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Research Article

Using Image Feature Extraction to Identification of Ancient Ceramics Based on Partial Differential Equation

Chuanbao Niu[1] **and Mingzhu Zhang**[2]

[1]*Institute of Art Media, Hefei Normal University, Hefei 230601, China*
[2]*Institute of Nursing, Anhui Medical University, Hefei 230601, China*

Correspondence should be addressed to Chuanbao Niu; niuchuanbao@hfnu.edu.cn

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This paper presents an in-depth study and analysis of the image feature extraction technique for ancient ceramic identification using an algorithm of partial differential equations. Image features of ancient ceramics are closely related to specific raw material selection and process technology, and complete acquisition of image features of ancient ceramics is a prerequisite for achieving image feature identification of ancient ceramics, since the quality of extracted area-grown ancient ceramic image feature extraction method is closely related to the background pixels and does not have generalizability. In this paper, we propose a deep learning-based extraction method, using Eased as a deep learning support platform, to extract and validate 5834 images of 272 types of ancient ceramics from kilns, celadon, and Yue kilns after manual labelling and training learning, and the results show that the average complete extraction rate is higher than 99%. The implementation of the deep learning method is summarized and compared with the traditional region growth extraction method, and the results show that the method is robust with the increase of the learning amount and has generalizability, which is a new method to effectively achieve the complete image feature extraction of ancient ceramics. The main content of the finite difference method is to use the ratio of the difference between the function values of two adjacent points and the distance between the two points to approximate the partial derivative of the function with respect to the variable. This idea was used to turn the problem of division into a problem of difference. Recognition of ancient ceramic image features was realized based on the extraction of the overall image features of ancient ceramics, the extraction and recognition of vessel type features, the quantitative recognition of multidimensional feature fusion ornamentation image features, and the implementation of deep learning based on inscription model recognition image feature classification recognition method; three-layer B/S architecture web application system and cross-platform system language called as the architectural support; and database services, deep learning packaging, and digital image processing. The specific implementation method is based on database service, deep learning encapsulation, digital image processing, and third-party invocation, and the service layer fusion and relearning mechanism is proposed to achieve the preliminary intelligent recognition system of ancient ceramic vessel type and ornament image features. The results of the validation test meet the expectation and verify the effectiveness of the ancient ceramic vessel type and ornament image feature recognition system.

1. Introduction

Ceramics is the collective name for pottery and porcelain, a category of materials and products that have been formed in human production and life for more than 10,000 years [1]. The definition of ceramics is a hard substance formed from minerals such as clay, which is formulated, crushed, and shaped after a series of physicochemical reactions under high-temperature firing, and there are types of daily use and architectural ceramics. Daily use and artistic ceramics are more varied and have a high degree of practicality and some appreciation and are a good example of the combination of industry and craft. Ceramic materials are defined as rocks made of aluminosilicates, mainly oxides, by chemical processes at high temperatures and in specific atmospheres (oxidation, carbonization, etc.), which are used to meet the

needs of human production and life and are mostly nonabsorbent, with some surfaces glazed and decorated with patterns. Ceramics is an invention rooted in technology, and ancient ceramic relics are a comprehensive reflection of the technological level, artistic style, and cultural elements of the times [2]. Chinese ancient ceramics have a clear genesis and a vast system, are widespread, and have important physical evidence and footnote in the heritage of Chinese culture, forming a large lineage of ceramic technology and culture that is both inherited and diversified. The world's earliest glaze is the original glaze of China's Bronze Age, after the formation, maturity, and development to the peak of creating a brilliant ceramic civilization [3]. The emergence of white porcelain is one of the five milestones in the history of China's ceramic development and its production for later generations of blue and white porcelain and colourful; pastel porcelain prosperity provided the material basis; especially the emergence of the Xing kiln Sui Dynasty transparent white porcelain has caused great concern in academic circles; its exquisite production process is breath-taking. The invention and application of composite decoration technology are one of the brilliant achievements of China's ceramic science and art, and this unique glaze decoration technique was widely used in the northern and southern kilns such as Jizhou kiln, Duandian kiln, Qiong kiln, Ningguo dragon kiln, and Changzhou kiln. Conducting value perception is one of the important tasks in the conservation and transmission of ancient ceramic relics.

The theory and application of data mining techniques have been improved and sound, driven by the continuous upgrading and innovation of computer science and database and other technologies in recent times. Nowadays, data mining technology has been interwoven with various fields, and the use of data mining technology to analyse problems related to various fields has become a research trend. In the study of ancient ceramics, data mining technology is also a very important and effective method. By constructing a suitable model from the sample data of ancient ceramics, the model can be used for both the classification and prediction of the sample [4]. The classification and prediction of samples mentioned here are called classification and regression problems in the data mining model, and classification and regression are the two data mining models that are most used and relatively well developed in data mining technology. In recent years, the use of statistical related methods in the field of ancient ceramic research in various regions of China has made a lot of progress, and results, such as the use of multivariate statistical analysis methods, VC program development tools, and other research on the classification problem of ancient ceramic ware, have obtained better classification results [5]. Therefore, in terms of the prospect and development trend of using data mining and other techniques in the field of ancient ceramic identification, the use of statistical correlation methods to analyse and process a large amount of accumulated ancient ceramic data, and discovering the inner links and patterns implied in the sample data, especially in the classification of broken sources and generations, the use of these methods can be more in-depth for the research work and can also achieve better results.

To address the shortcomings of these traditional denoising methods, it is important to find a denoising method that can effectively remove noise while considering image details and texture and edge structure information. In recent years, "appraisal" for commercial purposes has flooded the market, resulting in serious misinterpretation of the value of ancient ceramic relics. To deepen the value excavation and technology inheritance of ancient ceramics, innovate ancient ceramic identification methods, improve the level of ancient ceramic value recognition, and solve the problem of "visual identification" of ancient ceramics in the existence of two strong subjectivity, identification cannot be quantified; "scientific identification" is in need of professional technical support. In this paper, we propose the use of artificial intelligence and its auxiliary technology. This paper proposes an innovative identification method for ancient ceramics supported by artificial intelligence and its auxiliary technology and the initial realization of intelligent identification of ancient ceramics, which provides new methods and routes for future intelligent museums, intelligent identification of ancient ceramics, and value perception of inorganic cultural relics, etc.

