Research Article
Digital Art Design Effectiveness Model System Based on K-Medoids Algorithm

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With the development of the times, figurative expressions no longer meet the creative needs of artists and the aesthetic demands of the people. In order to express art in a more profound way, the perfect use of abstract graphics plays a crucial role in the success of the work. In recent years, there has been a surge in the creation of digital art, but there is relatively little theoretical literature on the combination of abstract graphics as a visual language and digital art. In addition, research on the theoretical aspects of digital art design is also relatively weak, so it is essential to analyse the formal aesthetics and innovative applications. In fact, digital art design has a very important role to play in promoting the development of creative cultural industries. In other words, the healthy development of digital art design can influence the future prospects of a country’s creative and cultural industries. Digital art design is an integrated and complex production process and labour outcome. In addition to its human, aesthetic, and social value, digital art also has an economic value. Digital art is a new art form that combines digital technology and artistic aesthetics. As such, digital art is characterised by high technology, diverse forms, popularised art, and the advantages of high communication, interactivity, and influence, which can provide more assistance for the innovation and application of abstract graphics. Digital art is multifaceted and has an artistic expression that cannot be matched by other forms of technology. Abstract graphics, driven by digital art, are full of novelty and interest and can greatly enrich people’s emotions and senses. Abstract graphics bring the experience of digital art to its fullest potential. The combination of digital art and abstract graphics offers more innovation and possibilities for the development of art and will bring great prosperity to art communication. With the widespread use of computer and network technology, the Internet has developed rapidly. In this context, digital art, as art created in a digital way and concept, has gained widespread attention. As a result, how to integrate existing computer resources in the new environment to build a model of digital art design effectiveness will cause a direct influence on the quality of digital art design with digital content innovation as the core. At the same time, as digital art becomes more and more popular, the demand for digital talents becomes very urgent. As a result, the cultivation of high-quality digital talents has become a major concern for society. Therefore, in order to explore the success of digital art design and the cultivation of digital art talents, and to better serve the innovation of digital art, this paper proposes a digital art effectiveness model based on the K-medoids algorithm. This model can provide a deeper and more comprehensive understanding of digital art and abstract graphics and provide theoretical support for professional design creation.

1. Introduction

Digital art design belongs to a new field that has emerged from a high degree of integration between science technology and art [1]. According to its characteristics, digital art design can be divided into two different levels: computer graphics technology [2] and art design [3]. Digital art in a broad sense is digital art. Digital art in a narrow sense generally refers to the use of computers to process or produce art-related designs, animations, audio-visuals, or other works of art [4]. In the early twentieth century, with the development of modern information technology and the rapid spread of computers, society entered a fully digital age. The use of various algorithms and mathematical models, such as machine learning [5, 6], text recognition [7, 8], and total life cycle assessment [9, 10], can accelerate the development of computer technology. In this context, the rapid development of scientific and industrial technology is increasingly contributing to artistic expression. This has led to the formation of modern art, video art, and design art [11].
The interpenetration of these three separate art forms has led to the formation of a new aesthetic ideology in the form of postmodernism, which has given rise to digital art.

Digital art is a comprehensive field that encompasses several disciplines. To be specific, digital art is an integrated form of artistic communication that encompasses art, sociology, technology, and aesthetics as well as popular culture [12]. As a result, digital art is a disciplinary synthesis of natural, social, technological, and humanistic disciplines and is a new type of discipline in which digital technology and art intersect. Considering the mass art, reproducible and commercial nature of digital art has accelerated the spread of digital art and has led to a trend towards the visualisation and graphicisation of art and culture in the direction of popularisation [13]. The wide application of computers, driven by digital technology, has expanded the means of creating works of art [14]. At the same time, the constant development of digital technology has also led to changes in the development of abstract graphics. Many disciplines between art and science, such as graphic design, costume design, and environmental design, have been broadened by the influence of modern digital information technology [15]. Correspondingly, the field of design has also undergone a quantitative to qualitative change, rising to a whole new level. Art is constantly evolving towards science, and science is gradually being transformed into art [16]. As a result, with the development of the times, figurative expressions are no longer sufficient to meet the creative needs of artists and the aesthetic demands of people. The combination of digital art and abstract graphics has created a different visual and aesthetic experience than before [17, 18]. The use of abstract graphics in digital art has played a crucial role in the development of the arts. People’s interest and enthusiasm for digital art are expanding, and it is becoming an integral part of life today, making it the most favourable time to develop digital art [19].

