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Research on Digital Indexing System for Artworks Driven by Artificial Intelligence

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Abstract – This research analyzes in detail the application of artificial intelligence technology in the digital index system of art works, and proves its significant effect on improving the efficiency of art works management, strengthening academic research support and enhancing public art experience. By integrating advanced technologies such as machine learning, deep learning and computer vision, the system is able to automate the processing and analysis of huge datasets of art works, enabling accurate and fast information retrieval and rich data analysis. The application of this technology greatly reduces the need for manual operation, improves the accuracy and efficiency of data processing, and provides the public with a more in-depth and personalized art experience through intelligent recommendation and interactive learning platforms. The artificial intelligence-driven digital index system for works of art is an important innovation in the field of art management and display, showing the broad prospect of the integration of art and technology.
Keywords: Artificial Intelligence; Digital Index; Index of Works of Art; Index System

Research background

In the modern art world, traditional indexing methods often face a series of limitations, which are mainly reflected in efficiency, accuracy and scalability. Traditional methods usually rely on manual operation, manual cataloging is not only inefficient, it is difficult to keep up with the rapid pace of art creation and accumulation, but also difficult to ensure the accuracy and comprehensiveness of the index. The traditional indexing system based on text description is often limited to the record of simple information such as title, author and creation age, which is difficult to deeply explore and present the deep characteristics of visual aesthetics, emotional expression and cultural connotation of artistic works. Moreover, it is prone to errors when processing large-scale data, and cannot cope with the increasing amount of information of artistic works. Due to the intervention of human factors, the subjective judgment of different indexers may lead to the inconsistency of index results, which affects the standardization and systematic management of information.

Research significance

The research drives cross-pollination between AI and art history and information science, providing new perspectives for understanding how AI can provide solutions in non-traditional fields. By applying artificial intelligence techniques to the indexing of works of art, the

research enriches the field of application of artificial intelligence and promotes theoretical discussions on how to process and parse complex visual and textual data through technical means.

From a practical point of view, the application of artificial intelligence technology to the indexing of works of art has greatly improved the efficiency and accuracy of data processing. Traditional manual indexing methods are costly and error-prone, while the intervention of artificial intelligence can reduce human errors and ensure the consistency and reliability of information by automating the processing of large amounts of data (Kinsaiying.2016). This is particularly critical for the establishment and maintenance of an art database, which can effectively support multiple practical needs such as art history research, art identification and trading (Chen Liang.2021).

The application of artificial Intelligence in the index of works of art By optimizing the organization and retrieval of works of art, artificial intelligence technology makes it easier for the public to access and understand art, increasing the accessibility and educational value of works of art. Especially in the context of multiculturalism, artificial intelligence can support the adaptation of multilingual processing and cultural content, and promote the sharing and popularization of global cultural heritage.

With the progress of artificial intelligence technology, its application in the field of art will increasingly touch on a wider range of fields such as creation, analysis and even criticism (Song Xiaokang, Zhao Yuxiang, Song Shijie, et al.2023). The current research can provide basic theoretical and technical support for these more complex applications, and promote the deep integration of AI in the art world.

Exploring the application of artificial intelligence in the digital indexing of works of art not only has an important contribution to the academic field, but also has a positive impact on the practical field and the broader socio-cultural field. Such research not only pushes the boundaries of technology and art, but also opens up new paths for the possibility of integrating art and technology in the future.

The theoretical basis of artificial intelligence and digital indexing of works of art

1. Overview of artificial intelligence technology

1.1. Machine learning

Machine learning, the cornerstone of artificial intelligence, is about enabling computer systems to automatically learn from large amounts of data and optimize their performance without the need for explicit programming. In the scene of digital index of works of art, machine learning algorithm can analyze multi-dimensional features of works of art, such as color distribution, texture pattern, shape composition, etc., and establish the mapping relationship between these features and index labels through the training process (Wu Dan, Liu Jing.2022). This process increases the automation of indexing and also ensures the accuracy and consistency of indexing results.

