

Retraction

Retracted: Art Product Recognition Model Design and Construction of VR Model

Security and Communication Networks

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] T. Wu, "Art Product Recognition Model Design and Construction of VR Model," *Security and Communication Networks*, vol. 2022, Article ID 3994102, 13 pages, 2022.

Research Article

Art Product Recognition Model Design and Construction of VR Model

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The artwork embodies a profound human history and carries the essence of human civilization. Its content is complex and covers a wide range. How to use advanced technology to quickly and accurately classify and retrieve is an important research topic in the field. In our study, we first according to the requirements of practical application scenarios and existing data conditions proposed an overall scheme of artwork identification and retrieval. Through the functional analysis of the software required and the comparison of various databases, we present the system architecture design and data conceptual design, and complete the system-level planning and design. Then, the crawler grabbing process is designed to obtain artwork graphic data, the artwork dataset production process and labeling status required for the target application scenario were introduced, and the category imbalance state of the target dataset was analyzed. Moreover, the database table structure design of the artwork identification and retrieval system, design and development of each functional module of the server, and the web client was introduced. Finally, according to the organization, structure, and characteristics of virtual reality system, a product design evaluation system based on virtual reality technology was constructed. A theoretical model VR-PDES was designed for the application of virtual reality technology in product design evaluation. The results of this research are of great significance for people to search for images of unknown artworks and improve the service capabilities and service levels of scenic spots.

1. Introduction

The artwork embodies a profound human history and carries the essence of human civilization. Its content is complex and covers a wide range. How to quickly and accurately classify and retrieve art products with the help of advanced technology is an important research topic in the field. Using the convenience of mobile terminal to obtain image data, combined with the recognition and retrieval technology based on image content, this “Internet +” method can quickly form the actual application effect in the scenic area, making the educational value, cultural value, and even collection of artworks. Value can flow directly and truly to the general public.

Google, Microsoft, Baidu, Hikvision, Taobao, Tencent, and other large domestic and foreign companies are at the forefront of the research and application in the field of

imagery. Uber, DiDi, SenseTime, Megvii, and other emerging visual technology companies and domestic cooperation with foreign universities to explore the application of images in security, driverless, retail, and other fields. At this stage, the number of computer vision papers published by domestic and foreign institutions and enterprises in top conferences such as CVPR and ICCV accounts for a large proportion, and the number of papers is also increasing rapidly. Image recognition and retrieval are the areas that researchers focus on.

Identifying and retrieving artworks based on image features mainly involve modeling the image content of artworks, and then identifying and retrieving them based on the representation of the constructed image content. Image recognition refers to giving the category information of images at the semantic level. In the field of artwork, image recognition needs to give the specific category of the image

in its field or judge that it does not belong to any category in the field. This multi-classification problem usually has many feasible solutions. Common methods include k-nearest neighbors, support vector machines, adaptive boosting methods, neural network methods, etc. Whether it is a recognition task or a retrieval task, the models they used are based on the feature quantities describing the image content to achieve the ultimate goal. Early information retrieval is mainly based on the content of text annotations, and image retrieval based on text annotations is also one of the most common image retrieval methods. Image visual information is closer to the objective information description of objects than text annotation content. Using image content to identify and retrieve artworks has the advantages of accurate, comprehensive, and objective information. The image content description of artworks can be based on local features or deep convolutional features. Both types of features have received more research attention in the past ten years.

There are many kinds of features that describe the visual content of images, and the first to achieve better results in recognition and retrieval tasks is the local features of the image. The local feature uses the gradient statistics of the region around the stable extreme point of the image to describe this sub-region. The most typical is the SIFT feature proposed by Lowe in 1999 [1]. This feature uses the Gaussian difference and downsampling method to establish a Gaussian blur map and Gaussian difference map in a continuous scale space similar to a pyramid structure and then uses 26 neighborhoods. The extreme values screen out the stable regional extreme points and, finally, use the direction-normalized regional gradient statistics to represent the feature points and their neighborhoods. When using local features for image recognition or retrieval, researchers mainly draw on the research results of document classification and retrieval. Sivic first introduced the bag-of-words model into the image field in 2003 to quantify the local features of images into visual images with certain semantic attributes. Vocabulary forms a visual bag-of-words model BOW [2].

The convolutional features of images are trained from convolutional networks. Important progress has been made in image recognition, object detection, semantic segmentation, and image retrieval. It is a hot research hotspot and application direction. From a cognitive point of view, convolutional neural networks simulate biological cognition to learn the features of input images. The features generated by this learning process are closer to human perception than artificially designed local features. In recent years, a breakthrough for deep convolutional network learning has been made. In 2012, Alex showed the huge advantages of convolutional neural networks by using the leading edge of deep convolutional neural networks in the recognition task of ImageNet large-scale datasets [3]. In the tasks related to image content recognition, classification models such as the VGG model [4], the inception model [5], and the ResNet model [6] continuously refresh the recognition accuracy to new heights in the classification tasks of the benchmark datasets. The size of the parameters is also gradually reduced. In the target detection task of image content, the RCNN

model [6], the Fast-RCNN model [7], and the Faster-RCNN model [8] have successively achieved staged progress in detection accuracy and real-time performance. In the pixel-level semantic segmentation task, the FCNN model [9] and the mask RCNN model of Kaiming in 2017 [10] have continuously pushed the accuracy and real-time performance of target pixel-level semantic segmentation to a higher level. In image content retrieval tasks, more and more researchers turn their attention to deep convolutional models.

Regardless of whether local features or deep convolutional features are used, when training images for classification tasks, the problem of dataset category imbalance often occurs. This type of problem is essential that real-world data conditions impose constraints on model recognition performance. Therefore, image data category imbalance is a common problem that classification models in pattern recognition need to face. Faced with this kind of problem, researchers have tried a variety of coping methods and techniques in the past ten years, mainly at the dataset level and the model level, to reduce the adverse effects of imbalanced datasets. When evaluating the recognition performance of the model, in order to more objectively evaluate the classification status of the classification model for each category in the imbalanced dataset, the researchers generalized the ROC curve and AUC value commonly used in classification problems in the medical field to common application scenarios to evaluate the performance of the model. For example, in 2006, Fawcett gave a systematic introduction to ROC curves and AUC values [11].