As shown in Figure 1, digital art design is a cross-cutting field and is a unique industry that is a composite of at least three industries. Firstly, it is an industry supported by the information technology industry [20]. Secondly, it is an industry with its roots in cultural industries [21]. Finally, it is an industry driven by creative industries [22]. The information industry is a collective term for industries engaged in the production of information technology, information services, information equipment, and products in the context of socioeconomic activities [23]. The cultural industries are those activities that deal mainly with activities based on symbolic goods, the economic value of which is derived from their cultural value. Creative industries are those industries that have the potential to generate wealth and employment through the generation and development of intellectual property, derived from the creativity, skills, and talents of individuals [24]. An industry that is a combination of these three industries is a creative cultural industry. To be specific, it refers to the industry that can create and enhance cultural resources with the help of high technology and can generate high value-added products through the development and application of intellectual property rights [25, 26]. As a result, digital art design is the core component of the entrepreneurial cultural industry, and its quantity and quality are directly related to the competitiveness of the creative cultural industry.

The main characteristics of digital art design are the following. Firstly, digital art design has a strong commodity character [27]. Commodity means that digital art design is a labour product and a labour product for exchange. This is a characteristic common to all cultural products that are produced in large batches by large machines [28]. The result of digital art design can therefore be considered as a means of earning a living for the designer, a commodity ready for exchange. As a result, it is quite reasonable to consider the result of the designer’s labour for exchange to be a commodity. It is the commodity nature of digital art design that has led to a further exploration of its value components on this basis [29]. In addition to this, digital art design is extremely easy to reproduce. The ease of reproduction of digital art design means that it can be reproduced quickly using advanced technology. The ease of reproduction is a function of the difficulty of conceptualising and creating the work in advance. The more advanced the technology is, the easier and cheaper it becomes to reproduce [30]. The history of mankind has gone through a period of manual reproduction, a period of mechanical reproduction, and a period of digital reproduction. Digital reproduction has both advantages and disadvantages. Specifically, it can provide the creative industries with a timely, rapid, and inexpensive means of distribution, allowing creative cultural products based on digital art and design to be sold worldwide, regardless of geography.

Graphics emerged as human society developed. As early as primitive society, graphics were used as a way to record information about life in a figurative way [31]. As societies became more social, people began to use graphics as a way to record and transmit information more easily, eventually evolving into writing. However, the changes in social production and the great wealth of material culture have led to a
significant change in the aesthetics of graphic art [32]. Concrete representations were no longer sufficient to meet people’s aesthetic needs, so abstract graphics, which are highly refined and simplified summaries of real things, were created. The term abstraction was first used to refer to the philosophical idea of the ability to integrate concepts by discarding concrete details in thought. The original meaning of abstraction is to extract the most critical and representative elements of a real thing and to simplify them to form a conceptual symbol without detracting from the essence of the thing. Abstract shapes are generally formed by combining geometric forms such as points, lines, and surfaces, reconstructing and abstracting figural objects to create a simple and powerful graphic representation [33]. The essence of abstract graphics is the simplification and generalisation of figural objects, and the simplicity of expression is the mode of thinking and expression that abstract graphics have always followed. Abstract graphics were born out of the desire to use symbolic metaphors to broaden the viewer’s imagination [17]. To a certain extent, the abstract form of representation can be free from the constraints of the abstracted object. To be specific, the artist can add his subjective imagination to the abstraction, combining the points, lines, and surfaces of the abstraction in an orderly or disorderly manner, thus enriching the meaning and connotation of the work itself. At the same time, abstract graphic design has the advantage and characteristic of being rich in form, free, and independent. It has a strong visual symbolism. By using abstract geometric structures and line elements to represent figural objects, the form can be highly summarised and the viewer can easily associate it with the meaning it conveys.