2. Status of Research

Compared with the traditional image enhancement method, the partial differential equation-based image enhancement method is a later developed image enhancement filtering method, which has the incomparable advantages of the traditional method. To evaluate the image quality of a noisy image restored by filtering, that is, to reflect the performance of the noise removal method, the existing criteria can generally be evaluated by both subjective and objective sides, respectively. Subjective evaluation is a qualitative method, which is susceptible to subjective emotions, and the evaluation results are subject to uncertainty [6]. Currently, most of the methods based on partial differential image enhancement are mainly based on pixel points to design adaptive diffusion coefficients to achieve smoothing or preservation of image details according to different pixel points. Such models as anisotropic diffusion, bidirectional Laplace filtering, and bidirectional impact diffusion are proposed. And the image enhancement process is to a large extent the enhancement of the image detail information [7]. The local detail information is mathematically expressed as the gradient of the image, so the adjustment of the image gradient to achieve the enhancement of image detail is also a more effective image enhancement method. Among them, the parametric activity model is proposed by using dynamics to study the evolution process of the curve [8]. First is by defining an initialized curve; next, the curve evolves under the joint action of its internal force as well as the external force based on image information and finally converges near the target boundary. This model transforms the extraction problem of the target edge into an optimization problem of the energy function. But this traditional model has some defects, such as being sensitive to the initialization position of the curve, being susceptible to noise, and easy to fall into local minima, and in addition, the model cannot converge to the

depression of the object. Until the gray value of the image reaches an average value and terminates, the anisotropic diffusion model can select different diffusion coefficients in different regions to smooth the image according to the local characteristics of the image. To improve the first problem, an improved algorithm based on balloon force is proposed. The main idea of the algorithm is to avoid the curve from falling into local minima by changing the external energy term, i.e., adding the expansion force term, while the internal energy term of the model remains unchanged. To overcome the problem of missing local depression capability, an improved method based on the gradient vector flow model (GVF) is proposed. The main idea of this model is to guide the curve evolution by introducing a gradient vector field so that the curve can converge to the depression region of the target. Later, the method was improved and the generalized gradient vector flow model (GGVF) was proposed [9].

The deep learning behind AlphaGo and Sophia the robot has attracted widespread attention from society and various countries, and related artificial intelligence institutes have been established [10]. The essence of deep learning developed from neural networks, and since deep learning has more layers of hidden layers than traditional neural networks, the more layers the more the essence of the object can be abstracted, which helps to see the distribution of data features [11]. The scientific processing of data is an important part of the use of modern nuclear analysis techniques to study ancient ceramics; multivariate statistical analysis methods use mathematical and statistical principles to analyse multivariate problems; especially with the upgrading and development of computer technology and innovation, multivariate statistical analysis techniques have been widely used in the processing of data in more high-end subject areas; some of the analysis techniques in multivariate statistical methods have become highly practical, simple, and effective modern processing methods [12]. In this paper, multivariate statistical analysis methods are used to deal with multivariate data analysis problems, and common multivariate statistical analysis methods include ANOVA, scatter analysis, factor analysis, discriminant analysis, and fuzzy cluster analysis, to reasonably classify the tires and glazes of ceramic samples of different origins and help categorize the genus of ceramic samples; for example, fuzzy cluster analysis uses a quantitative mathematical modelling method, according to a batch of analysis objects of multiple observations to find out some specific statistic confidence level that can measure the sparsity of each other, and use the characteristics of fuzzy mathematical linear algebra transpose symmetry to establish fuzzy line comparison relationship and classify the research objects [13]. The use of multiple analytical tools to identify and classify the ceramic sample data makes more effective use of experimental data, improves the precision of scientific research, and makes the experimental conclusions reliable [14].

Learning accuracy is the ratio of the number of correctly classified samples to the total number of samples; Fl-score is the summed average of precision and recalls for a category, here the average of F1-score for each category. Precision is the ratio of the number of correctly predicted samples for a category to the total number of predicted samples for that category, here the average of precision for each category. Recall is the ratio of the number of correctly predicted samples for a category to the total number of samples for that category, here the average of precision for each category; recall is the ratio of the number of correctly predicted samples for a category to the total number of samples for that category, here the average of recall for each category. Recall refers to the ratio of the number of samples correctly predicted for a category to the total number of samples predicted for that category, here the average of the recall rate for each category. The recognition rate of the inscription marker image feature refers to the probability that the currently detected inscription marker image feature can be accurately recognized in the learning library. The system proposes a combination of artificial intelligence-related technologies, the main visual features of ancient ceramics, and intelligent application systems to achieve the design and implementation of a nondestructive intelligent identification system for the main visual features of ancient ceramics. The system fully considers the design and implementation of deep learning calls, third-party language calls, and ancient ceramic image databases and proposes a relearning mechanism to solve the problem of incomplete recognition.

3. Analysis of Ancient Ceramic Identification by Partial Differential Equation Image Feature Extraction Technique

3.1. Improved Partial Differential Equation Image Feature Extraction Algorithm. In practical engineering physics problems, to obtain the unknown physical quantities with time and space and the construction of equations or systems of equations, in such relations include not only the partial derivatives of space and the partial derivatives of time but also the class of equations also called partial differential equations:

$$f = \lim_{n\longrightarrow\infty} \sum_{i,j}^{n} a_{ij} \frac{\partial^2 u}{\partial x_i \partial x_j} - \lim_{n\longrightarrow\infty} \sum_{i=1}^{n} b_i \frac{\partial u}{\partial x_i} - cu, \tag{1}$$

$$f(x, y) = \frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial y^2}, \tag{2}$$

$$\frac{\partial u}{\partial t} - \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = f(x, y). \tag{3}$$

Image processing methods based on partial differential equations firstly model the object under study, i.e., construct partial differential equations, and the methods for constructing partial differential equations in image processing problems can be mainly classified into the following categories [15]. For a particular image, the energy generalization function is constructed and converted into a partial differential equation problem by the variational method and the gradient descent flow method, and finally, the image processing process is completed by the solution of the partial differential equation. By

modelling the curve or surface in the image, or a higher one-dimensional curve or surface such as a level set function, the image processing process is completed by controlling the evolution of the curve or surface. In this study, two statistical methods, gray-level cooccurrence matrix (machine vision) and Tamura texture feature (human vision), were used to count the texture features of ancient ceramic texture images to improve the effectiveness and accuracy of the identification of ancient ceramic texture features. The construction method is based on the image problem directly to establish the diffusion term and diffusion direction of the partial differential equation, and the more typical method of this type is the P-M equation. To use finite difference methods in partial differential equation problems, the continuous problem must first be discretized by doing a ratio operation on the difference of functions between two adjacent points and the distance between these two points and then taking partial derivatives of the variables in the resulting function:

$$I(x+\Delta x)-I(x)=\frac{\partial I}{\partial x}\Delta x+\frac{1}{2}\frac{\partial^2 I}{\partial x^2}(\Delta x)^2, \tag{4}$$

$$\frac{\partial I}{\partial x}=\lim_{\Delta x\longrightarrow 0}\frac{I(x-\Delta x)-I(x+\Delta x)}{2\Delta x}-\circ\left(\Delta x^2\right). \tag{5}$$

The denoising method based on variational theory usually needs to consider the properties of the target image, then seek the most ideal form of energy general function by studying these properties, and represent the contents of the image by spatial parametrization, and finally obtain the corresponding partial differential equation for solving to obtain better denoising performance [15]. The improved partial differential equation image feature extraction framework is shown in Figure 1.