There are two main methods of image recognition at present: one is to construct visual words to establish image representation for identification and classification, and the other is to construct neural network models (mainly convolutional neural network models) for identification and classification. In 2003, Sivic proposed the bag of visual word model (bag of visual word, BOW) and used it to describe the visual content with specific attributes in the image dataset [2]. The class center points formed by local features through clustering can be used as visual words, and a certain dimension of high-level features of deep convolutional networks can also be used as visual words. Looking back at the SIFT feature extraction process summarized by Lowe [1], the process can be divided into two steps: finding key points and building local descriptors. In the first step, the key points are formed by extracting the extreme points in the scale space for screening. When performing local feature clustering, a random k-d tree approximation K-means algorithm is often used [12]. The visual word is the basis of the visual content of the image, and the description of the image content constructed by local features is based on this visual word. Since the common visual words between images are difficult to describe the characteristics of a single image, the statistics of such visual words have little contribution to the description of the image content and should be distinguished from the less common visual words between images. When describing image content frequently, visual words are also given different weights. This weight (inverse document frequency, IDF) is inversely proportional to the frequency of visual

words appearing between different images. The weighted description is the word frequency-inverse document frequency value, which can accurately describe the image content. After the image content description amount is constructed, it can be recognized and classified by common classifiers, or it can be directly used for retrieval tasks. Therefore, the image content description amount has important content representation significance for image recognition retrieval [13].

There are many choices of common neuron activation functions, such as sigmoid function, tanh function, ReLU function, etc. [14]. These activation functions can approximate the linear or nonlinear output characteristics of biological neuron activation. Multiple neuron structures are connected to form an artificial neural network. Neurons at various levels in the network can represent signal patterns in different levels of meaning. The learning process of simulating biological neural structure adjusts the weight parameters and bias parameters of neurons, so that different neurons have different responses to the input; that is, neurons can describe various input patterns, and neurons located in the same layer are different from each other. The larger the output value, the more obvious the pattern is. The last layer of the neural network is usually the output layer. The larger the output of the neuron in the output layer, the more obvious the category attribute is, so as to realize the classification. In an artificial neural network, the input of each neuron includes the output of all neurons in the previous layer, which is fully connected. When the neurons in a layer are fully connected, a fully connected layer is formed. However, image signals belong to two-dimensional signals (such as grayscale images) or three-dimensional signals (such as RGB images). The spatial relationship within the image is different from that of ordinary one-dimensional signals. Its texture, color, brightness, and other characteristics often show regional distribution, strip distribution, or linear distribution, and these characteristics can be observed from the operation results by performing a convolution operation with a specific convolution kernel. Therefore, the full connection of multi-dimensional signal input neurons can be realized within the field of view of the convolution kernel, and the basic neurons of the convolutional network can be constructed. The neurons of the convolutional layer only connect the input within the field of view of the convolution kernel, and a convolution kernel only needs one bias parameter. Multiple convolutional layers are stacked to form a deep convolutional network, and the parameter size of the same input is much smaller than that of the fully connected layer [15]. Pooling the convolution output graph by sub-regions (e.g., mean sampling, maximum sampling) can significantly reduce the total number of output neurons and enable the convolution of the next layer to cover a wider initial graph, and the amount of computation is also significantly reduced; usually, a convolutional layer is followed by a pooling layer. The output of the depthwise convolutional layer is passed through the fully connected classification layer; that is, the final category output can be obtained.

The application of virtual reality technology in product design and development provides a new way for product design [16]. Combined with equipment stereo glasses, helmets, data gloves, trackers, etc., and projection equipment through digital models, the virtual world of the product is generated. This virtual world is the combination of the entire virtual environment and a given simulation object. It acts on people through vision and touches to create an immersive feeling. Everyone's operation and modification can timely reflect on the digital model. In this way, the information interaction among people and between people and machines is more real and accurate, and the validation products provide a new development direction for design evaluation [17].

The equipment required by virtual reality technology is complex and expensive. Evaluation data can be collected on the basis of virtual reality technology under current conditions [18]. Use personal computers and software to cooperate to carry out product design evaluations. Process data information through a personal computer and output the final data through the personal computer. Finally, form an intelligent product design evaluation system based on virtual reality technology support, called VR-PDES (virtual reality-product design evaluation system). The application of a VR-PDES for product design evaluation can simplify and intelligentize the product design evaluation method of complex systems. Using the VR-PDES can obtain more accurate evaluation results. It is convenient and practical. It can reduce a large number of mathematical analysis tasks in traditional design evaluation. It greatly shortens the time of data processing. It is convenient and intuitive to obtain product design evaluation results, so as to better assist designers and producers to make correct decisions, improve the efficiency and success rate of product design, and reduce the risk of new products.

In our study, we first proposed an overall scheme of artwork identification and retrieval; second, designed a crawler grabbing process; third, designed a development of each functional module of the server and the web client; and fourth, constructed a product design evaluation system. Section 2 introduced the scheme design method and data collection process of artwork recognition retrieval; Section 3 is the results of the study and discussion; Section 4 is the main conclusions.

