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Computer-Aided Design and Applications

# Using CAD Technology and Multimodal Data Analysis to Explore the Craftsmanship of the Intangible Cultural Heritage: Li Pottery Art

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**Abstract.** Intangible cultural heritage (ICH) is not only an important manifestation of national identity and cultural diversity but also a bridge connecting the past and the future. This article aims to explore the application and effect of CAD technology and multimodal data analysis in the ICH art production process. Through on-the-spot investigation, I learned about the traditional production technology of Li Pottery art and the challenges it faces. Through data collection and analysis, much information about Li Pottery's modeling, decoration, production time, and so on was obtained. Through the practice of CAD technology, the design of Li Pottery is optimized and innovated. Through multi-modal data analysis, the historical origin and cultural connotation of Li Pottery are deeply explored. The research results show that CAD technology and multimodal data analysis have obvious application advantages in Li Potery's art production process. They not only improve the design accuracy and production efficiency of Li Potery but also provide a scientific basis for its protection and inheritance. The conclusion is that these two technologies have injected new vitality into the inheritance and development of Li Pottery's art and provided new ideas for its innovation and application in modern society.

**Keywords:** Li Potery Art; CAD Technology; Multimodal Data Analysis; Production Technology; Intangible Cultural Heritage
**DOI:** https://doi.org/10.14733/cadaps.2025.S3.286-299

## 1 INTRODUCTION

In the vast field of cultural heritage protection and inheritance, the selection of 3D digital methods for specific skills, such as pottery craftsmanship, also faces complex and refined challenges, especially for non-technical expert user groups, such as ceramic artists, art historians, cultural heritage protection commissioners, etc. The knowledge base is the source of intelligent decision-making in the system, which not only defines the advantages and limitations of the various 3D digital methods mentioned above but also integrates professional knowledge in the field of ceramic art, such as the special requirements of different materials for scanning technology, the integration strategy of traditional craftsmanship and modern digital technology, etc. Given this situation, some scholars aim to design and develop an expert system that focuses on the selection of 3D digital methods for ceramic art craftsmanship. At the same time, the interface also provides flexible query options, allowing users to quickly filter suitable 3D digital solutions based on their specific needs (such as digital purposes, budget constraints, and time requirements). This information includes but is not limited to scanning accuracy, scanning speed, colour reproduction ability, adaptability to complex shapes and materials, device portability, compatibility with post-processing software, etc [1]. Through algorithm analysis, the knowledge base can intelligently match the characteristics and requirements of ceramic works input by users, eliminate unsuitable or inefficient digital solutions, and provide accurate suggestions. The interface design is intuitive and user-friendly, allowing users (even non-technical experts) to input detailed information about ceramic works through simple operations. The database is one of the core components of expert systems, which extensively collects detailed technical specifications of various 3D digital technologies, equipment, and accessories related to ceramic art in the market. Specifically, in response to the characteristics of pottery craftsmanship, the database also focuses on collecting special scanning techniques and solutions that can capture the morphological changes, glaze colour glossiness, and texture details of clay in a moist state. The system aims to become a bridge connecting cultural heritage protection with advanced digital technology, tailoring the most suitable 3D digital solution for each unique ceramic artwork [2].

In the integration of ceramic craftsmanship and modern technology, three-dimensional (3D) printing technology, with its flexibility in material design and infinite combination, is gradually becoming a cutting-edge means of shaping highly complex, artistic, and functional ceramic works. However, despite its broad prospects, the common problem of insufficient density in the 3D printing ceramic process remains a major obstacle to its widespread application in high-end ceramic art creation and industrial manufacturing [3]. Given the current lack of in-depth exploration on how to achieve dense 3D printing ceramics, this review specifically focuses on the core principles of mainstream 3D printing technology in ceramic art. They elaborated on how each 3D printing technology, such as photopolymerization stereolithography, selective laser sintering, melt deposition modelling, and adhesive spraying, uniquely affects ceramic materials, analyzing at the microscopic level how they affect material stacking, sintering behaviour, and final density [4]. This process not only involves a deep understanding of technical principles, but also requires a unique pursuit of material texture, colour, and texture in ceramic art, exploring how to balance artistic expression and material performance by optimizing printing parameters. Especially, regarding natural materials such as kaolin and porcelain stone commonly used in ceramic art, this paper explores how to achieve more uniform sintering in the 3D printing process, in order to achieve or approach the high-density and delicate texture of traditional ceramic works. And deeply explore the role played by key parameters such as raw material characteristics, energy input, and material interaction in promoting the ceramic densification process for each technology. Next, we focus on how to overcome the challenge of insufficient density by adjusting the properties of raw materials (such as powder particle size distribution, particle morphology, chemical composition, etc.) and precisely controlling energy input (such as laser power, sintering temperature curve, post-treatment process, etc.) [5]. In order to significantly enhance the density and mechanical properties of 3D printed ceramics while preserving the unique charm of ceramic craftsmanship, and meet the diverse needs from artistic creation to industrial applications.