The energy generalized polar solution problem can be transformed into solving the corresponding Euler equations. Euler's equations are usually nonlinear and are computationally intensive and difficult to calculate numerically using traditional discretization methods. To solve this problem, the solution of the static nonlinear Euler equation can be transformed into a dynamic nonlinear Euler equation problem by introducing a "time" auxiliary variable. When the evolutionary process tends to a steady state, the solution of the Euler equation is obtained. This process is also known as the gradient descent flow method:

$$E(u)=\int_{x_0}^{x_1}F(x,u,u_x)dx. \tag{6}$$

Due to the complexity of partial differential equations, it is difficult to get the analytical solution of partial differential equations directly in image processing based on a partial differential equation. Therefore, the approximate solution of the partial differential equation can only be obtained by some numerical calculation methods. In practical applications, the most applied computational methods include the finite element method, finite difference method, and spectral method. Due to the low computational complexity of the finite difference method, it is more commonly used in image processing based on partial differential equations. In this section, the numerical computation process based on the finite difference method is introduced. The ratio of the difference between the function values of two adjacent points and the distance between the two points is used to approximate the partial derivative of a function concerning a variable [16]. The idea was used to transform the problem of maidenheads into a different problem. For example, the partial derivative of a function concerning time is often approximated by forward differencing:

$$\frac{\partial I}{\partial x}\Big|_{i-1/2}^{n}\approx\frac{u_{i+1}^n+u_i^n}{\Delta x}. \tag{7}$$

Finite difference methods, finally, are used to obtain the evolutionary form of an equation by converting an intractable partial differential equation into the expression form of an algebraic equation. Finite difference methods contain three categories: explicit, semi-implicit, and implicit. Among them, the semi-implicit form is easy to compute and has high stability, which is more widely used in image processing based on partial differential equations. The classical full-variance denoising method is studied with the development of variational denoising methods and the function of the ROF model, and for the problem of "step effect," a higher-order full-variance improvement method is proposed to suppress the step effect in flat areas of images [17]. Compared with some traditional denoising models, the new model has superior noise removal performance, a higher definition of the denoised image, and better protection of edge information and detailed texture. The effectiveness and stability of denoising are much better, as shown in Figure 2. And if it is set to a smaller value, the global convergence effect will be worse, but at the same time the local convergence result will be better, so it is generally considered that the particle inertia weight range is set between 0.8 and 1.2:

$$\frac{\partial I}{\partial x}=\frac{\partial}{\partial x}\left(k\frac{\partial I}{\partial x}\right)-\frac{\partial}{\partial y}\left(k\frac{\partial I}{\partial y}\right), \tag{8}$$

$$\frac{\partial I}{\partial x}=\operatorname{div}\left(D\nabla I\right). \tag{9}$$

The homogeneous diffusion of the isotropic diffusion method causes the same degree of diffusion in the characteristic regions such as the edges, textures, and corner points of the image as in the flat homogeneous regions of the image, resulting in blurring the edges and detailed textures of the image in the process of removing the noise. In the process of filtering, as the scale parameter increases and the frequency of iteration increases, the degree of blurring of the image increases until the gray value of the image reaches an average value and terminates. The model of anisotropic diffusion, on the other hand, can smooth the image by choosing different diffusion coefficients in different regions according to the local characteristics of the image. In some relatively flat areas, the diffusion coefficient is increased to improve the

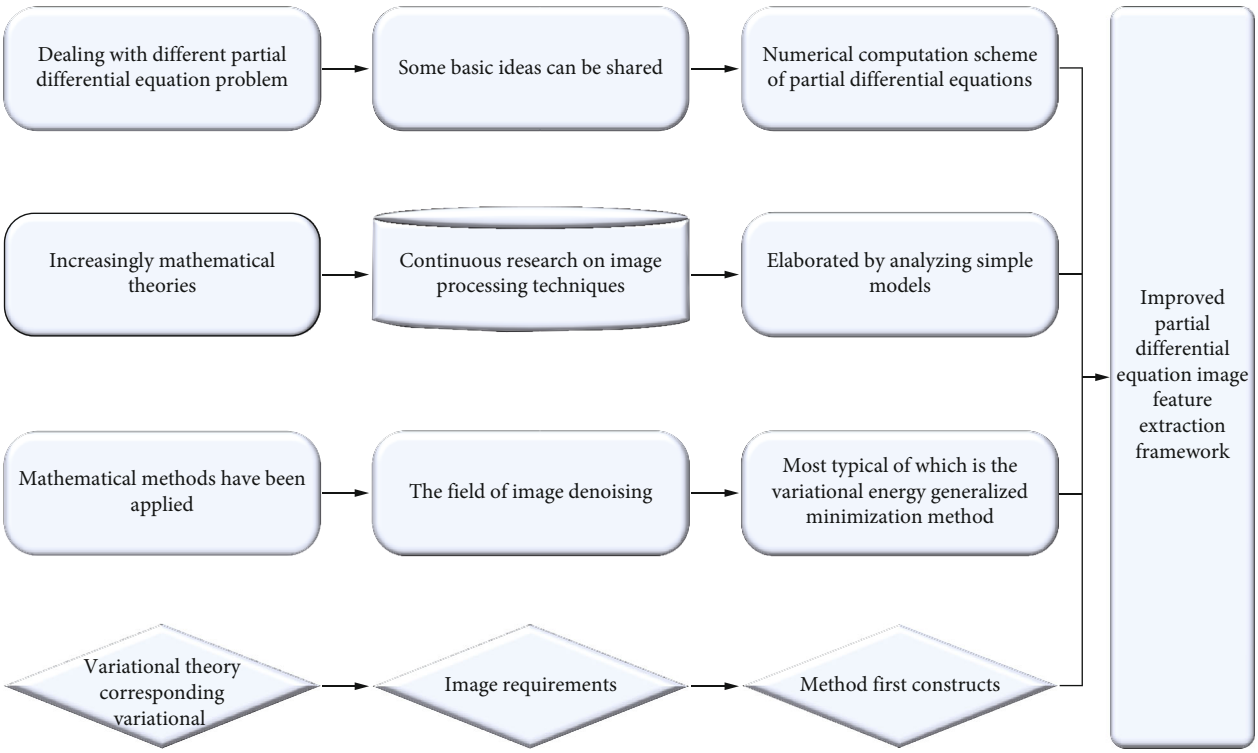

Figure 1: Improved partial differential equation image feature extraction framework.