2. Scheme Design and Data Collection

2.1. Scheme Design. The identification and retrieval system designed in this paper is aimed at the actual application scene of the scenic spot, using the image content of the artwork as a clue to identify the information needs of the user in the actual scene and the existing graphic data of the artwork in the scenic spot, the graphic data of other collections, and the industry website [19]. The graphic data of the platform and the related graphic data of the e-commerce platform are connected. The starting point of the requirement is the artwork query image submitted by the user, which is also the input query data for the identification retrieval system. The endpoint of the requirement is the most

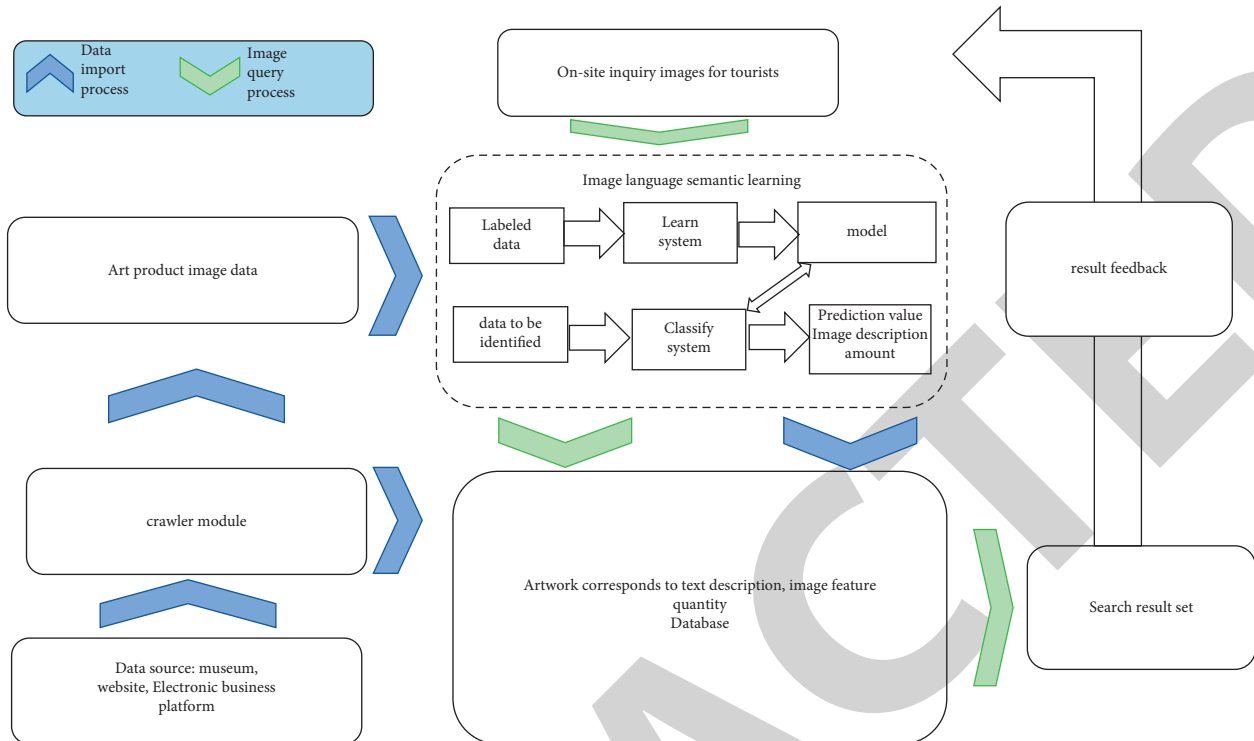


FIGURE 1: Schematic diagram of the overall scheme of artwork identification and retrieval.

relevant part of the query image in all graphic data that has been imported into the system. The identification and retrieval system must not only understand the images provided by the demand side but also understand all the images included and crawled by the system in advance. Through the understanding of the image, the system will complete the construction of the image description required for the identification and retrieval process, that is, complete the mapping of the image to the image content description (Figure 1). Each image included and crawled by the system has many textual descriptions directly corresponding to it.

The unstructured data of artwork images involved in this paper are acquired in a different way from ordinary sensor data collection processes. Artwork images are mainly captured by a variety of cameras. The sources of the data used in the project include some graphic data of cultural objects provided by partners, as well as graphic data of artworks displayed on third-party websites. Crawling artwork data from third-party websites will effectively supplement the data provided by existing partners. Expanding the data scale through web crawling can not only provide enough information for the query but also provide enough training samples for the identification and retrieval model to make the model more generalizable and effectively reduce the possibility of overfitting.

Due to the diversification of data sources, all the images collected for the first time need to be preprocessed such as de-duplication and outlier point screening, and the existing semantic labels must also be checked by matching to remove erroneous items. Before image semantic learning, the labeled image data are organized to form training datasets,

validation datasets, and test datasets. These data will be used for semantic feature learning of artworks and image description encoding learning. The learning process of image semantic understanding can obtain the final recognition model and its model parameters, and the learning process of image description coding can obtain the image coding model suitable for retrieval calculation and storage. After the images of all corpora are encoded by the encoding model, the corresponding encoding description of each image is generated and then imported into the database for use in the subsequent retrieval process. Therefore, the model for image semantic understanding must have sufficient semantic understanding ability and computational response speed. The similarity between the codes created by the image coding model should be consistent with the similarity of the initial image description and have more convenient storage and faster distance calculation feature.

This paper presents the architectural design of the artwork identification and retrieval system, as shown in Figure 2. The entire system is built on the Internet platform, which ensures that every visitor can obtain this artwork identification and retrieval service through image content after accessing the network. The cloud database, SSM framework, and cloud server are the operating platform of this system, providing overall data support and operation support. Above the operating platform is the service layer of the system, including query and retrieval services, data update services, image understanding services, feature extraction service, image coding service, realizing the organic connection between the operating platform, customer service terminal, and management platform. And above the

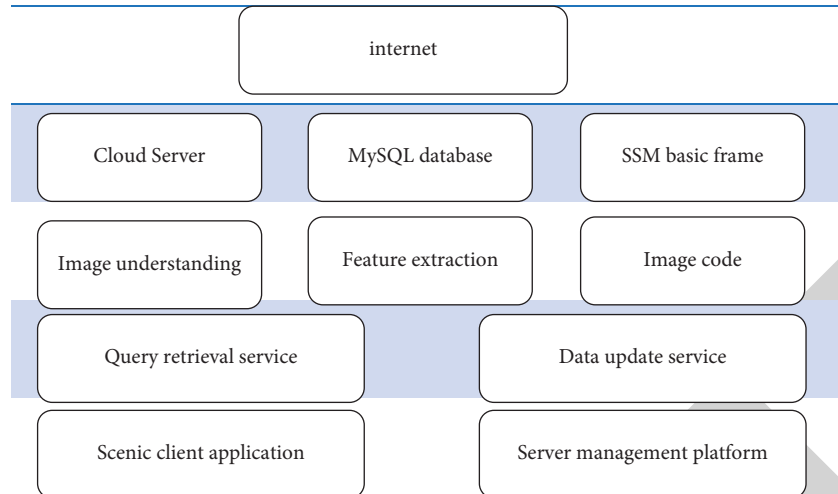


FIGURE 2: Artwork recognition and retrieval system architecture diagram.

service layer is the application layer directly facing users and administrators, including client applications and server management platforms.