This study focuses on the development and application of the digital art and design effectiveness model based on the standard development methodology of the K-medoids algorithm. In order to develop the model, it is necessary to implement a data centre platform, a portal platform, a unified authentication subsystem, and an application integration platform in the digital management information system. As a result, the development and application of this system can greatly enhance the management of digital art and design and provide a basis for innovation.

2. Cluster Analysis

As a typical unsupervised division-based clustering algorithm, K-medoids has the advantages of simple clustering idea, high feasibility of clustering process, and near-linear time complexity of clustering. At the same time, the K-medoids algorithm can also show good technical support for complex data mining, so it has been developed rapidly in many industries. In the field of digital art design, the K-medoids algorithm has also been widely applied. In addition, the K-medoids algorithm is a common data mining method. It is an unsupervised algorithm that classifies data points with the same class and common attributes into the same class. In the same class, the similarity of the clustered objects is high. Conversely, in different classes, the similarity of the clustered objects is very low. With this classification method, more accurate classes can be obtained than with the K-means method.

2.1. K-Means Algorithm. Cluster analysis techniques are widely used in various fields and have been improved for different applications. At the same time, cluster analysis techniques allow for the development of corresponding algorithms and models. Broadly speaking, these methods can be classified as lattices, hierarchies, densities, and delineation methods. In the era of big data, structured and semistructured data resources are growing rapidly and users are searching for information in a wider and wider range. The introduction of cluster analysis technology can effectively improve the classification of similar information, so that individuals in the same class have a high degree of homogeneity. This technique allows for a high degree of heterogeneity between individuals in different categories, thus effectively increasing the accuracy of the user’s information.

One of the traditional clustering algorithms is the K-means algorithm. The detailed process of the K-means algorithm can be seen in Figure 2. The division-based clustering starts by specifying the number of clusters \( k \). Assuming that the sample contains \( m \) data objects, \( k < m \). Then \( k \) initial centroids are selected from the data sample and iterated until the initial threshold is met.

The corresponding target value function is shown in

\[
T = \sum_{i=1}^{k} \sum_{d \in x_i} \|d - \mu_i\|_2^2, \tag{1}
\]

where the existing data set is \( D = \{d_1, d_2, ..., d_m\} \), the class cluster result after conducting the K-means algorithm is \( X = \{x_1, x_2, ..., x_k\} \), and \( \mu_i \) refers to the mean value.

There are two types of hierarchical clustering: cohesive hierarchical clustering and split hierarchical clustering. The former starts at the bottom, where each data sample is initially in one class and then continues to merge the least distant clusters to form new clusters. The algorithm ends when all the data belong to a single cluster or when a certain end condition is reached. The latter takes a cluster that includes all the data as a starting point and splits it into a number of subclusters. Each subcluster continues to split downwards until eventually each cluster contains only one data element, as illustrated in Figure 3.

2.2. K-Medoids Algorithm. The K-medoids clustering algorithm is a division-based clustering method. Compared to K-means, the K-medoids algorithm is easier to implement and has better convergence and time complexity. As a result, the K-medoids algorithm can give better results when searching globally.

The K-medoids algorithm divides the \( m \) data objects into \( k \) classes as reference centres for clustering. The data objects that are not classified into classes are then classified into neighbouring clusters according to the distance priority principle. The K-medoids clustering algorithm is based on the principle of optimality of the clustering criterion.
function, using the object closest to the cluster centre as the class centre. As a result, this algorithm can significantly enhance robustness and is relatively effective for small data sets.

Among the $k$ clusters that are eligible in the output, the effect of clustering is usually measured using an absolute error standard function, defined by

$$ A = \sum_{i=1}^{k} \sum_{z \in c_i} (z - c_i)^2, $$

where $z$ refers to the object of the cluster $c_i$.

