics are highly consistent with the actual ancient ceramics before restoration. Only in this way can it be proved that the digital restoration effect of ancient ceramics has been best presented, and the restoration efficiency and benefits have been better.

Comparison of Remediation Results of Different Methods

Taking the sample in this paper as an example, the differences between the 3D simulation technology and the traditional manual repair technology are compared, including the repair time, repair cost and repair effect, and the results are shown in Table 2.

Table 2. Repair Results of Different Methods

Method	Repair Time (D)	Repair Cost (RMB)	Repair Effect (%)
4K microscope + 3D scanning technology	1.5±0.2	26.45±1.52	95.45±0.12
Artificial repair	3±0.4	526.42±10.36	85.42±0.85
Differences	Big differences	Big differences	There are differences

Based on the repair results in Table 2, it can be seen that the method proposed in this paper is better than manual repair in terms of repair time, repair cost and repair effect, among which the repair time and repair cost are significantly better than manual repair, but there is a certain difference between the repair effect and manual repair, and the difference is relatively small, and the main reason for the above problems is that the 3D scanning technology can simulate the data of the repair sample, so as to realize the comprehensive analysis of the data and improve the overall repair effect of the data, the cost of the experiment is smaller. However, manual repair needs to carry out a large number of repair materials and tools for repair, the cost of repair is relatively large, in terms of

repair effect, and the difference between 3D scanning technology and manual repair is relatively small, mainly because the sample repair personnel have many years of repair experience, can make relevant judgments, so as to improve the repair effect, and 3D scanning technology belongs to the objective judgment means, the repair effect is related to 3D technology, so the difference between the two is small. The statistical analysis of the factors affecting the restoration of ancient ceramics is carried out, and the results are shown in Table 3.

Table 3. Techniques Influencing the Restoration of Ancient Ceramics

	color	curve	shape	Material	pattern
Archaeological data	192.299	0.711	1	-	-
Simulation technology	1.001	0.008	-0.859**	1	-
Scan the device	2.299	0.711	1.000**	-0.859**	1

* $p < 0.05$ ** $p < 0.01$

Table 3 shows that the main factors affecting the restoration of archaeological ceramics are archaeological data, followed by scanning equipment and simulation technology. Also, color is the most difficult item to fix, followed by shapes, materials, and curves. It can be seen that strengthening the collection of archaeological data, returning raw materials and colors are the main directions of archaeological excavation, and simulation technology and pattern restoration are relatively easy.

Access to the Website and How to Do It

In order to facilitate the study of ancient ceramics in the later period to complete the relevant archaeological restoration, other relevant personnel can visit this website through the extranet, and can visit the website: <http://www.shijingwxf.com/to> access and restore information related to porcelain. In the process of data restoration, the details of the restoration and the restoration content can be compared, and the specific data can be accessed and repaired through the platform and the entire restoration can be understood, so as to promote the development of the restoration technology of the recent Chinese pottery. The restoration of ancient ceramics has a promoting role in the cultural exchanges between China and foreign countries, as well as the research of Chinese ceramic culture and the development of ceramic ethics, and can understand the exchange process of Chinese and foreign culture and history.

THE IMPACT OF DIGITAL RESTORATION TECHNOLOGY OF ANCIENT CERAMICS ON THE CULTURAL HERITAGE INDUSTRY

Improve the Restoration Accuracy of Ancient Ceramics

Improve the quality and efficiency of the restoration of ancient ceramic cultural relics. The application process of traditional ancient ceramic restoration technology, requires a lot of manpower and material resources, and it takes a long time. In addition, there is also a clear subjectivity. The application of digital restoration technology of ancient ceramics can greatly improve the accuracy of restoration work, achieve effective high-precision scanning and 3D modeling, and accurately restore the damage of ancient ceramics (Maritan et al., 2023). In addition, it will also improve the accuracy and actionability of the information related to the restoration work. In other words, the digital restoration technology of ancient ceramics will be able to affect its restoration work and improve its overall restoration quality, greatly saving labor costs and operation time. In addition, the digital restoration technology of ancient ceramics will also provide more restoration attempts and experiments, so as to make the restoration preparation more adequate and improve the final restoration effect (Mayo-Torné, Herrerin, & Guardia, 2023). In order to carry out comprehensive restoration and protection of ancient ceramics, archaeologists can use the digital restoration technology of ancient ceramics to improve the integration of ancient ceramic restoration work and modern digital technology, and ensure the improvement of the restoration effect of ancient ceramics. At the same time, it improves the true restoration degree of ancient ceramic restoration. As we all know, ancient ceramics are a kind of precious cultural relics in traditional Chinese culture, carrying unique historical and cultural memories of Chinese civilization, and having extremely high artistic value. However, due to the influence of age and various other factors, many of the current ancient Chinese ceramics have been damaged

to varying degrees in the process of preservation (Crow, K., & Powis, T. G., 2023). Moreover, there are some ancient ceramics that are more seriously damaged, and there are also some missing problems. If the traditional manual restoration method of ancient ceramics is used to complete the restoration of ancient ceramics, then it is difficult to achieve accurate, efficient and fast repair results. At the same time, new damage may also be caused to the original.