Specifically, the database is an abstract warehouse that stores the target dataset. It organizes and stores the target dataset according to the exact data organization form or the relationship between the data. The development of information technology in the past few decades has formed three common forms of databases: hierarchical databases, network databases, and relational databases [20]. These three databases connect and organize the storage of datasets according to different data structures. There are two main types of database models used in current mainstream Internet applications, namely, relational databases and nonrelational databases. The relational database model reduces various complex data structure relationships to simple binary relationships, that is, data relationships in the form of two-dimensional tables [21]. The relational database implements various operations on the data on the basis of two-dimensional tabular data. One or more relational tables in the data table provide target data link paths for these data operations. Operations such as selection can realize most of the management operations of the database. The birth of nonrelational databases is to deal with the application scenarios of ultra-large-scale massive data and high concurrent requests. Common relational databases are not applicable in such scenarios. However, considering the data scale and the performance of data management, it is more reasonable to use a relational database for the artwork identification and retrieval system in this paper. The earliest relational databases have been around for over forty years.

The relational database developed from theory to today's multiple optional application products is Oracle database, SQL Server, and MySQL. MySQL is different from the other two. It is an open-source database and has good processing efficiency. It is the first choice for small and medium data management systems. MySQL was first used in Linux systems and was gradually ported to other operating systems. It has excellent cross-platform performance. In addition,

MySQL occupies less resources and is fast, and the use of MySQL does not require commercial authorization similar to Oracle or SQL Server. Considering comprehensively the performance, operation efficiency, management convenience, and economic conditions, the art recognition retrieval system in this paper adopts the open-source MySQL relational database.

2.2. Data Collection. This research has massive artwork graphic data from various museum websites, industry platform websites, and e-commerce platforms, and e-commerce platforms also have massive artwork images and corresponding market price information data to be supplemented and formatted into a dataset with wide coverage and a large amount of information. This information is suitable for fast crawling by crawlers. The design workflow of crawling is shown in Figure 3.

This research uses Python language to complete the crawler design, also uses the web page parsing tool Urllib library and requests library to crawl static pages, and uses the interface-less browser PhantomJS and driver Selenium to crawl dynamic pages.

Whether using local features or deep convolutional features to build an image recognition model, the supervised training process requires sufficient labeled artwork image data for model learning and training. In the training phase of the model, in order to ensure that the model converges reasonably and determines the performance level achieved by the model, a validation dataset and a test dataset are required for verification and testing.

When crawling artwork data on various website platforms, some artworks themselves have been manually labeled and classified and stored in corresponding page directories according to these categories. These known categories can be used as label data to describe the categories of artworks. After sorting out all category information, removing duplicates and removing errors, there are 30 categories of images corresponding to labeled artworks, and

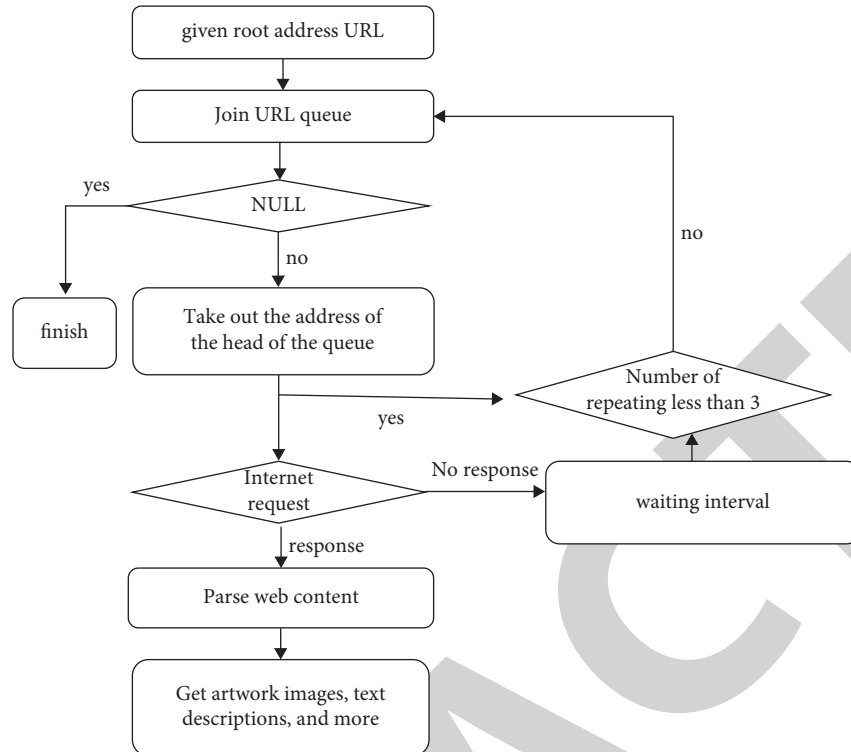


FIGURE 3: Artwork-related website crawler flowchart.

each category has several subcategories, a total of 29990 labeled image data, and a total of 8,3000 images of artworks without labels. The labeled image data will be used for the training of the recognition retrieval model of the artwork image content. All images with and without tags, as well as the corresponding artwork text and other related information, will be used for the final identification and retrieval application.

The class imbalance problem is particularly pronounced with labeled data, with the highest number of classes having over 3000 data and the lowest having only 40 data (Table 1). Sort the number of all categories from small to large, and draw the class imbalance state diagram as shown in Figure 4. The highest and lowest class number ratio is 83.3, the average adjacent number ratio is 1.2, and the imbalance distribution state is an approximately linear increase of two-stage ladder-like.