Thus, the detailed process of the K-medoids algorithm can be seen in Figure 4.

The K-medoids clustering algorithm is able to obtain more desirable classification results by repeatedly calculating and updating the mean value of the objects around the cluster centroids in the clustering process. In the design process of digital art, this approach is utilised to produce initial classes by categorising different art resources in aggregate through categories and other means. The K-medoids clustering algorithm is then used to cluster and analyse the feature codes of knowledge until the classes converge.

In the feature extraction phase, the knowledge information that has not yet been determined by the classification
during the training process is expressed according to the feature vector of knowledge information as follows:

\[ I = [b_1, b_2, \ldots, b_n]^T, \]

where \( b_n \) refers to the \( n \)th information in the digital art design process.

After that, the classification of the knowledge information to be classified and the training set is calculated according to the vector angle cosine formula, as shown in

\[ \text{sim}(I, I_i) = \frac{\sum_{k=1}^{n} z_k z_{ik}}{\sqrt{\sum_{k=1}^{n} z_k^2 \sum_{k=1}^{n} z_{ik}^2}}. \]

Also, the principle of using the vector angle cosine can be seen in Figure 5.

The K-medoids algorithm takes the centroid that makes the total difference function negative as the new class centre each time a new centroid is selected, based on calculating the difference between the sum of the squares of the distances from all data points in the original class to the class centre and the sum of the squares of the distances from all data points to the new centroid after replacement. This approach can effectively avoid the influence of the algorithm on outliers and is highly robust. At the same time, the clustering results are independent of the order in which the data object points are entered, so the clustering method also has the advantages of data object translation and orthogonal transformation invariance.

2.3. Experimental Analysis. In order to ensure the effectiveness of the experiments, the content of digital art design is analysed in order to reduce the dimensionality of the calculations. The experiments are carried out using the method proposed in this paper. The data set is derived from a database of digital art and design provided by a company, with 10 categories. Four of these categories are selected for this study: painting, clothing, sketching, and music. The experimental data are shown in Table 1.

<table>
<thead>
<tr>
<th>Value</th>
<th>( P ) value</th>
<th>( R ) value</th>
<th>( F ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>76.4</td>
<td>77.2</td>
<td>73.5</td>
</tr>
<tr>
<td>12</td>
<td>79.7</td>
<td>78.1</td>
<td>74.2</td>
</tr>
<tr>
<td>15</td>
<td>84.2</td>
<td>82.1</td>
<td>80.5</td>
</tr>
<tr>
<td>19</td>
<td>75.1</td>
<td>73.4</td>
<td>71.9</td>
</tr>
<tr>
<td>21</td>
<td>76.2</td>
<td>75.8</td>
<td>74.6</td>
</tr>
</tbody>
</table>

Figure 5: Principle of using the vector angle cosine.

Figure 6: Four main role objects in the digital art design effectiveness model.

Table 1: Experimental data of digital art design.

<table>
<thead>
<tr>
<th>Category</th>
<th>Painting</th>
<th>Clothing</th>
<th>Sketching</th>
<th>Music</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training set</td>
<td>287</td>
<td>305</td>
<td>214</td>
<td>563</td>
</tr>
<tr>
<td>Testing set</td>
<td>194</td>
<td>143</td>
<td>176</td>
<td>324</td>
</tr>
<tr>
<td>Total number</td>
<td>481</td>
<td>448</td>
<td>390</td>
<td>887</td>
</tr>
</tbody>
</table>

Table 2: Classification result.

3. Digital Art Design Effectiveness Model

3.1. Demand Analysis. The main difference between digital art and design and other fields is that there is no single model. In other words, it is a complex systemic project that integrates creativity, research, and development. It includes not only design foundations, design concepts, and design skills, but also the development of practical skills such as hands-on production. This is why the user should be given priority when designing effective models for digital art and design. Figure 6 summarizes the four main role objects in the digital art design effectiveness model.