When exploring the deep integration of ceramic craftsmanship and modern technology, some scholars have designed a computer-aided engineering (CAE) basic framework specifically designed for optimizing the surface layer of polished ceramics. The quality of functional ceramic chips as electrolytes in high-temperature solid oxide fuel cells directly affects the energy conversion efficiency and service life of the fuel cell. However, there are surface defects such as pores, scratches, and defects in the Tian Yi OIIT of the functional ceramic core. Machine vision inspection, as a non-contact detection technology, has the advantages of high efficiency and repeatability and is increasingly being valued by people. A complete surface defect detection system for functional ceramic chips was designed based on machine vision technology to meet the demand for surface defect detection. Taking defect detection as an example, summarize the research status of machine vision defect detection at home and abroad and summarize the characteristics of existing technologies [6]. The screening of surface defects in domestic functional ceramic chips still adopts manual visual inspection, relying on the naked eye observation of inspectors and subjective judgment to complete surface quality assessment. This manual visual inspection method is inefficient and easily influenced by subjective factors. A machine vision defect detection system was designed to meet the detection requirements of surface defects on functional ceramic chips. The upper computer management software is responsible for data storage and management, executing surface defect detection algorithms, and conducting statistical analysis and visual feedback on defect detection results. It summarizes and analyzes the current research status of surface defect detection in functional ceramic chips, and introduces the application of machine vision technology in defect detection, as well as the characteristics and advantages of machine vision and deep learning detection technology [7]. It mainly includes a lower computer functional ceramic chip image acquisition control unit, upper computer management software, etc. The lower computer image acquisition unit obtains surface image data of the functional ceramic chip.

In the deep exploration of the integration of ceramic craftsmanship and modern technology, some scholars have constructed a complex mathematical model. This model cleverly couples Maxwell's equations with the heat equation in both directions and considers the interaction between the thermal and chemical interfaces. For this reason, the controller we developed takes this into special consideration by finely adjusting the input power to avoid overheating and protect the work from damage. In addition, compared with traditional heating processes, the ceramic art process using electromagnetic wave heating exhibits lower greenhouse gas emissions, reflecting its environmental advantages [8]. This model aims to simulate the physical and chemical changes of ceramic works in a specific heating environment, especially when high-frequency electromagnetic waves (such as 2.45GHz) are used for heating. Some scholars have chosen single-mode cavities and rectangular waveguides as media for electromagnetic wave transmission and integrated experimental data into chemical models through model-fitting methods to accurately predict the dynamic changes in the chemical transformation of ceramic materials during heating. To achieve this complex simulation, COMSOL Multiphysics software was used as a powerful computing platform, combined with a specially designed MATLAB controller. Experimental verification shows that the model is highly consistent with experimental data, providing a reliable theoretical basis for innovation in ceramic technology. This controller can intelligently manage input power and cavity impedance, ensuring that the heating process is both efficient and safe, which is crucial for fine glaze colour changes and structural stability in ceramic works [9]. It is worth noting that due to the high dielectric properties of ceramic materials, electromagnetic waves will experience significant attenuation when propagating inside the material, which may lead to local overheating. Further research has revealed a close relationship between electromagnetic efficiency and thermal field, with boundary convection coefficient becoming a key factor affecting electromagnetic heating performance. Parameter research analyzed the influence of different velocities and convective coefficients on the efficiency of the heating process. The results indicate that increasing the speed helps to reduce the maximum temperature, thereby improving the efficiency of electromagnetic heating, which is particularly important for fast and uniform heating requirements in ceramic technology [10].

This study will analyze the production technology and cultural connotation of Li Pottery art and reveal its unique modeling rules and decorative features. This article also discusses the application potential of CAD technology in the design and production process of Li Potery and evaluates its practical effects in improving design accuracy, optimizing the production process and reducing costs. Through this study, we hope to achieve the following goals: first, to provide scientific and technological support for the inheritance and development of Li Pottery's art and promote the modernization of its production process; Secondly, explore the application potential of CAD technology and multimodal data analysis in the field of ICH protection and research, and provide reference experience for the protection and inheritance of other ICH projects; Finally, through this study, we can promote the deep integration of science and technology and culture and contribute cultural wisdom to building a community of human destiny.

The purpose of this study is to explore the production technology of ICH art by using CAD technology and multimodal data. Firstly, the research background and significance are summarized, and then the history, technological characteristics, and inheritance status of Li Pottery art are deeply analyzed. Then it discusses the application of CAD technology in the design and production of Li Potery and the role of multimodal data analysis in Li Potery research. Finally, the application effect of the technology is demonstrated through case analysis, the prospect is summarized, and some suggestions are put forward to promote the sustainable development of Li Potery art.