2.3. Construction Method of VR-PDES Model. Kansei engineering provides research method guidance for system construction. “Kansei Engineering” is a comprehensive interdisciplinary subject between art and design, engineering, and other disciplines. Akira Harada, chairman of the Department of Perceptual Cognition and Neuroscience at the Graduate School of the University of Tsukuba and professor at the School of Art and Design, believes that this kind of synthesis and intersection involves many fields of humanities and natural sciences such as art science, psychology, disability studies, basic medicine, and exercise physiology.

TABLE 1: The initial labeled artwork images divide the dataset by categories.

Categories	Number	Categories	Number
Accessories	60	Jewelry jade	2000
Bamboo and wood teeth	300	Jewelry	80
Books and periodicals	120	Wood carving	230
Bronze	250	Printing/painting	3300
Record player/record	80	Musical opera	100
Ceramic/purple sand	18000	Ancient painting	1200
Clock instrument	300	Disc play	150
Weapon	50	Court religion	200
Weaving	400	Sculpture	400
Enamel	160	Seal	300
Foreign exhibits	60	Old metal coins	100
Furniture	200	Stationery supplies	300
Glassware	50	Bill paper money	190
Law book	500	Gold/silver/bronze	310
Engraved	300	Life utensils	300

Human neural network system provides technical support for the construction of VR-PDES. This system uses artificial neural network method to realize system evaluation data processing. The core algorithm used is network. The idea of realization is to use the design parameters of the product design evaluation in virtual reality as the input end of the network. The design evaluation result of the product is the output end of the network. In the middle is the hidden layer. The product evaluation data and results obtained in the virtual reality environment are used as training samples of the network. The method has a simple operation process,

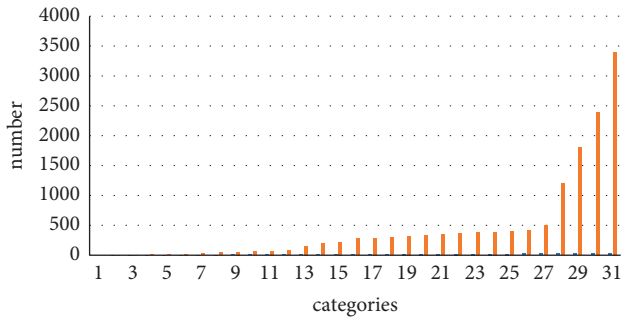


FIGURE 4: Artwork initial labeled data category imbalance distribution map.

does not require designers to have professional knowledge in multiple fields, and meets the evaluation requirements of general designers.

Because the objective things themselves feel different under different environmental conditions, the corresponding evaluation results and decisions made are also different. Only the design evaluation results obtained in the actual use environment of the product are more accurate and effective, and the decision can be made more correct. There are many uncertain factors in the traditional product design evaluation process relying on the experience and intuition of the evaluator. Therefore, there is a need for a method to reduce the uncertain factors in the comprehensive evaluation process and to evaluate the product design more reasonably. In other words, it is necessary to have a higher problem-solving rate. VR-PDES is a kind of intelligent evaluation system for complex systems that meets the above requirements.

Several key technologies in the construction of VR-PDES are the combination of virtual world, user information tracking collection, and software system. The virtual reality system simulates and generates a virtual reality environment through computer and simulation technology, so that the objects in the virtual reality environment can interact with the user more naturally and realistically. User information tracking and collection are to map the multi-dimensional information of the user's thinking and perception in the virtual reality environment to the digital space of the computer to generate corresponding data information and provide necessary and effective information data for the establishment of the system database.

User information tracking mainly includes key technologies such as spatial tracking, sound localization, visual tracking, and viewpoint sensing, which can help obtain detection and operation data of user operations in virtual reality environments.

High-speed large data processing capability is required between mapping and feedback, so high-performance computing processing technology with high computing speed, strong processing capability, large storage capacity, and strong networking characteristics has become our technical basis for realizing virtual reality. It includes some techniques such as pattern recognition, remote network, visualization, database, and advanced retrieval. For the

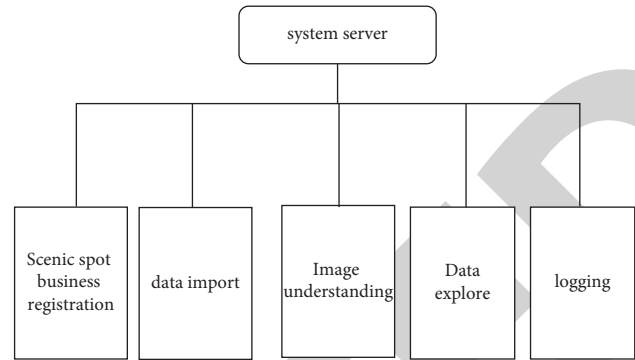


FIGURE 5: System server function tree.

application of VR-PDES, in order to enhance the credibility of virtual reality, it must have the ability to evaluate product design with multi-user participation. Therefore, the collaborative environment is very important for this system. It is an extension of interactivity, which refers to multiple users interacting in the same virtual space. The user is aware of the presence of the SIM, allowing users to interact with each other. The collaborative environment can meet the multi-person presence, or multi-person participation mode can meet the comprehensiveness of a system.

The hardware of the VR-PDES consists of a virtual environment generator, input and output devices, and data interfaces.

3. Results and Discussion

3.1. Server Architecture Design and Configuration. The software platform of this paper provides online services for artwork identification and retrieval applications by building a website. The software platform server program selects the model-view-control (MVC) layered architecture that has been widely used at present, in order to reduce the coupling relationship between programs, improve the convenience of system maintenance, and expand the scalability of the system. In the framework selection of system development, this paper selects the current mainstream development frameworks Spring, SpringMVC, and MyBatis (SSM framework). These frameworks can enable the software platform server program of this paper to be completed quickly and integrate the MVC layering idea into the program.