1.2. Deep learning

As an advanced stage of machine learning, deep learning is able to capture nonlinear relationships and complex patterns in data by building deep neural network models. In the

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field of art works index, deep learning technology can dig deep into the deep characteristics of art works, such as the artist's creation style, emotional expression of the work, historical background, etc. These features are often difficult to accurately capture through traditional indexing methods, but deep learning technology can build a richer and multidimensional indexing system for works of art with its powerful learning ability.

1.3. Computer vision

Computer vision is the direct application of artificial intelligence in the field of image processing, which enables computers to understand and interpret image content as humans do. Computer vision technology plays a vital role in the digital indexing system of works of art. Through image recognition, segmentation, feature extraction and other steps, computer vision technology can automatically preprocess art works and provide high-quality image data for subsequent index construction (Jiang Yuan, Yang Xujun.2019). Combined with machine learning and deep learning technology, computer vision can also realize the automatic classification, annotation and retrieval of art works, which greatly improves the intelligence level of the index system and user experience (Xu Tao, 2013).

2. The concept and construction of digital index of works of art

Digital index of works of art, as a scientific method to transform traditional art forms into quantifiable and searchable digital information, reveals the internal characteristics and external manifestations of works of art through technical means, and provides strong support for art research, education and public appreciation. This process requires a high degree of precision and comprehensiveness, ensuring that the indexing system truly reflects the unique value of the work of art.

The digital index of works of art based on artificial intelligence technology first needs to clarify the objectives and principles of index construction, that is, to ensure that the index system can fully cover the multi-dimensional information of works of art, while maintaining the accuracy, consistency and accessibility of data.

Secondly, an AI-driven data acquisition and pre-processing process is designed to transform the artwork into a standardized data format suitable for processing by artificial intelligence algorithms through steps such as digitization, noise removal and feature extraction. In this process, it is necessary to make full use of advanced technology in computer vision, image processing and other fields to ensure the quality and efficiency of data.

Then, the intelligent index generation module is built, and artificial intelligence technologies such as deep learning and natural language processing are used to conduct in-depth analysis and mining of the pre-processed art work data. By building complex models and algorithms, the module can automatically identify key features such as theme, style and emotion of works of art, and generate corresponding index tags and metadata to reflect the essential features of works of art.

Finally, the index database and retrieval platform are constructed, and the generated index data is combined with the digital resources of art works to form a complete index system. Users can enter keywords or select specific criteria through the search platform to quickly locate the works of art they are interested in. At the same time, the retrieval platform also provides a wealth of visual tools and interactive interfaces to help users better understand the content and background of art works.

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3. Advantages of artificial intelligence in the indexing of works of art

Artificial intelligence technology realizes efficient processing and index construction of art works data through highly automated processing process. This process not only greatly shortens the time period for index production, but also reduces the reliance on human labor, enabling a large number of artworks to be quickly transformed into searchable and analyzable digital resources. This efficiency improvement provides a more convenient way for art research, education and public appreciation, and accelerates the communication and exchange of art and culture.

Traditional indexing methods are often limited by the subjectivity and limitations of manual annotation, and it is difficult to capture the complex features of artistic works comprehensively and accurately. Artificial intelligence technology can use advanced algorithms such as deep learning and image recognition to dig deep information such as style elements, emotional colors, and theme ideas in artistic works, and generate more accurate and comprehensive index labels accordingly. This precision enhancement enhances the practicability of the index system, provides more abundant and detailed data support for art research, and promotes the in-depth development of academic research.

The introduction of artificial intelligence technology has also given the digital indexing system of art works greater scalability. With the continuous growth of the amount of data and the continuous optimization of the algorithm model, artificial intelligence can flexibly respond to the new index requirements and challenges, and realize the dynamic expansion and upgrade of the index system. In addition, artificial intelligence also has the potential for cross-field application, and it can easily integrate the index resources of different art categories, and build a digital index system of artistic works with extensive coverage and rich content. This scalability ensures the continuous development and improvement of the index system, and also provides strong support for the diversified and global dissemination of art and culture.

The advantage of artificial intelligence in the index of works of art has promoted the rapid development and popularization of the digital index system of works of art, which has brought unprecedented opportunities for art research, education and cultural communication. In the future, the digital index system of art works will be more intelligent and accurate, and contribute more to the inheritance and development of art and culture.