## 2 OVERVIEW OF ICH ART

A significant phenomenon reflects the flourishing development of the economy in various regions of the country, reflected in the integration of ceramic craftsmanship and the modern construction industry. With the crystallization of traditional and modern technology, ceramic tiles not only carry the functional requirements of architecture but also integrate profound cultural and artistic values. Vital et al. [11] focus on the quality optimization of ceramic tile production in ceramic art, aiming to introduce advanced quality management tools into this traditional craft field. He went deep into the front line of the factory, conducted in-depth interviews with employees and the factory director, collected a large amount of on-site inspection data, and carefully drew a manufacturing process flowchart for eight-hole bricks. By using scientific methods to discover and solve defects in the production process of sealing bricks, we ensure that the final product meets both building standards and showcases the beauty of pottery. With the continuous expansion of the construction industry, especially the rapid development of inland areas, the ceramic tile industry has ushered in unprecedented growth opportunities, but at the same time, it also faces urgent challenges of improving product quality and reducing production failures and waste. In order to further investigate the root causes of problems in the production process, Wang et al. [12] systematically analyzed various factors that lead to brick cracking, cracking, and other failures, including raw material quality, environmental factors, and human operations. This flowchart not only visually displays each key step from raw material preparation to finished product delivery, but also provides a solid foundation for subsequent quality analysis. These suggestions cover multiple aspects, such as optimizing raw material ratios, improving production processes, strengthening equipment maintenance and upkeep, improving production environments, and enhancing employee skills.

In the refinement and innovative development of ceramic technology, ceramic cutting tool materials have become indispensable tools for processing hard and difficult-to-form materials due to their unique advantages - high hardness, excellent wear resistance, and chemical stability. In order to further improve the applicability and performance of ceramic cutting tools in ceramic technology, Yang et al. [13] innovatively proposed a simulation model that combines sintering densification theory with three-dimensional cellular automata technology. The root of these excellent performances lies in the complex microstructure of ceramic cutting tool materials, so in-depth exploration and optimization of their microstructure are particularly important. Its performance far exceeds traditional cutting tools, bringing revolutionary changes to fine carving and shaping in ceramic art creation. How to affect the grain growth of TiB2 TiC SiC nanocomposite ceramic materials during spark plasma sintering (SPS) process. This model not only combines crystal plasticity theory, but also deeply studies key factors such as nanoparticle content, sintering temperature, sintering pressure, and holding time. Through this simulation model, a dynamic evolution model of grain growth in TiB2 TiC SiC nanocomposite ceramic cutting tool materials was successfully constructed, and the optimal sintering process parameter combination was obtained through detailed calculations and analysis. This study not only provides a scientific basis for optimizing the microstructure of ceramic cutting tools but also opens up new avenues for the innovative development of ceramic technology. The results indicate that the composite ceramic cutting tool material prepared under the conditions of a sintering temperature of 1600 ° C, holding time of 7 minutes, and sintering pressure of 40MPa has excellent mechanical properties. This research achievement not only provides valuable theoretical guidance for the research and production of ceramic tool materials in ceramic technology. This lays a solid foundation for us to gain a deeper understanding of the underlying mechanisms of grain growth in ceramic materials and explore more possibilities for high-performance ceramic materials.

In the pursuit of ultimate creativity and exquisite craftsmanship in ceramic art, manufacturing dense ceramic products that combine complex and intricate features with geometric beauty has always been a challenging but fascinating task. Yamazaki et al. [14] ingeniously integrated various ceramic materials to create a variety of ceramic structural works that are both technical and aesthetically pleasing. Traditionally, ceramics have been known for their hardness and fragility, which, to some extent, limits artists' freedom to explore shapes and forms. When combined with multi-nozzle deposition technology, artists can cleverly utilize the anisotropic shrinkage caused by changes in suspension composition to create naturally formed unique ceramic structures. However, with the advancement of technology, an innovative method combining ceramic robot casting and photopolymerization technology has emerged, bringing unprecedented possibilities to ceramic processes. This innovation enables ceramics to maintain their unique texture while having unprecedented flexibility in form, providing ceramic artists with vast creative space and allowing their imagination to soar freely in three-dimensional space. Through two finely controlled secondary moulding methods, self-assembly assisted moulding and mould-assisted moulding, artists are able to shape complex and diverse ceramic structural forms accurately. This technology not only breaks through the limitations of ceramic materials themselves but also innovatively achieves the manufacturing of flexible and/or stretchable ceramic green bodies (which we can call "flexible ceramic bodies" or "expanded ceramic bodies"). From exquisite patterns to magnificent sculptures, each piece showcases the unique charm of the fusion of ceramic craftsmanship and modern technology. Zhang et al. [15] achieved a final density close to the theoretical density after sintering these ceramic works through a carefully designed heating process. What's even more exciting is that this technology can achieve fine feature manufacturing as low as 65 microns, adding unprecedented refinement and delicacy to ceramic works. At the same time, maintaining excellent mechanical stiffness ensures that the artistic and practical value of the work coexist. In summary, this innovative approach combines robot casting, photopolymerization technology, and modern ceramic art concepts. Not only does it simplify the manufacturing process of complex ceramic products and reduce processing costs, but it also injects new vitality and possibilities into ceramic art.