According to the overall scheme and system software planning, the specific functions of the server are expanded in the form of a function tree, as shown in Figure 5. Among them, image understanding and data query are the two core functions of the server. For the sub-module of image understanding, this paper establishes the VGG-16 model to describe the image content of artworks. The deep learning framework used is TensorFlow. This framework not only has advantages in rapid model building, but also has obvious advantages in practical application deployment. Reliability and scalability are advantages, so the server-side image understanding still uses Google's open-source framework TensorFlow for deployment. This module involves a large

number of matrix operations and has extremely high requirements for processing capabilities. Therefore, a separate image understanding server is set up to handle this part of the function. In addition, the system deploys a separate main server to carry the remaining functions of data import and data query.

3.2. Database Table Structure Design. Seven relational patterns can be established from the database ER diagram of the artwork recognition retrieval system. These seven data tables corresponding to each relationship mode are scenic spot information in Table 2, all artwork information in scenic spots in Table 3, business information in Table 4, business artwork information in Table 5, e-commerce platform information in Table 6, industry platform electricity platform art information in Table 7, and artwork query information query Table 8. All records involving the description of artwork image content use a binary hash code constructed based on a deep convolutional model.

The scenic spot information table provides the basic information of scenic spots or museums, including name, address, brief introduction, and official website link. The name of each scenic spot or museum must be unique.

Scenic Artwork: The table provides detailed information on the collections or exhibits each scenic spot or museum, and the item names must be unique.

Merchant information: The shop table provides the registration information of merchants in the Wenwan collection industry around the scenic spot on this platform, including name, account password, address, and brief introduction.

The merchant artwork table provides the detailed information of the art and crafts operated by the registered merchants on the platform, in which the merchant number of the item should correspond to the information in Table 4.

The data provided by the platform artwork table are the artwork details of each platform crawled from the crawler.

The platform information table provides information on e-commerce platforms and industry platforms that the system crawls artwork data, including names, brief introductions, and links to the main website.

Retrieval query: The query table provides records of artwork query information, including possible QR codes, binary hash codes generated based on image content, and status flags indicating whether the current retrieval is complete or not.

In addition to the previous information tables that need to be directly stored, the identification retrieval process also requires some intermediate tables to assist in completing the information recording of the retrieval process. The two-dimensional code-based retrieval result table (Table 9) and the binary hash code-based retrieval result table (Table 10) are, respectively, used in the record retrieval process. The processing result of the software

platform assists the server and client of the software platform to transmit.

3.3. Image Understanding Module Design and Development.

The image understanding module on the server uses the VGG-16 model to perform migration training on the initial artwork dataset in an oversampling manner, then calculates the high-level feature center points of each category, and trains the hash layer of tanh approximate binary quantization encoding. The model parameters and the calculated class center points are saved locally in the image understanding server in the form of configuration files.

The request of the image understanding module can be initiated by the data query module or by the data import module, and the processing result is sent back to the request initiator separately. The specific interfaces are shown in Table 11.

The program that executes image understanding builds the VGG-16 model and binary hash coding model based on the TensorFlow open-source framework. The images in the data import phase are directly read from the local area, and the images in the data query phase are read from the main server in the local area network.

3.4. Data Import Module Design and Development.

During data import, the system maintainer batches the prepared artwork graphic data into the database in the form of script calls, and the graphic data uploaded by the merchant are an interface call request initiated by the web client. The text description file during batch import must meet the prespecified format, so as to facilitate batch processing of script programs. The data batch import interface is shown in Table 12, and the web upload text import interface is shown in Table 13. The operation flow of the module is shown in Figure 6.

When querying data, the user uploads the images of the retrieved items using the web client to search for similar artworks and introduction information, or to find similar products on sale and introductions. This module also requires an image understanding module to implement binary hash encoding of image content and image recognition and classification.

The registration and login module here is only provided for the registration of users of merchants near the scenic spot, so that the art products of the merchants can be presented online. Tourists who need to query and retrieve services do not need to register. Before using data import, merchants must complete registration and login to have upload permission. The merchant initiates a registration request, the client prompts to enter the relevant information and confirms the server calls the registration verification module to confirm the validity of the registration information, the account can be assigned if the rules are met, and

TABLE 2: Definition of scenic spot information table.

Id name	Id class	Id constraints	Id description
Scenery id	Int (8)	Primary key	Number
Scenery name	varchar (45)	Not null, unique	Name
Scenery located at	varchar (45)	Not null	Address
Scenery description	varchar (200)	Not null	Introduction
Scenery url	varchar (100)	Not null	Link address

TABLE 3: Scenic artwork table definition.

Id name	Id class	Id constraints	Id description
Artwork id	int	Primary key	Number
Artwork name	varchar (45)	Not null, unique	Name
Scenery id	int (8)	Not null, foreign key	Scenery spots id
Artwork bcode	char (6)	Not null	Binary hash code of the item image
Artwork description	varchar (200)	Not null	Introduction
Artwork origin located at	varchar (45)	Not null	Address
Artwork origin time	varchar (45)	Not null	Age
Artwork url	varchar (100)	Not null	Link address
Artwork picFile	varchar (100)	Not null	Figure address
Artwork QR code	varchar (100)	—	QR code

TABLE 4: Definition of shop information.

Id name	Id class	Id constraints	Id description
Shop id	int (8)	Primary key	Number
Shop name	varchar (45)	Not null, unique	Name
Shop pawd	varchar (16)	Not null	Account password
Shop located at	varchar (45)	Not null	Address
Shop description	varchar (200)	Not null	Introduction

TABLE 5: Definition of merchant artwork.

Id name	Id class	Id constraints	Id description
Artwork id	int	Primary key	Number
Artwork name	varchar (45)	Not null	Name
Shop id	int (8)	Not null, foreign key	Shop id
Artwork bcode	char (6)	Not null	Binary hash code of the item image
Artwork description	varchar (200)	Not null	Introduction
Artwork price	decimal (6,2)	Not null	Price
Artwork picFile	varchar (100)	Not null	Figure address

TABLE 6: Industry platform e-commerce platform artwork table definition.