The key technology of digital index of art works driven by artificial intelligence

1. Information extraction technology

Information extraction technology is the key link in the research of digital index system of art works driven by artificial intelligence. Image recognition and text mining technologies of artificial intelligence play a crucial role in this process, they can automatically extract and process data from art works, and provide the necessary data basis for index construction.

1.1. Image recognition technology

In particular, convolutional neural network (CNN) in deep learning has been widely used in the analysis of artwork images. These networks are trained to recognize subtle features in a work of art, such as elements such as color, texture, shape, and composition. In addition, image recognition is not limited to static feature recognition, but can also analyze the

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evolution of artistic styles and genres, thus providing a scientific basis for the classification and archiving of artistic works. In this way, artificial intelligence technology can achieve efficient extraction and more accurate interpretation of the visual information of artistic works.

1.2. Text mining technology

It is used to process descriptive texts related to works of art, such as artist biographies, artwork reviews, and historical records. Using natural language processing (NLP) technology, artificial intelligence systems can identify key information from complex text data, such as creative background, artistic significance, historical influence and cultural value (You Weishan, Li Jie.2023). Text mining can not only extract explicit information, but also excavate the hidden meaning and emotional color in the text through advanced functions such as emotion analysis, which is particularly important for understanding the social and historical background of artistic works.

By combining image recognition and text mining techniques, AI provides a comprehensive data extraction and analysis framework for digital indexing of works of art. The framework automates the processing of large amounts of visual and textual data, and its performance will continue to improve over time through continuous learning and optimization. The application of these techniques not only improves the efficiency of the index of works of art, but also greatly enhances the accuracy and reliability of the index system. Image recognition and text mining technologies of artificial intelligence play an irreplaceable role in the field of digital indexing of artistic works. Through the application of these technologies, the digital index of works of art is more scientific and systematic, which greatly promotes the modernization and internationalization of information management of works of art.

2. Feature representation and dimensionality reduction

In the research of artificial intelligence-driven digital indexing system for works of art, feature representation and dimensionality reduction are the key technical links in processing and extracting information. The effective transformation of information extracted from art works into feature vectors and the reduction of data redundancy through feature dimensionality reduction technology are crucial to improve the indexing efficiency and accuracy of the system. Through the research and application of these technologies, artificial intelligence can provide an efficient and accurate art works index tool, can promote the modernization of art information management, and provide strong technical support for the research, trading and promotion of art works.

2.1. Feature representation

Transform the properties of a work of art into a mathematically tractable form, the feature vector. This process usually involves encoding visual and textual information about an artwork, such as converting visual information such as color distribution, texture patterns, artistic styles, and textual information such as artist styles and periods of work into numerical form. An effective feature representation not only captures key information about a work of art, but also provides standardized input for subsequent data processing.

2.2. Feature dimension reduction

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High dimensional data often leads to low processing efficiency and easy overfitting. Feature dimensionality reduction can reduce the interference of irrelevant features and improve the efficiency of data processing. Commonly used feature dimensionality reduction techniques include principal component analysis (PCA), linear discriminant analysis (LDA) and, more recently, autoencoders. These techniques can effectively extract the most representative features from high-dimensional data, reduce the redundancy of information, and retain the most critical information for the index system.

By implementing feature dimensionality reduction, AI systems can process large-scale art works data sets more efficiently, improve data processing speed and index accuracy. In addition, the data after dimensionality reduction can also improve the training efficiency and prediction performance of the machine learning model, and make the entire art works index system more economical and practical because of the reduced computation.

3. Index algorithm

In the research of digital indexing system of works of art driven by artificial intelligence, the indexing algorithm is one of the core technologies, which directly affects the efficiency and accuracy of the system.

3.1. Hash index

Hash index provides fast data retrieval through hash tables and is suitable for scenarios that require quick access to large amounts of unstructured data. In the digital index of Works of art, the hash index can quickly match and retrieve works of art with similar characteristics, for example, quickly find works of similar style through the hash value of the image. The main limitation of a hash index is that it is very sensitive to small changes in the data, which can lead to hash conflicts, which can affect the accuracy of the index.