Improve the Realism of the Display of Ancient Ceramics

The digital restoration technology of ancient ceramics will provide a more authentic and rich way of displaying and protecting the cultural heritage industry. For example, archaeologists can use digital reconstruction and virtual display to allow the audience to see and appreciate the original appearance of these ancient ceramic relics up close, and feel the characteristics and charm of these ancient ceramic relics. In addition, because the restoration technology of ancient ceramics can effectively restore the damaged parts of it, it will also allow the audience to have a deeper understanding and understanding of the true appearance of ancient ceramic relics after a long time of baptism. So, this creates more opportunities for the viewer to have an immersive experience and make it feel real. Moreover, the application of digital restoration technology of ancient ceramics will also be conducive to the further protection of the original ancient ceramic cultural relics. For example, archaeologists will find that this will save the original ancient ceramic artifacts from being frequently moved and moved, and can avoid the damage caused by the dense flow of people. The application of digital restoration technology of ancient ceramics can give the cultural heritage industry a higher depth of communication and exchange, improve the influence of traditional Chinese culture (Oh & Jung, 2023), and improve the overall communication power. Using digital media, archaeologists will be able to remotely appreciate and learn ancient ceramics from various regions and periods of ancient times, enhance archaeologists' understanding of the culture of various regions of China and improve foreigners' understanding of Chinese culture.

Promote Cultural Exchanges Between Countries

In the process of applying the digital restoration technology of ancient ceramics, archaeologists will find that it can provide a stronger impetus for the further development of the cultural heritage industry and the expansion of business models. For example, through digital platforms, archaeologists can carry out online exhibitions and explanations of ancient ceramics, as well as the sale of related conceptual derivatives. In this way, it will be possible to broaden the market channels and audience for the further development of the cultural heritage industry. In addition, digital platforms can also facilitate rapid cooperation and exchanges between countries and regions, thereby promoting cross-cultural dialogue and enhancing the understanding of traditional Chinese culture among archaeologists in various countries and regions (Sun et al., 2023). In addition, the digital restoration technology of ancient ceramics will also improve the display effect of its cultural relics, and enable these cultural relics to be displayed in virtual and real as much as possible (del Solar Velarde, 2023), so as to improve the cultural artistic conception. Alternatively, visitors can experience the charm and beauty of ancient ceramics from a distance, thereby increasing the interest of archaeologists in the cultural heritage industry. In addition, the digital restoration technology of ancient ceramics will also provide more diverse product customization and development opportunities for the cultural heritage industry activities related to ancient ceramics (Železný, Kulhánek, Pešta, & Kočí, 2023). For example, using 3D printing technology, archaeologists will be able to make corresponding replicas of ancient ceramics, or related customized cultural products, so as to adapt to the individual needs of consumers. In this way, archaeologists can use the digital restoration of ancient ceramics to create more commercial models and provide sufficient financial support for the cultural heritage industry. In this way, the cultural heritage industry related to ancient ceramics will be further developed (Zhao & Zhang, 2023)

The Actual Value of Ancient Ceramic Restoration

As an important part of Chinese culture, ancient ceramics are a comprehensive reflection of the production process of ancient culture. Through the analysis of the pattern texture in ancient ceramics, we can explore the cognition of pattern patterns in ancient culture and compare it with modern cognition. For example, whether there is a difference between the number of ancient and modern petals, whether there is a difference between the proportion of materials used in the production of porcelain in ancient times and the materials produced today, and whether there is a difference between the shape of pots and bowls in ancient times and today. Another example is whether the cultural content reflected in ancient porcelain is consistent with the documentary records in reality. Porcelain has always been the main content of Chinese archaeology, which has an important supporting role in the confirmation of documents, the excavation of ancient culture, and the way of life and production of ancient humans. Because ancient porcelain has been buried underground for thousands of years, its material design is affected by the natural environment, and it is easy to be broken or missing during restoration. Therefore, it is necessary to carry out non-human intervention repair to improve the effect of repair. Simulation technology

can minimize the damage to ancient porcelain, dig deep into its actual value, and more accurately reflect the life and production mode of ancient humans.

CONCLUSION

The digital restoration of ancient ceramics has the function of connecting the past with the future, and it also has an extremely important impact on the cultural heritage industry. Considering that the digital restoration technology of ancient ceramics will greatly promote cultural exchanges between countries and regions and China, and improve the overall development speed of the cultural heritage industry, this paper will carry out a detailed study on the topic of "Connecting the Past and the Future: Digital Restoration Technology of Ancient Ceramics and Its Impact on the Cultural Heritage Industry". After research, I analyzed the damage to ancient ceramics, used a 4K microscope to determine the location of the damaged ancient ceramics, and carried out anastomosis treatment through technical measurement and chromaticity comparison. The 3D simulation software is then used to repair and simulate, determine the filling material and filling location, and finally output the actual rendering. The results showed that the microscope was able to determine the location of the damage and assist in the restoration of ancient ceramics through color observation. 3D simulation can reduce the damage to ancient ceramics and find the optimal restoration plan for ancient ceramics. Finally, the simulation results of ancient ceramics were confirmed according to the relevant historical documents, which greatly improved the restoration effect of ancient ceramics. The digital restoration technology of ancient ceramics can reduce the unnecessary time and money investment of archaeologists, and at the same time, it can also ensure the accuracy, actual efficiency and effect of ancient ceramic restoration. Therefore, the digital restoration technology of ancient ceramics has positive application value and significance for the restoration and protection of cultural relics. There are still some deficiencies in human research, which are mainly reflected in the equipment conditions and research objects. The test equipment is not accurate enough to perform in-depth analysis and measurement. In the future, other laboratory equipment will be used to validate and refine the research content of this paper.

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