Id name	Id class	Id constraints	Id description
Artwork id	int	Primary key	Number
Artwork name	varchar (45)	Not null, unique	Name
Platform id	int (8)	Not null, foreign key	Shop id
Artwork bcode	char (6)	Not null	Binary hash code of the item image
Artwork description	varchar (200)	Not null	Introduction
Artwork price	decimal (6,2)	Not null	Price
Artwork url	varchar (100)	Not null	Link address
Artwork picFile	varchar (100)	Not null	Figure address

the merchant registration information is entered into the database and returns a successful registration response; otherwise, it returns a failure response. When the merchant

logs in again, the server calls the merchant login module to verify the validity of the account and password, and responds to the information entry page if it is legal; otherwise,

TABLE 7: Definition of platform information.

Id name	Id class	Id constraints	Id description
Platform id	int (8)	Primary key	Number
Platform name	varchar (45)	Not null, unique	Name
Platform description	varchar (200)	Not null	Introduction
Platform url	varchar (100)	Not null	Link address

TABLE 8: Lookup table definition.

Id name	Id class	Id constraints	Id description
Query id	int	Primary key	Number
Query bcode	char (6)	Not null	Query the binary hash code of an image
Query QR code	varchar (100)	—	QR
Query finished	tinyint	Not null	Retrieval completion status flag

TABLE 9: Definition of search result table based on QR code.

Id name	Id class	Id constraints	Id description
Artwork id	int	Primary key	Number
Resource	tinyint	Primary key	Search result source indication (0/all 1/scenery spot 2/shop 3/website)
Query QR code	varchar (100)	—	QR
Query id	int	Not null	Inquiry number

TABLE 10: Retrieval result table definition based on binary hash code.

Id name	Id class	Id constraints	Id description
Artwork id	int	Primary key	Number
Resource	tinyint	Primary key	Search result source indication (0/all 1/scenery spot 2/shop 3/website)
Distance	tinyint	Not null	Hamming distance
Query id	int	Not null	Inquiry number
Artwork picFile	varchar (100)	Not null	Figure address
Artwork description	varchar (200)	Not null	Introduction

the login data are reset to empty and a corresponding error is displayed.

3.5. Web Client Development. The paper uses JSP and JavaScript technology in designing the web client. In a broad sense, JSP is a dynamic web page technology, which converts dynamic web pages into web pages through back-end Java program processing and transmits them to browser clients. The view layer of the MVC layered idea is mainly embodied as an intuitive and operable web interface in the software platform of this paper.

Based on HTML5, this paper combines the scripting language JavaScript to add dynamic features to the web client, such as event response, so as to make the page interaction effect better and optimized. In addition, the appearance design of the page adopts CSS3, which provides pixel-level control for web page display, such as setting web page fonts and colors.

When designing the view layer, in order to separate the code unrelated to the business logic from the interface, to

decouple the view layer and the controller, and to facilitate later maintenance and secondary development, this paper mainly uses jquery when developing the web client. Ajax technology and JSON data format are used for front-end and back-end communication. After the JSON data protocol between the front-end and the back-end is formulated, data are requested from the server through JavaScript, and the interface is re-rendered after getting the response to update the data. The interaction between JavaScript and the back-end usually adopts the asynchronous communication mode; that is, the browser will not enter the response wait after sending a request to the server, but will continue to execute the subsequent code. When the server returns the data, the browser will execute the message response function to complete the response action.

The interface of the web client includes four pages: photo query, retrieval display, business registration and login, and information entry.

The photo query page is the main page that provides users with query operations. This page includes query image upload function, photo upload image function, and QR code scan

TABLE 11: Image understanding module request interface definition.

Item	Description
Method name	ImageParse
Call method	TCP communication trigger call in LAN
Request parameters	Parameter 1: String queryImage, query image path identifier Parameter 2: Int queryType, query type identifier, 1 QR code, 0 photo image Parameter three: Int queryFrom, the request originating source identifier, 1 for query, 0 for import
Return parameter	String, which needs to be parsed again and restored to binary hash code/QR code/identification category

TABLE 12: Data batch import module interface definition.

Item	Description
Method name	ArtworkImport
Call method	Console script call, TCP communication trigger call in LAN
Request parameters	Parameter 1: String artwork_source, import image path identifier Parameter 2: String artwork_descript, the path identifier of the text description file Parameter three: Int artwork_type, import type ID (1 QR code, 0 images) Parameter 4: Int artwork_from, import source ID
Return parameter	Boolean, import success flag

TABLE 13: Merchant upload text import module interface definition.

Item	Description
Inquiry address	https://223.3.86.94:8808/shop_artwork/upload
Inquiry method	POST
Response format	JSON
Inquiry parameter	Parameter 1: String artwork_name, the name of the imported artwork image Parameter 2: Int shop_id, merchant ID Parameter three: String artwork_description, brief description Parameter four: Float artwork_price, price information
Responsive parameter	—
Responsive code	00, 201, 400, 401, 403, 404, 408, 500

upload function. The retrieval display page is the identification retrieval result display page after the user clicks the search, and the page includes the identification result and the retrieval item result. The search item contains the result image and the corresponding text content. The entire display page also provides filtering and filtering operations for search results, so that users can view different search sets separately. The realization function of the merchant registration login page is to register the scenic spot merchants and upload artwork images. The page prompts you to enter relevant information and confirm. The server calls the registration verification module to check the legitimacy of the user information. If it is legal, the account is created and the image and text information is allowed to upload. The client information entry page is a page that provides the merchant with the operation of uploading artwork images and texts after the merchant logs in. This page includes image file upload operations and text-related information input operations. After the merchant completes the entry of the information on the page, the server calls the data import module to check the validity of the information imported by the merchant. If it is

legal, the artwork data uploaded by the merchant are entered into the system database, and the image understanding module is called to produce the image content binary of the image of the item. Hash code, these information will be entered into the system database together, and the entry success response will be returned; otherwise, the entry failure response will be returned.

3.6. *System Frame Model Diagram for VR-PDES.* Based on the previous content analysis and research, this study proposes a product design evaluation system based on virtual reality technology—VR-PDES. VR-PDES frame is shown in Figure 7. The environment for evaluation work is jointly constructed by the virtual reality system and the product modeling design system driven by design intent. The system is constructed by the design evaluation information data obtained in the virtual reality system. As a user experience, the virtual environment provides a user environment with a strong sense of immersion, and the tracking and evolution of user experience information are obtained through the interaction between the user and the virtual reality system.