3.2. Tree index

Such as B trees and B+ trees, mainly used in database indexes, support range queries and ordered data access, which makes tree indexes suitable for art works databases that need to perform complex queries. For example, tree indexes can provide efficient query performance when sorting and scoping works of art by age or author. The tree index structure is complex and relatively expensive to maintain, especially in an environment where data is frequently updated.

3.3. Graph index

The use of graph structures to store and query data is particularly suitable for representing complex relationships and pattern recognition, which is particularly important in the indexing of works of art. Through the index of images, it is possible to effectively explore the connections between works of art, such as styles, influences and historical backgrounds. Graph indexes have the advantage of being able to handle highly interconnected data sets, but their construction and query processes are computationally expensive and may require optimization algorithms to improve performance.

Each index algorithm has its unique application scenario and performance characteristics. When selecting the index algorithm suitable for the digital index system of works of art, comprehensive consideration should be made according to the specific application

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requirements and data characteristics. Through reasonable selection and optimization of indexing algorithms, artificial intelligence technology can significantly improve the efficiency and accuracy of digital indexing systems for works of art, thus promoting the management and research of works of art.

4. Search optimization strategy

In the digital index system of art works driven by artificial intelligence, the search optimization strategy is the core link to improve the user experience. These strategies aim to improve the search speed and accuracy by optimizing the search algorithm, so as to better meet the diversified needs of different users.

4.1. Application scenario analysis and optimization

The search optimization strategy is widely applicable to all kinds of art works digital index systems, especially when faced with massive art works data and high concurrent user access, the effect is particularly significant. In cultural institutions such as museums and art galleries, users may need to search quickly according to different interests, themes or artist styles. Efficient search optimization strategies can ensure that users can quickly find the required works of art and improve the overall service efficiency. For professional researchers, they may need to perform more complex and precise retrieval operations, such as similarity retrieval based on image features or cross-media retrieval.

4.2. Response time optimization

In the art works index system, the optimization of response time is directly related to the satisfaction of user experience. In order to shorten the waiting time of users and improve the response efficiency of the system, the application of caching technology has become a key strategy. Specifically, the system will intelligently identify high-frequency and high-cost query requests, and store the results of these queries in the cache after pre-calculation. When the same or similar query occurs again, the system can quickly retrieve the stored results from the cache and present them directly to the user, thus avoiding the repeated calculation process and greatly shortening the response time. This strategy can improve the retrieval speed, reduce the burden of the server effectively, and ensure the stable operation of the system under high concurrent access.

4.3. Diversified and personalized needs optimization

Through user behavior analysis, AI can identify users' preferences and needs and automatically adjust the ranking and presentation of search results. For example, if a user frequently searches for works by a certain type of artist, the system can learn this preference and prioritize related works by that artist in future queries.

4.4. Semantic search technology

Semantic search technology shows its unique advantage in the search field of art works because of its ability to deeply understand the deep intention of query. It goes beyond the limitations of traditional keyword-based matching to capture the emotion, abstraction, and context behind queries and return more accurate and meaningful search results. For artistic

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works, this feature is particularly important, because their descriptions often contain rich emotional colors and complex artistic concepts. Semantic search technology can more effectively meet users' needs for deep exploration of artistic works.

The application potential of artificial intelligence index system in art works management

1. Improve management efficiency

The application of artificial intelligence index system in the management of works of art has significantly improved the management efficiency, which is mainly reflected in the ability to automatically process a large amount of information about works of art and reduce manual intervention.

With artificial intelligence technology, the process of indexing and classifying works of art can be fully automated. Using image recognition and text analysis technology, the system can automatically identify the style, age and artist information of art works, and automatically classify and label them accordingly. This automation not only improves the speed of data processing, but also ensures the consistency and accuracy of information processing. Art institutions can quickly organize and access a large amount of collection information, which greatly improves the efficiency of daily management (Dai Mengfei.2024).