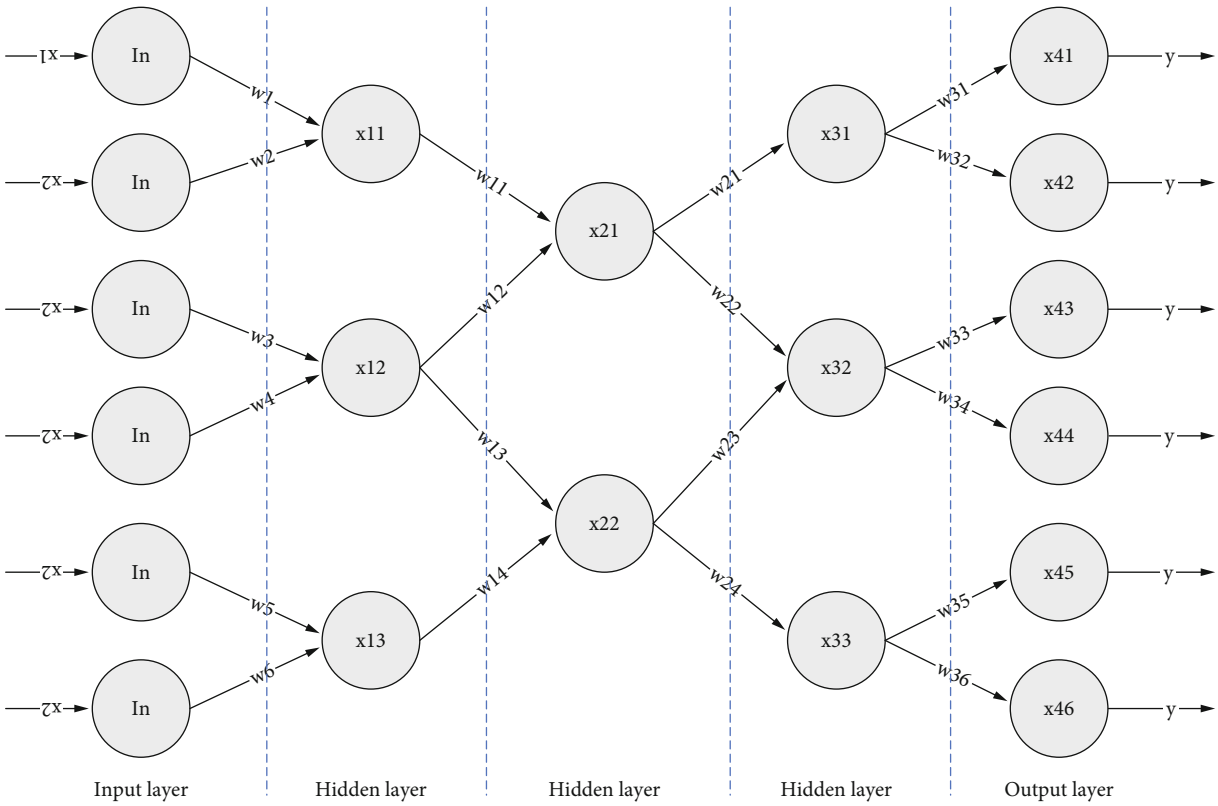

Figure 2: Neural network structure topology diagram.

denoising performance; in the edge areas of the image, the diffusion coefficient is decreased to protect the edge features:

$$\left|\nabla^2 I\right| = I_{\eta\eta} - I_{\xi\xi}. \tag{10}$$

For the extraction of ancient ceramics, there is no definite method to achieve the complete extraction of ancient ceramics. The methods in the framework of digital image processing can only extract the relevant features of a certain type of ancient ceramics of a specific dynasty or extract only some special features, and the extraction methods deal with a single object and do not have generalization characteristics. However, ancient ceramics are a heritage of Chinese traditional culture, and there are various types of vessels and ornaments, which require a feature extraction method with generalization characteristics and are suitable for multiple scenes of ancient ceramics. With the development of artificial intelligence, deep learning, and other related technologies, this extraction method theory and implementation become possible. The deep learning networks mentioned above emerged from the continuous development of deep learning and have advantages for a certain class of images, but all learning networks need to be built under a basic learning framework and programmed to be implemented, and the platform building and programming implementation need to be supported by software and hardware resources. The focus of this study is how to implement ancient ceramic image feature extraction using deep learning; the study does not focus on how to build the framework but to obtain high-quality extraction results.

3.2. Experimental Design of Image Feature Extraction for Ancient Ceramic Identification. Statistical methods of texture features in digital image processing generally have statistical methods, geometric methods, model methods, signal processing methods, etc. Ancient ceramic decorations are usually real-life images of people, landscapes, plants, animals, and other images of ancient ceramic decorations presented and also celadon, white porcelain, and other relatively single-colour types of decorations; considering the texture characteristics of ancient ceramic decorations, it is more suitable to use the signal processing method to describe. The method is a statistical method built on the image time and frequency analysis and multiscale space [18]. Among them, grayscale cooccurrence matrix and Tamura texture features are two commonly used signal processing methods. In this study, two statistical methods, grayscale symbiotic matrix (machine vision) and Tamura texture features (human vision), are used to count the texture features of ancient ceramic ornament images to improve the effectiveness and accuracy of texture feature recognition of ancient ceramic ornament. Grayscale cogeneration matrix of texture features (GLCM), a proposed statistical method for image texture features, is based on the premise that the spatial distribution relationship between pixels in an image contains image texture information and the statistical values former for the pixels in the image of ancient ceramic ornamentation. The grayscale cogeneration matrix generally has 14 statistics, and in this study, four statistics of contrast, autocorrelation, annoyance, and homogeneity are selected to describe the grayscale cogeneration matrix of ornamentation features according to the characteristics of ancient ceramic ornamentation images:

$$f(i^g) = \pi_{w1} p^g(i^g, \theta) + \pi_{w2} p^g(i^g, \theta), \tag{11}$$

$$s_k^g = T\left(i_k^g\right)^2. \tag{12}$$

The particle swarm optimization algorithm includes parameters such as the weight of particle inertia, the maximum velocity of particle motion, and the particle swarm size. The most important of these parameter settings are the inertia weight of the particles and the learning factor of the model. In this paper, the required parameters in the particle swarm optimization algorithm are set based on the empirical method. According to the empirical method, the learning factor of the model takes values between 0 and 4, and in general, the learning factor is set the same, which is set to 2 [19]. For the setting of the inertia weight of the particles, it is considered in the empirical method that since the inertia weight of the particles describes the degree to which the particles in the model maintain their original velocity, the model has better performance in global convergence when the inertia weight of the particles is set to a larger value. When set to a smaller value, the effect on global convergence will become worse, but at the same time, the local convergence results will become better, so it is generally believed that setting the particle inertia weight range between 0.8 and 1.2 will ensure both better performance on global convergence and the convergence speed of the model. In the problem of particle size setting of the population parameters, it is usually considered that the particle size in the particle swarm model is set to 20~40 particles; in fact, most of the practical applications using 10 particles can meet the experimental needs, and the model achieves good efficiency, and when faced with very complex and large data problems, the model population size can be adjusted appropriately to expand the particle swarm population size, as shown in Figure 3.

At the same time, make sure that other users are not allowed to modify the database arbitrarily and only have the power to query and export. You cannot put messy data into it at will. If you want to put data into it, you need to send a request to the system administrator. Among the identification operations include three parts of identification information, according to the different information of sample data, flexible use of identification methods, compared with the analysis results of reference data, different types of data to take different processing methods, biased towards the research object and where the research centre is. The data identification and analysis module are the keys to this system; to ensure the reliability and validity of the data, the experimental data is divided into two parts, part of which is displayed as the final test results, and the other part is used as reference data, using other analysis methods, and finally, through comparison, the advantages of different methods of analysis are summarized:

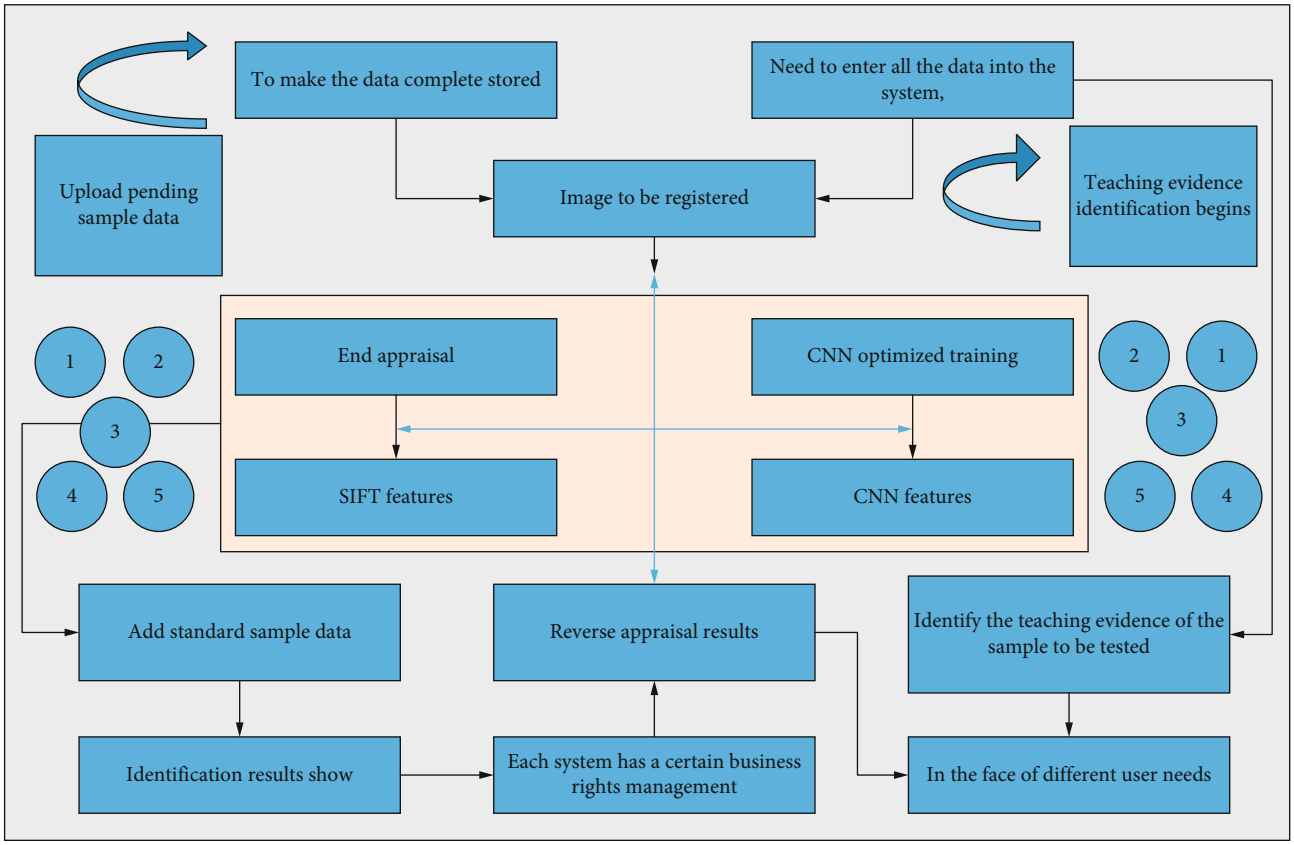

Figure 3: Flow chart of data identification.

$$v_k^g = G\left(z_k^g\right)^2, \tag{13}$$

$$\Delta u = A_{mm}u - uA_{nm}. \tag{14}$$

Each system has a certain business rights management; in the face of different user needs, clear what can be done and what cannot be done. To make the data completely stored in the database, you need to enter all the data into the system, so as not to lose data and at the same time to ensure that no other users arbitrarily modify this database and the users only have the power to query and export and cannot arbitrarily put into messy data; if you want to put data into the system, then you need to send a request to the system administrator, pending a clear analysis of business needs. If you want to put data into it, you need to send a request to the system administrator, and after the business requirements are analysed clearly, you can store the data after the administrator's screening to confirm that there is no malicious modification [20]. There is also the process of identification system progress that needs to carry out certain listening business, that is, logging; this needs to be operated by the later maintenance staff to view. The user management module, that is, management of user information, including the system administrator login interface, registered ordinary user login interface; their interface will be different depending on the rights; the system administrator will do timely feedback on the information of other users; to make ordinary members have qualifications, it must be ensured that membership information in the MySQL data exists, and by built-in membership, to provide the driver of the program to achieve the desire of the database access phase, this membership deep credential provisioning procedure is defined in the project's configuration file web.xml, which configures the user's application to be authenticated using forms, as shown in Figure 4.