3.2. Analysis of Model Operating Environment. The model runs on a standard server, which needs to be set up as a web server and database server. When a certain number of users access the system at the same time, the server is able to keep
the system running and provide the services required by each user. In addition, users need to access the server via the network. Therefore, only the user side and the server side are connected to the LAN and the server is accessed via the LAN, which ensures both speed and network security.

Combining the advantages and disadvantages of 
C/S and B/S, this model uses a combination of 
C/S and B/S architecture. For example, for the database, a B/S web application environment is used for the data query service. The C/S web application environment is used to run on the campus network. As a result, the overall structure of the digital art design effectiveness model is shown in Figure 7.

C/S mode applications can be developed with client-side applications according to the actual situation. If the client has a high processing power, more tasks can be implemented on the client side. If the network communication conditions are good and the server computing performance is high, then more computing operations can be implemented on the server side. For example, some management information systems based on the C/S model even integrate all functions on the server side, where most of the processing tasks such as data access, logical operations, data storage, and control of the system’s business processes are realised. This leads to a surge in network access, which needs to be supported by good network conditions. With the server as the focus of the entire system, the server is slow to respond and may even become “jammed” when a large number of users access the server at the same time. Due to the difficulties of synchronising data in a C/S structure, the use of a C/S structure for the entire digital art and design effectiveness model will result in inefficient operation. However, the C/S structure can share some of the transaction processing requirements and can handle more complex business processes. Therefore, the digital art and design effectiveness model proposed in this study adopts a C/S architecture for the implementation of some core modules that need to handle complex business.

3.3. Principle of Digital Art Design Effectiveness Model. In the formal digital art and design environment, learning tasks are set in accordance with the content or requirements of the model and are required to be completed by the designer. The designer is a passive participant, whereas the activity is something that the designer needs to actively engage in to complete. As a result, the designer can develop their own creative style and form at the right time when working with digital art design. In addition to this, the designer’s role, access to tools and resources, and the resultant outcomes should be given appropriate internal links when creating digital art.

It is also important to note that, with the creation of digital art, creating online has become a focus of research. What is unique about online creation compared to traditional design models is that it has to reflect both the centrality of the designer and the special aspects of the online environment in the design of the activity. When designing online, special attention is paid to the following aspects. For example, the design of a designer-centred online platform, the provision of design tools, resources and technical support, and the creation of learning contexts in which designers can flexibly apply their knowledge.

4. Conclusion

The application of computers in digital technology has expanded the channels of artistic expression, and the change in artistic thinking in the context of digital technology has led to changes in the development of abstract graphics. Digital art is a combination of natural and social disciplines, technology, and the humanities and is a new discipline that combines digital technology and art. The combination of abstract graphics and digital technology allows for the creation of works full of novelty and interest. In the context of digital art, the fusion of information and big data has begun to visualise abstract graphic information. Combined with augmented reality technology, the senses interact with virtual reality in real time. The combination of abstract graphics as a visual language for digital art expression and digital technology is highly integrated and has significantly changed the traditional use of graphics production, design thinking, and aesthetic thinking. Digital art, as a different form of art from the traditional ones, has the characteristics and advantages of being high-tech, high-impact, and highly interactive. As a result, digital art can be used to express a wide range of subjects in a multitude of ways. The multifaceted use of digital art reflects the emotional resonance, digital information, and humanistic concepts in a modern context. The concept of abstract graphics in digital art is transformed from an objective to a more subjective expression of the subject matter, with design thinking becoming more experimental and beginning to explore the future and the unknown in greater depth.

The digital art design effectiveness model designed for this study has a relatively good overall plan. And the model can be well combined with the K-medoids algorithm so that the data shared between modules can be clustered and analysed. However, the specific implementation of each module’s functionality is relatively straightforward, with the implementation focusing on the more commonly used functions. However, the development of this model is essentially a prototype development approach, but one that is different from the prototype development approach. The requirements and planning for the model were completed prior to development and only some of the functionality was not code-specifically implemented. The model will be refined and improved as it is used.
Data Availability

The labeled data set used to support the findings of this study is available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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References