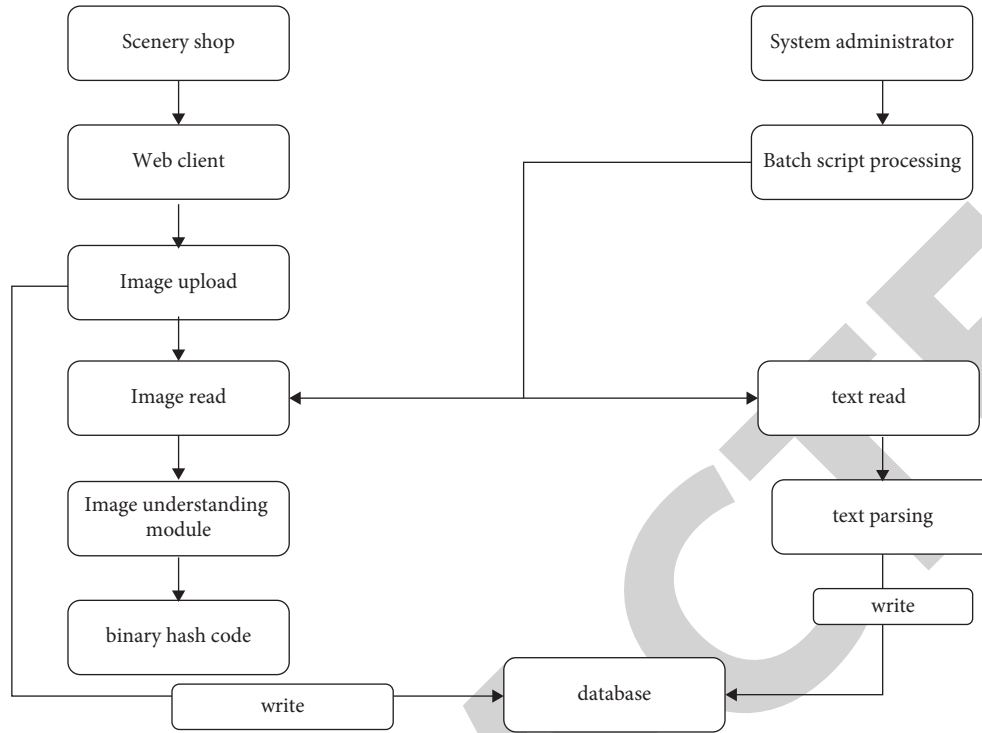


FIGURE 6: Data import operation process.

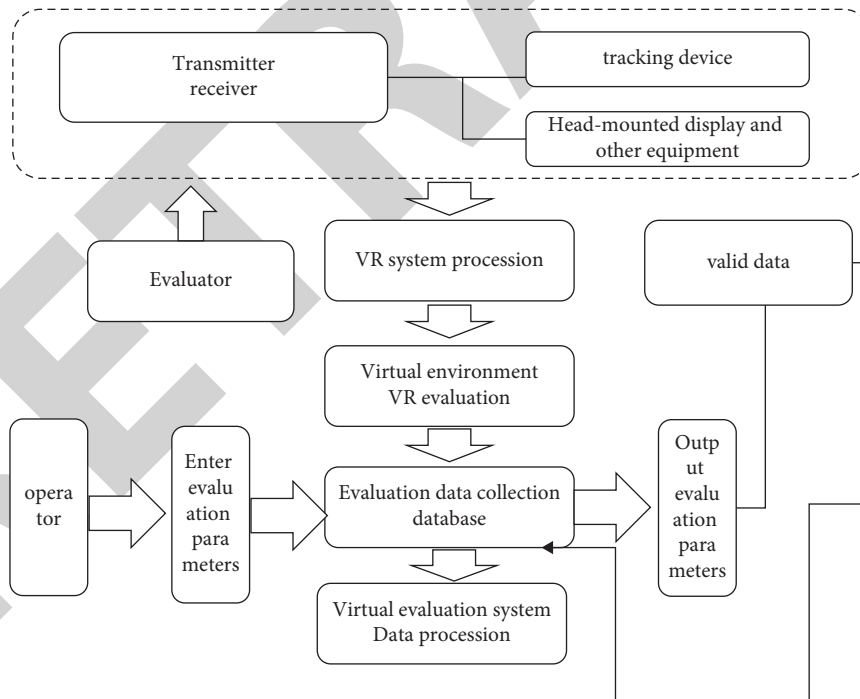


FIGURE 7: VR-PDES frame.

4. Conclusions

In our study, we first studied the image-based artwork recognition and retrieval solution, discussed the system function and architecture in detail, analyzed and compared the system database, and completed the data requirement

discussion and conceptual design, and then grabbed artwork-related graphic data from multiple platforms through crawler programs, summarized all the data to complete a large-scale artwork dataset, and analyzed the imbalanced state of image dataset categories; moreover, the SSM framework is used to complete the development of all

business processes on the server side, and the TensorFlow deep learning framework is used to complete the development of the image understanding module on the server side. The client in this chapter has completed the development and implementation of multiple pages with JSP, JavaScript, and other technologies; finally, in this study, a product design evaluation system (VR-PDES framework) based on virtual reality technology was established.

When constructing and using datasets, self-built datasets are not as accurate as well-crafted datasets under crowdsourcing. Noise data in datasets will interfere with artwork recognition and retrieval models to some extent. Therefore, the performance optimization of artwork recognition and retrieval can also start from the dataset to reduce the adverse interference of noisy data as much as possible. In the development and implementation of the software platform, this paper has completed the development of all server-side modules and web-side applications. At present, the WeChat applet application is sought after by the public. Therefore, the subsequent introduction of the applet application into the artwork identification and retrieval system will further broaden its application. Apply channels and improve the service level of scenic spots.

Data Availability

The experimental 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 conflicts of interest.

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