Artificial intelligence index systems are outstanding in reducing human intervention. Traditional art work management requires a lot of manual input and data proofreading, which is not only time-consuming but also error-prone. By learning and adapting, artificial intelligence systems can continuously optimize their indexing and classification algorithms, reducing their dependence on manual operations. The AI system can also automatically update records of art works, such as new exhibition information and art reviews, further reducing the workload of managers.

By analyzing historical data and market trends, the system can advise managers on strategies for buying, lending or exhibiting art. This data-based decision support not only enhances the scientific nature of management, but also enhances the ability of art institutions to respond to market changes.

The artificial intelligence index system significantly improves the efficiency of art works management by increasing the degree of automation of information processing and reducing manual intervention. This not only makes the daily management of art works more convenient and efficient, but also provides powerful data support and decision-making aid for art institutions, showing the huge potential of artificial intelligence in the field of art works management.

2. Promote academic research

The artificial intelligence index system can quickly extract and sort out key information from a large number of works of art through advanced image recognition and text analysis techniques. Such information includes, but is not limited to, the artist's life, the creation background of the work, the classification of artistic styles, and historical evaluation. This kind of automatic data sorting and classification improves the speed of information retrieval, and ensures the accuracy and consistency of information, which provides a reliable research basis for art researchers.

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The AI indexing system also has powerful data analysis capabilities, enabling it to correlate and compare data on works of art from different sources. For example, by analyzing works of art from different periods or regions, researchers can gain a deeper understanding of the evolution of artistic styles and the impact of cultural exchanges. This kind of cross-culture and cross-era data correlation analysis greatly broadens the vision and depth of art research.

The artificial intelligence index system also supports complex query operations, enabling art researchers to quickly obtain specific information according to specific research needs. Whether it is a detailed study of a particular artist or a broad overview of a particular art genre, the system provides accurate search results. This flexibility and adaptability promotes the efficiency and depth of academic research.

The application of artificial intelligence index system in art works management has greatly promoted the development of art academic research by providing efficient information retrieval tools. This technological advancement has not only brought unprecedented convenience to art researchers, but also contributed to art education and academic exchange around the world.

3. Enhance public experience

In public art exhibitions, AI indexing systems help visitors better understand the artworks on display by providing detailed information about the works and their backstories. For example, through the touch screen or mobile device, the audience can query the age of the art work, the life of the artist, and the historical and cultural background behind the work. Ai can also recommend other works that may be of interest based on the audience's interests and past art browsing history, making the audience's exhibition experience richer and more personalized.

In the application of online art platform, the artificial intelligence index system enables users to easily discover and explore new works of art through efficient search and recommendation algorithms. The system is able to analyze users' browsing and interaction data to provide customized art recommendations. This personalized experience improves user engagement, increases the exposure of art works, and promotes the activity of the art market.

Ai indexing systems can also play an important role in the field of art education. By incorporating virtual reality (VR) or augmented reality (AR) technologies, the system can create immersive art experiences such as virtual art galleries or interactive art teaching scenes that enable the public to learn art techniques or learn about art history in a virtual environment, thus greatly enriching the form and content of art education.

By providing rich information support and personalized interactive experience, the artificial intelligence index system has greatly enhanced the public's art appreciation experience in public art exhibitions and online art platforms. This not only makes artistic works more accessible and understandable, but also promotes the popularization and dissemination of artistic culture.

Conclusion

By exploring the application of artificial intelligence in digital indexing systems for works of art, this study reveals its significant potential in art management, academic research, and enhancement of public experience. Artificial intelligence technologies, especially machine learning, deep learning and computer vision, provide powerful technical support for the automated indexing of works of art, which not only improves management efficiency and

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reduces human errors, but also optimizes the accuracy and speed of access to information. Through efficient information retrieval function, intelligent index system greatly promotes the depth and breadth of art research, enabling researchers to quickly obtain the required data and insight into the complex correlation between art works. In terms of enhancing the public art experience, the artificial intelligence index system improves the audience's sense of participation and educational value by providing a highly interactive and informative platform, which in turn promotes the wide dissemination of art and culture. The application of artificial intelligence technology in the digital index of art works not only promotes the integration of art and technology, but also opens up a new path for the management, research and education of art works in the future, showing a wide and far-reaching impact.

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