The classification and prediction of samples mentioned here are called classification and regression problems in data mining modes. Classification and regression are also the two most used and relatively well-developed data mining modes of data mining technology. In this paper, we use a Gaussian mixture model to estimate the distribution of the gradient histogram. To enhance the image's weak detail information while preventing overenhancement, an extended enhancement of the gradient histogram fitted by a bimodal Gaussian function is proposed. The gradient histogram is divided into two gradient ranges corresponding to weak edge detail and clear edge detail. These two gradient ranges are then adaptively extended [21]. The gradient range for the weak edge detail extended more than the clear edge detail. This will enhance the weak details while preventing overenhancement of the clear edge details. To reconstruct the enhanced image from the transformed gradient field, we use a method based on the matrix sinusoidal transform for a quick and simple solution. The principle and implementation of the extended gradient histogram enhancement with a bimodal Gaussian function fit will be described next:

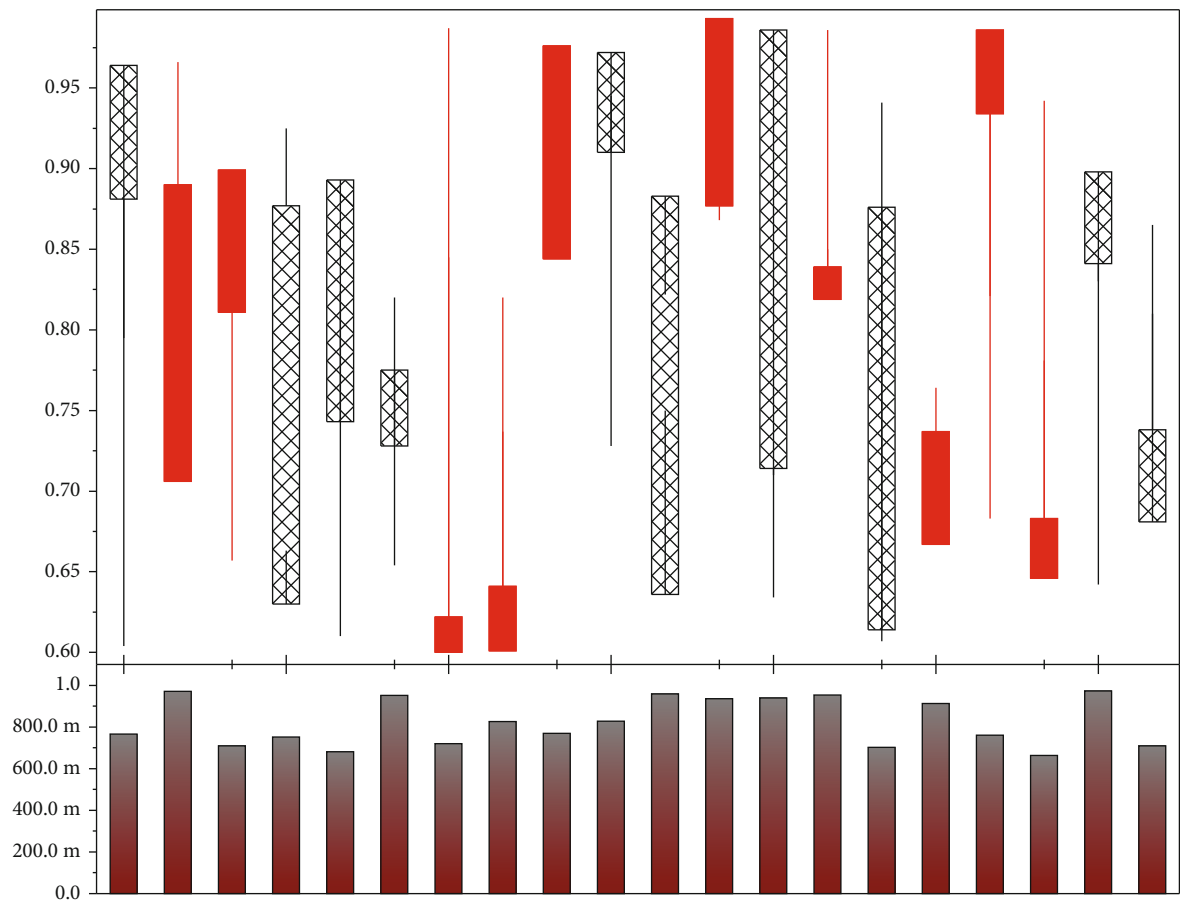

Figure 4: Test data information.

$$AW - WA = P_1 \text{ div } (S)P_2^T. \tag{15}$$

The multilayer perceptron was used, and the parameters were debugged several times, 3 hidden neurons were selected, 80% of the test samples were used as training samples and 20% were used as prediction samples, and the prediction model was built with hyperbolic tangent excitation in the hidden layer, constant equation activation output, and the stopping rule of infinite approximation to the lowest error [22]. The tire data of the three places can be distributed in their respective corresponding positions and coupled with high accuracy; it indicates that the tire raw materials of the three places are highly differentiated, and the raw materials of the three places are not of the same origin.

4. Results and Analysis

4.1. Performance Results of Partial Differential Equation Image Feature Extraction Algorithm. Infrared images, usually, have a low signal-to-noise ratio and contrast, so that edge details are often buried in the background of the noise. In the previous section, we considered the enhancement of faint details. To provide high-quality image information for image applications such as daymark detection and tracking, edge detail enhancement and denoising of images are necessary. For the enhancement of noise-containing images, the noise is also amplified when the edge details are enhanced by conventional methods, such as histogram equalization methods. Therefore, the enhancement and denoising of IR images are a challenging task. Based on the gradient field reconstruction method presented above, the same Gaussian mixture model was used to fit the distribution of the gradient histogram in this section. A denoising and enhancement method for gradient field hierarchical reconstruction estimated by the Gaussian mixture model was proposed. Due to the presence of noise in the image, to achieve noise removal while enhancing the image, the gradient values are divided into three parts corresponding to the faint details of the image, the noise, and the edge details of the clear target. Then, the gradient of the weak details is increased and the gradient of the noise is reduced by constructing a segmentation function. To further suppress the noise, an anisotropic diffusion constraint is added when reconstructing the enhanced image. In this section, the principle and implementation of the denoising and enhancement method for gradient field hierarchical reconstruction based on Gaussian mixture model estimation are developed. In this paper, we use a Gaussian mixture model to fit the distribution of the gradient histogram into three gradient ranges corresponding to the faint details, noise, and clear edges of the target in the image. We then construct a segmentation function that adds weak gradient detail and suppresses the