## 3 APPLICATION OF CAD TECHNOLOGY IN LI POTTERY ART PRODUCTION PROCESS

### 3.1 Brief Introduction to CAD Technology

**Figure 1**: Representative works of ancient Li Pottery.

Figure 1 shows the representative works of ancient Li Tao. Figure 2 shows the scene of a Li ceramic artist manually drawing blanks. The research on turning ceramic models mainly focuses on the establishment of mechanism models, which usually contain a lot of data that needs to be measured. In the establishment of the cutting temperature mechanism model, the data that needs to be measured include cutting force and fracture frequency, which means that the cutting temperature value can only be calculated under the premise of knowing the cutting force and fracture frequency. Therefore, the existing mechanism models for machinable ceramics are not suitable for optimizing process parameters. And establish a machinable ceramic cutting temperature and roughness model through numerical simulation. That is to say, it requires large-scale experiments, a large amount of manpower and financial investment, which is obviously unrealistic. Instead of knowing a set of process parameters to calculate the corresponding cutting temperature. If parameter optimization is carried out on the mechanism model, it is necessary to measure the cutting force and fracture frequency corresponding to each possible arrangement and combination of the process parameters involved. The independent variables only contain cutting process parameters, which meet the requirements of multi-objective optimization. However, currently, there is basically no one involved in the algorithm modelling methods for machinable ceramic cutting temperature and roughness.

**Figure 2**: Li Pottery craftsmen pull blanks by hand.

These patterns not only contain cultural elements such as nature worship and totem belief but also reflect the Li people's love and yearning for life.

The firing process is the last level Li Pottery has made. The craftsman needs to control the temperature and time accurately to ensure that the pottery can be successfully discharged from the kiln and present an ideal colour and texture. This link not only tests the skill level of craftsmen but also contains rich experience and wisdom. Although Li Pottery's art bears rich cultural connotations and aesthetic value, it faces severe inheritance challenges in modern society. With the change in modern lifestyle and the shrinking of market demand, many traditional Li Pottery skills have gradually lost their living space and soil. In addition, the aging of inheritors and the loss of skills are becoming increasingly prominent, which makes the inheritance and development of Li Pottery art a dilemma. Figure 3 shows an elderly inheritor of Li Pottery, whose vicissitudes of life and Li Pottery's works together tell the hardships and difficulties of Li Pottery's artistic inheritance.

Fortunately, however, in recent years, with the promotion of ICH protection awareness and the intervention of scientific and technological means, the inheritance and development of Li Potery art has also ushered in new opportunities. Many scholars, artisans, and cultural institutions began to devote themselves to the recording, research, and inheritance of Li Pottery art and explored the innovation and protection of Li Pottery production technology by modern scientific and technological means. CAD technology is a design method based on a computer system, which allows designers to create, modify, analyze, and optimize design objects through 3D modeling software. This technology is widely used in architecture, automobile, aviation, and other fields, and it greatly improves the accuracy and efficiency of design. In the field of cultural heritage protection, CAD technology has been gradually applied to the design and restoration of traditional handicrafts, providing a new means for the inheritance of ICH projects. Tables 1 and 2, respectively, show the comparison of design parameters and production processes for Li teapots.

**Figure 3**: Li Pottery's inheritor and his works.

| *Design Parameter* | *Traditional Manual Design* | *CAD Technology Design* |
|---|---|---|
| Precision | Depends on the inheritor's experience and intuition | High-precision, quantifiable adjustments |
| Design Efficiency | Time-consuming and laborious, difficult to modify quickly | Quick modifications, real-time feedback |
| Design Consistency | Difficult to guarantee | Highly consistent, replicable |
| Design Flexibility | Limited, depends on manual skills | High flexibility, parametric design |

**Table 1**: Comparison of Li Potery design parameters.

| *Production Stage* | *Traditional Manual Production* | *CAD Technology Integrated Production* |
|---|---|---|
| Moulding | Hand shaping, turntable moulding | Precise cutting with CNC machines |
| Mould Making | Hand carving is time-consuming and laborious | CAD design, CNC machine processing |
| Production Efficiency | Low, depends on manual skills | High, automated production |
| Product Quality | Difficult to ensure consistency | Highly consistent, quality controllable |
| Production Cost | High, material waste and time costs | Low, reduced trial and error costs |

**Table 2**: Comparison of Li Potery production processes.

### 3.2 Influence of CAD Technology on Production Efficiency and Cost Control of Li Potery

Accurate design and simulation through CAD technology can reduce the trial and error cost in the actual production process. Designers can quickly test and optimize different design schemes in a virtual environment, which avoids the waste of materials and time costs in actual production. Table 3 shows the production efficiency and cost control of Li Potery.

| *Influencing Factor* | *Traditional Manual Production* | *CAD Technology Integrated Production* |
|---|---|---|
| Trial and Error Cost | High, material waste and time costs | Low, virtual environment testing |
| Production Efficiency | Low, depends on manual skills | High, automated production |
| Mass Production Capability | Low, difficult-to-achieve large-scale production | High, rapid mass production |
| Cost per Unit | High, limited by manual production efficiency | Low, economies of scale |
| Influencing Factor | Traditional Manual Production | CAD Technology Integrated Production |
| Trial and Error Cost | High, material waste and time costs | Low, virtual environment testing |

**Table 3**: Comparison of production efficiency and cost control of Li Pottery.

The combination of CAD technology and advanced manufacturing equipment can realize the mass production of Li Pottery. Traditionally, the production of Li Potery depends on manual operation, and it is difficult to achieve mass production. Using CAD technology CNC machine tools and other equipment, the rapid and accurate mass production of Li Potery can be realized, and the cost of a single product can be reduced.

## 4 THE ROLE OF MULTIMODAL DATA ANALYSIS IN LI POTTERY'S ART RESEARCH

### 4.1 Multi-Modal Data Acquisition of Li Potery Art

In Li Potery's art research, the collection of multimodal data is the primary task. This includes collecting images, videos, audio, and related text materials from Li Pottery. The image data can record the visual characteristics of Li Potery, such as modelling and ornamentation. Video data can provide the dynamic process of the Li Potery production process; Audio data can record the oral tradition and sound information in the production process related to Li Pottery; Text data includes historical documents related to Li Pottery, oral materials of inheritors, etc.

For a complex system, the individuals in the system are abstracted as a node, and the association between individuals is abstracted as an edge, thus constructing a complex network. In the research of analyzing the production process of ICH art by using CAD technology and multimodal data, every production link of Li Potery art is abstracted as nodes, and the association between links is abstracted as edges of a complex network describing the production process of Li Potery art is constructed. Through this network model, we can more clearly reveal the internal structure and evolution law of Li Pottery's artistic production process. The degree $k_i$ of node $i$ signifies the count of edges connecting it to other nodes in the network, or equivalently, the number of nodes directly linked to it. The node's degree is calculated as:

$$k_i = \sum_{j \in \Gamma\ i} a_{ij} \quad (1)$$

Where $\Gamma\ i$ denotes the set of neighbor nodes of node $i$, and $a_{ij}$ stands for the element value at the corresponding $i$ row and $j$ column in the network's adjacency matrix. The term $N_{new}\ k$ represents the average degree of all nodes in the network.

Maximizing the quality function $Q$ leads to an improved feature division. A higher score indicates greater conformity of the detected feature parameters to the objective facts. The quality function $Q$ is defined as follows:

$$Q=\frac{1}{2m}\sum_{ij}\left[A_{ij}-\frac{d_i d_j}{2m}\right]\delta\ C_i C_j \tag{2}$$

$$x_{k+1}=f\ x_k,k\ +w_k \tag{3}$$

$$z_{k+1}=h\ x_{k+1},k\ +v_{k+1} \tag{4}$$

Dempster/Shafer's evidence theory reasoning process assumes equal weight for each piece of evidence and defines the Euclidean distance from evidence $E_i$ to the evidence set $E$ as follows:

$$S_i=\frac{1}{n}\sum_{j=1}^{n}d\ m_i,m_j\ \ S_i\in\left[0,1\right. \tag{5}$$

Among them, $S_i$ serves as an index to measure the conflict degree of evidence $E_i$, indicating the difference between this evidence and others. A small value $S_i$ implies that $E_i$ is consistent with other evidence, resulting in a low conflict degree. Conversely, a large value of $S_i$ suggests that $E_i$ significantly differs from other evidence, indicating high ambiguity and conflict.