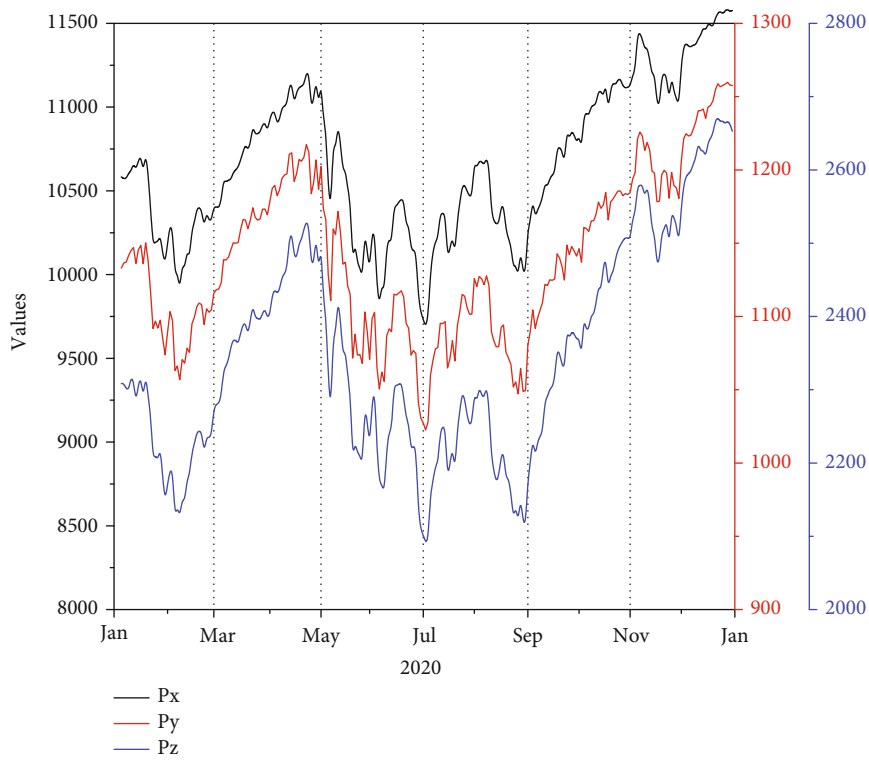

Figure 5: Gaussian fit distribution of the gradient histogram.

gradients of noise. Figure 5 shows the simulation results of the Gaussian and gradient functions.

Compared with some traditional denoising models, the new model has superior noise removal performance, a higher definition of the denoised image, and better protection of edge information and detailed texture. At the same time, the peak signal-to-noise ratio is significantly improved, and the effectiveness and stability of denoising are more excellent. Discover the internal connections and laws implicit in the sample data, especially in the classification of source and dating. Using these methods can not only deepen the research work but also achieve better results.

The experimental results are analysed, and it can be seen from Figure 6 that because the gradient used to detect the edges in the PM model in the process of noise processing is easily affected by the noise, making the image edge regions blurred to a high degree, and because the image is ground off many spikes, corner points and other edge information in the process of denoising result in the image's edge structure being incompletely preserved and the contour features of the character's face being erased somewhat.

The overall image recognition of the inscription is an important part of the intelligent recognition of ancient ceramics; there are many methods about machine image classification recognition, traditional car license plate recognition, door number recognition, and other combination of text recognition problems, which generally use multilabel classification methods for training and the number and other problems as whole feature recognition; such recognition is more reliable compared to the segmentation of the individual recognition effect and is also the future trend of the combination of the license plate and door number recognition. Google has also achieved good accuracy for the recognition of door numbers in general street view by using this method. Considering the convenience of deep learning and the maturity of its application in the field of image classification and recognition, this study uses deep learning as the basis to achieve classification and recognition of inscription model recognition image features.

5. Experimental Results of Image Feature Extraction for Ancient Ceramic Identification

The sample NAA data fields and sample XRF data fields are like the PIXE experimental data and ceramic type information stored in the sample database. To analyse the data effectively, the data in the database is usually sorted from the most informative to the least informative. To analyse the data effectively, the data information in the database is usually displayed on the front-end page according to the order of the data information from the largest to the smallest, so that the user can see the data with more information first, which is convenient to analysing the data. The designed PIXE field information is shown in Figure 7.

The sample data management module is one of the core modules of the system, which manages the core data of the ancient ceramic samples and provides data support for the identification and analysis of ancient ceramics. Taking PIXE data information as an example, the ancient ceramic data management mainly includes the management and

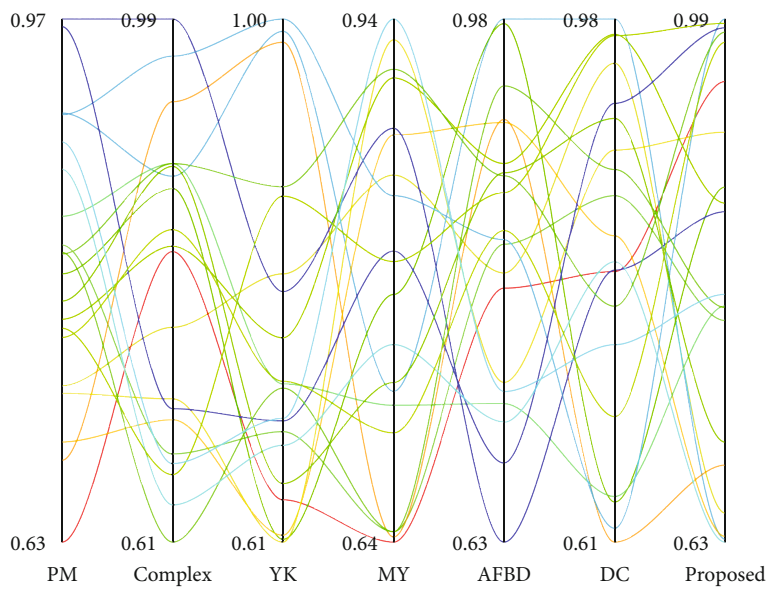

Figure 6: Performance values of the new model approach at different noise levels.