### 4.2 Application of Multimodal Data Analysis in Li Pottery Art Research

Through image analysis and computer vision technology, we can accurately extract and classify the features of Li Pottery's modelling and ornamentation. This will help us to deeply understand the artistic style and production process of Li Pottery, and provide a scientific basis for its protection and inheritance. Table 4 shows the detailed classification of Li Pottery's modelling and decorative features.

| *Shape Category* | *Specific Shape Description* | *Pattern Category* | *Specific Pattern Description* |
|---|---|---|---|
| Round | Round, flat bottom, smooth edges | Geometric Patterns | Combination of straight lines, curves, circles, triangles, etc. |
| Oval | Oval, pointed bottom, slightly wavy edges | Plant Patterns | Combination of flowers, leaves, vines, etc. |
| Square | Square, flat bottom, straight or rounded edges | Animal Patterns | Combination of bird, animal, fish, etc. images or elements |
| Irregular | Irregular shape, a combination of multiple forms | Human Patterns | Human figures, human activity scenes, etc. |

**Table 4**: Classification of Li Potery modelling and decorative features.

Audio analysis technology also plays an important role in Li Pottery's art research. By analyzing the audio data related to Li Pottery, we can reveal the sound characteristics in the manufacturing process, such as knocking sound and rubbing sound, which are of great significance for understanding the manufacturing process and material characteristics of Li Pottery. Table 5 is the analysis of the sound characteristics of the Li Potery production process.

| *Crafting Stage* | *Specific Crafting Operation* | *Sound Feature* | *Frequency Range* |
|---|---|---|---|
| Material Preparation | Selecting, cleaning, and crushing raw materials | Knocking sound, friction sound | 200-500Hz |
| Shaping | Hand shaping, turning on a wheel, trimming edges | Patting sound, squeezing sound | 500-1000Hz |
| Drying | Natural air drying, oven drying | No significant sound features | - |
| Trimming | Polishing, carving patterns | Friction sound, cutting sound | 1000-2000Hz |
| Firing | Loading into kiln, igniting, cooling | Burning sound, cracking sound | 200-800Hz |

**Table 5**: Sound characteristics of the pottery production process.

Text analysis technology is also indispensable in Li Potery's art research. Through the analysis of historical documents related to Li Pottery, oral materials of inheritors, and other text data, we can deeply explore the historical origin, cultural connotation, and inheritance context of Li Pottery, and provide rich historical and cultural background for the protection and inheritance of Li Pottery. Table 6 is an analysis of the historical and cultural connotations of Li Pottery.

| *Historical Period* | *Specific Era* | *Cultural Connotation* | *Related Literature/Oral History* |
|---|---|---|---|
| Ancient | Pre-Christ to early AD | Sacrificial, daily use items, reflecting ancient Li social life | "History of the Li Ethnic Group", oral history from inheritors |
| Medieval | Early AD to 15th century | Trade, and cultural exchange, reflecting interactions between the Li and other ethnic groups | "General History of Hainan", trade records, inscriptions |
| Modern | 16th to 20th century | Cultural heritage, artistic creation, reflecting the inheritance and innovation of Li culture | Modern research papers, artistic creation insights, museum collection records |

**Table 6**: History and cultural connotation of Li Potery.

### 4.3 Multi-Modal Data Analysis Helps the Inheritance of Li Pottery's Art

Multimodal data analysis not only provides a new method for the study of Li Potery art but also provides a new idea for its inheritance and innovation. By analyzing multimodal data, we can more accurately grasp the traditional essence and unique charm of Li Pottery art, and provide strong support for its inheritance and development in modern society.

## 5 CASE ANALYSIS

### 5.1 Case Background and Data Collection

In the aspect of data collection, the production data of the workshop in the past year were collected, including the shape, decoration, production time and material consumption of Li Pottery. At the same time, the images, videos, audio and related text materials in the production process of Li Potery were recorded by using multi-modal data acquisition equipment.

### 5.2 Application Effect of CAD Technology in Li Potery Production Process

By introducing CAD technology, the manufacturing process of the workshop has been significantly improved. Using CAD software, the shape and ornamentation of Li Pottery were accurately designed and optimized, and the precise moulding and mould making was realized by advanced manufacturing equipment such as CNC machine tools.

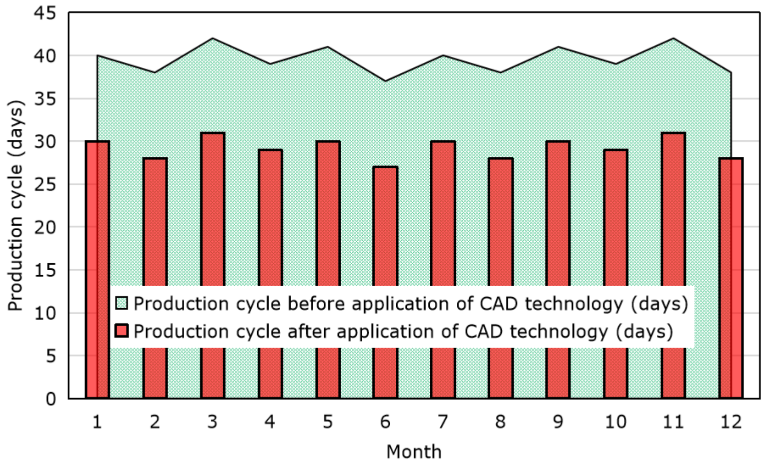


**Figure 4**: Comparison of the production cycle before and after the application of CAD technology.

As can be seen from Figure 4, after the application of CAD technology, the production cycle of Li Pottery is obviously shortened, and the average production time is reduced by about 10 days per month.

### 5.3 The Role of Multimodal Data Analysis in Li Pottery Research

Through the multi-modal data analysis method, the Li Pottery of this workshop is deeply studied. Image analysis and computer vision technology are used to extract and classify the features of Li Pottery's modelling and ornamentation. The sound characteristics in the production process are revealed by audio analysis technology. Using text analysis technology, the historical origin and cultural connotation of Li Pottery are deeply explored.

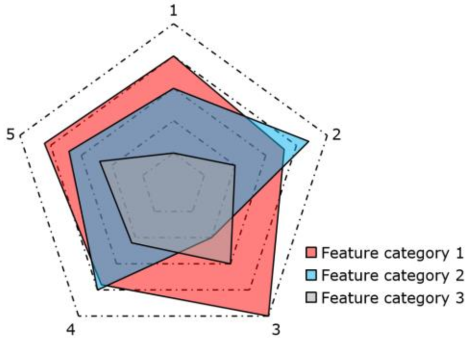


**Figure 5**: Classification results of Li Potery modeling features.

Figure 5 shows the classification results of Li Potery modelling features, and it can be seen that the frequency of different types of modelling features in Li Potery is different, which provides a useful reference for subsequent design and production.

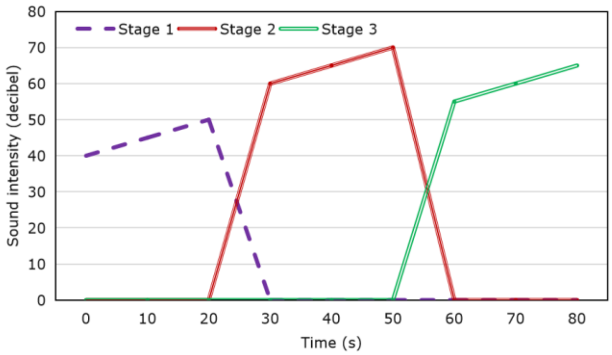


**Figure 6**: Analysis of sound characteristics in the manufacturing process.

Figure 6 reveals the sound characteristics in the manufacturing process, and the beginning and end of different manufacturing process stages can be judged by the change in sound intensity, which provides a basis for optimizing the manufacturing process.

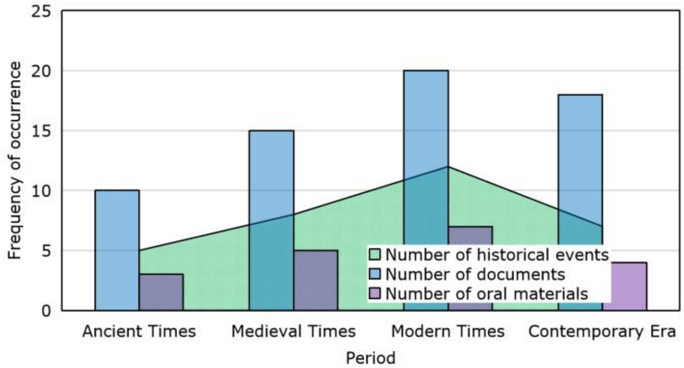


**Figure 7**: Mining results of Li Potter's historical origin and cultural connotation.

Figure 7 shows the historical origin and cultural connotation of Li Pottery excavated by text analysis technology. It can be seen that the development process of Li Pottery and its association with different historical events provide a rich historical and cultural background for the protection and inheritance of Li Pottery.

## 6 CONCLUSIONS

Intangible cultural machinable ceramics have superior physical and chemical properties and are widely used. However, due to its high hardness, the previous grinding method was used, resulting in lower processing efficiency. CAD technology and multimodal data analysis can improve the efficiency of ceramic machining, but there are also urgent problems such as tool breakage and high roughness that need to be solved. Today's optimization algorithms are powerful tools, and using algorithms to optimize process parameters is a way to solve problems. However, there are certainly unknown limitations, and in order to fundamentally solve the problem of machining quality, it is necessary to truly master the mechanism of machinable ceramic cutting. In mechanism research, there are often many unknown parameters that are difficult to solve, and algorithm tools can effectively solve this problem. Combining the advantages of theoretical derivation and algorithm tools, using algorithms to optimize and solve unknown parameters in the mechanism research process will greatly improve the quality of modelling. The design of weights is the most important in the multi-objective optimization process. Although the weight design method proposed in this paper can meet the needs of parallel optimization, it is still not systematic enough and cannot be applied to serial optimization. Further improvement is needed. Looking forward to the future, we can further explore more application scenarios of these two technologies in Li Pottery art and extend them to the protection of other ICH projects to contribute cultural wisdom to building a community of human destiny.