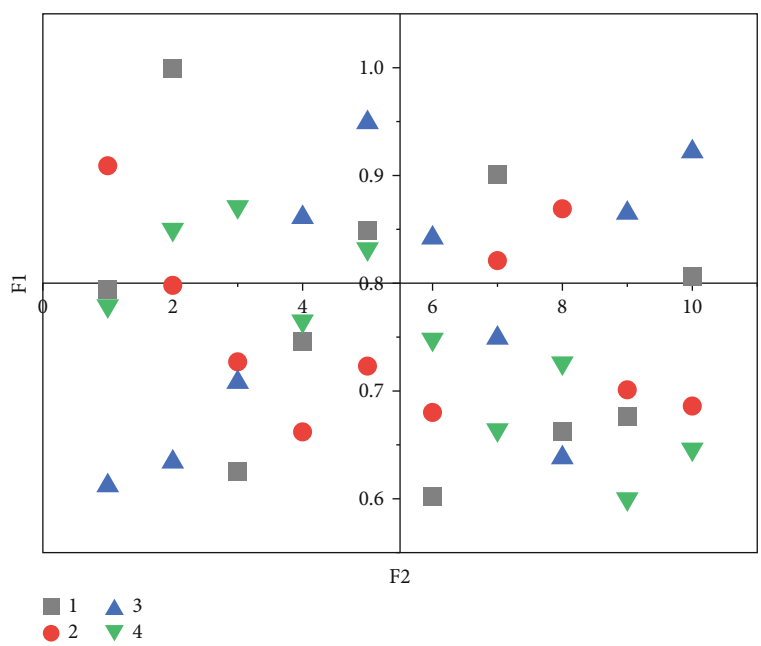

Figure 7: Test sample identification results.

maintenance of the standard sample PIXE data and fast paging query and provides the query results into an Excel file for users to download; the module also provides an Excel data upload template; users fill in the template format to import the sample data; the data can be easily imported into the system database. In addition, taking into account the expansion of the product database, it is necessary to establish a temporary data table, its structure is similar to the standard data table, ordinary users in the addition and modification of sample data are operated on the temporary table, and this can effectively avoid the damage caused by the direct entry of useless data into the system database, in addition, to make the identification results more reliable, but also designed to expand the security of the standard sample data, for example. If the data is valid and reasonable, the data can be imported into the standard sample database for more people to use to achieve the purpose of capacity expansion. The sample PIXE data interface is shown in Figure 8.

After getting the sample data information through the experiment, it is put into the system database, and then, the key data analysis module is carried out; this part involves the specific algorithm of data analysis, which needs to understand the working principle of factor analysis, cluster analysis, etc., and then design the implementation of system

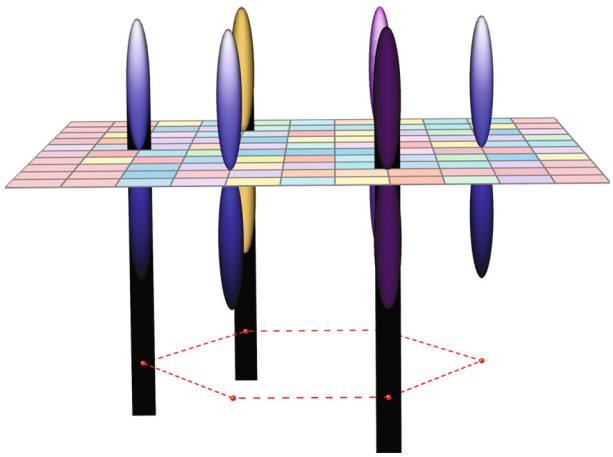

Figure 8: Sample PIXE data.

data analysis according to the specific needs; each data analysis has its operation process; the following will describe the implementation of data application analysis.

In today's big data economy, classification is often used to find the common features of data in the database and the existence of a set of data objects linked by mapping the relationship with the function expression of regression analysis, and also, the idea of clustering is used to separate the similarity and maximum difference of data to ensure that the correlation between different categories is very low and the properties of data in the same category are very close, as well as the use of ultra-advanced neural network recognition technology to the nonlinear and undisciplined data. These underlying algorithmic principles helped build the data analysis module for the experiments in this paper. By modelling the curve or surface in the image, or a high one-dimensional curve or surface such as a level set function, the image processing process is completed by controlling the evolution of the curve or surface.

There are many discriminant analysis methods, including Fisher's discriminant, distance discriminant, and k-nearest neighbour algorithm. A systematic equation is established to screen the classification, and the discriminant function is the equation given by this classifier, and the result of the discriminant maximizes the difference between two groups and minimizes the dispersion between each group internally. After calculating the grouping mean of the categories for samples of known categories, for the observed quantity of any sample to be tested, if for any sample to be tested, if the new sample is closest to the grouping centre of the nth category, then this sample can be considered to belong to the nth category. When using SPSS software for discriminant analysis of the test sample data, the attribution categories of each sample are set considering that the discriminant analysis is to determine multiple categories and to ensure that each category is allowed to be better classified after projection.

6. Conclusion

Based on the principles of multivariate statistical analysis methods, several important data analysis techniques are used for data processing, functional design, database construction, and business process design carried out, in addition to the preparatory work required for system coding, as well as the principles and operations of the implementation process of the key modules of the system, and the principles of some nuclear analysis techniques required in the implementation process of the system are introduced in detail to help. It also describes in detail the principles of some of the nuclear analysis techniques required in the implementation of the system to help users to recognize the advantages and disadvantages of these techniques. The physicochemical properties of ancient ceramics are closely related to the colour characteristics of the decoration images, and the content of certain elements is the root cause of the variation of the image characteristics of the decoration. Therefore, a multidimensional feature fusion method is proposed to identify ancient ceramics with colour features and texture features, machine vision and human vision mixed fusion, grayscale cogeneration matrix and average Euclidean distance of Tamura texture features as texture features, and colour histogram and HSV colour space average similarity rate as colour features. The experimental samples of Yaozhou kiln celadon, Yue kiln celadon, pastel, and enamel are used for experimental validation with 20% pretzel noise (simulating impaired grain image features) and random partial missing (simulating partial missing of grain image), and the validation results meet the expectation of grain image feature recognition. The method fully considers machine vision and human vision, considers both texture features and colour features, and achieves effective recognition of grain image features of ancient ceramics of different types of ages and kilns. For the intelligent recognition system for image features of traditional ceramic products (works), system requirements are oriented to specific problems, and based on the proposed and validated methods for recognizing image features of vessel types, ornaments, and inscriptions, the system functions and performance requirements are proposed. The system is divided into 5 modules and detailed design for image feature data storage, deep learning service packaging, and third-party programming language call to implement the minimal prototype system. After dividing the test cases, the system is tested for application, and the test results meet the expectations, and the problems in the test are analysed, and the machine intelligent recognition of ancient ceramic image features is initially realized.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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