## 7 ACKNOWLEDGEMENT

This work is supported by the Hainan Provincial Philosophy and Social Sciences Planning Project, Study on the Digital Dissemination of Haitian Intangible Cultural Heritage Skills in the Context of the Construction of Free Trade Port (NO.HNSK（YB）23-69).

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## REFERENCES

[1] Adane, A.; Chekole, A.; Gedamu, G.: Cultural Heritage Digitization: Challenges and Opportunities, International Journal of Computer Applications, 178(33), 2019, 1-5. https://doi.org/10.5120/ijca2019919180

[2] Budak, I.; Santosi, Z.; Stojakovic, V.: Development of expert system for the selection of 3D digitization method in tangible cultural heritage, Tehnički Vjesnik, 26(3), 2019, 837-844. https://doi.org/10.17559/TV-20180531120300

[3] Chen, Z.; Sun, X.; Shang, Y.; Xiong, K.; Xu, Z.; Guo, R.; Zheng, C.: Dense ceramics with complex shape fabricated by 3D printing: A review, Journal of Advanced Ceramics, 10(1), 2021, 195-218. https://doi.org/10.1007/s40145-020-0444-z

[4] Hou, Y.; Kenderdine, S.; Picca, D.: Digitizing intangible cultural heritage embodied: State of the art, Journal on Computing and Cultural Heritage (JOCCH), 15(3), 2022, 1-20. https://doi.org/10.1145/3494837

[5] Hu, F.; Mikolajczyk, T.; Pimenov, D.-Y.: Extrusion-Based 3D Printing of Ceramic Pastes: Mathematical Modeling and In Situ Shaping Retention Approach, Materials, 14(5), 2021, 1137. https://doi.org/10.3390/ma14051137

[6] Jiang, C.-P.; Hentihu, M.-F.-R.; Lei, T.-Y.: Three-dimensional slurry printing technology in ceramic and metal application, Solid State Phenomena, 311(1), 2020, 21-26. https://doi.org/10.4028/www.scientific.net/SSP.311.21

[7] Jiao, P.; Alavi, A.-H.: Artificial intelligence-enabled smart mechanical metamaterials: advent and future trends, International Materials Reviews, 66(6), 2021, 365-393. https://doi.org/10.1080/09506608.2020.1815394

[8] Kuzin, V.-V.; Grigor'Ev, S.-N.; Volosova, M.-A.: Basic Framework for Computer-Aided Engineering of Polished Ceramic Surface Layers, Refractories and Industrial Ceramics, 61(3), 2020, 349-354. https://doi.org/10.1007/s11148-020-00485-1

[9] Mahmood, M.-A.; Visan, A.-I.; Ristoscu, C.; Mihailescu, I.-N.: Artificial neural network algorithms for 3D printing, Materials, 14(1), 2020, 163. https://doi.org/10.3390/ma14010163

[10] Ramos, P.-A.-V.; Albuquerque, D.-M.-S.; José, C.-F.: Pereira. Numerical simulation and optimization of the ceramic pigments production process using microwave heating, Chemical Engineering and Processing, 169(1), 2021, 108567. https://doi.org/10.1016/j.cep.2021.108567

[11] Vital, D.-F.; Alencar, D.-B.-D.; Mauro, C.-A.-S.: Optimization of the Production Process of Sealing Bricks in a Ceramic Factory in Urucurituba City in Amazonas – Brazil, International Journal for Innovation Education and Research, 7(10), 2019, 38-55. https://doi.org/10.31686/ijier.Vol7.Iss10.1728

[12] Wang, D.; Zhao, B.; Jiang, M.: Three-dimensional modeling of grain structure growth within ceramic tool material, Journal of the European Ceramic Society, 44(4), 2024, 2000-2012. https://doi.org/10.1016/j.jeurceramsoc.2023.11.013

[13] Yang, Z.; Sun, Q.; Cheng, H.: Preparation of three-dimensional ceramic substrate by multiple electroforming for UV-LED hermetic packaging, Ceramics International, 45(17), 2019, 22022-22028. https://doi.org/10.1016/j.ceramint.2019.07.218

[14] Yamazaki, S.; Ohshita, S.; Oota, M.; Baba, H.; Onuki, T.; Kunitake, H.; Kato, K.: Crystalline IGZO ceramics (crystalline oxide semiconductor)–based devices for artificial intelligence, International Journal of Ceramic Engineering & Science, 1(1), 2019, 6-20. https://doi.org/10.1002/ces2.10005

[15] Zhang, D.; Peng, E.; Borayek, R.; Ding, J.: Controllable ceramic green-body configuration for complex ceramic architectures with fine features, Advanced Functional Materials, 29(12), 2019, 1807082. https://doi.org/10.1002/adfm.201807082