Design and Research of Artwork Interactive Exhibition System Based on Multi-Source Data Analysis and Augmented Reality Technology

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***Abstract*—The current system has problems such as low efficiency of data processing, lack of smooth user experience and poor combination of display content and interactive technology, etc. There is a pressing need to optimize the integration of data analysis and augmented reality technology to improve the interactivity and visual appeal of exhibitions. This paper introduces and validates a combined prediction model based on multi-source data from the Internet. When using speeded-up robust features (SURF)-64 with a threshold of 500, the number of feature matches is 800, and the matching time is 162.85 ms. At a threshold of 1000, the number of matches drops to 510, and the time decreases to 96.54 ms. For SURF-128, the corresponding matches were 763 and 496, with times of 208.63 ms and 134.21 ms. This indicates that increasing the threshold not only reduces the number of matches but also shortens the matching time, likely due to fewer feature points simplifying the matching process.**

***Keywords*—Multi-source data; feature analysis; augmented reality technology; artwork interactive exhibition system; prediction model**

I. Introduction

With the popularization of the Internet and the leap of technology, the power of art information dissemination has been significantly enhanced, crossing the boundaries of time and space and widely reaching the public. The integration of digital media has given birth to new art forms, making art everywhere and profoundly affecting life [1, 2]. Artistic creation and technology are deeply integrated, computer technology and digital media have broadened the territory of art, traditional art has been revived under digital empowerment, and its forms of expression are more prosperous and more diverse [3]. Current AR systems in art galleries often focus on enhancing visitor engagement through virtual content, but they typically suffer from limitations such as poor integration of real-world and virtual objects, inadequate feature matching, and limited interactivity. For instance, many systems use basic tracking technologies or simplistic feature extraction methods, which result in a disjointed user experience and less precise placement of virtual elements. Several existing studies have addressed these issues by introducing advanced tracking algorithms and feature extraction techniques, but challenges like real-time performance and seamless interaction between users and virtual content persist. Furthermore, some AR applications still lack immersive interactivity, offering only passive viewing experiences rather than engaging users actively in the artistic exploration process. Our system significantly improves on these limitations by utilizing multi-source data analysis and advanced feature extraction algorithms, such as SURF-64 and SURF-128, which enable more precise object detection, quicker feature matching, and smoother integration of virtual objects into real-world environments [4, 5]. In today's information-driven era, new innovations continuously emerge, and artistic expressions and aesthetic standards are constantly evolving. People's appreciation for the aesthetics of science and technology has become mainstream, as seen in their acceptance and love for new art forms, which also influence our understanding of traditional art [6, 7]. The spread of digital technology has broadened our aesthetic perspectives, encouraging artists to explore new forms of expression and ideas that align with and lead this evolving aesthetic trend [8, 9]. One notable shift is the enhancement of artistic interactivity and participation. Digital technology allows new art forms to be more open and interactive, contrasting with traditional art's one-sided dynamic where artists create and viewers merely observe. In digital art, the audience actively participates in the creative process [10]. AR has revolutionized the way people engage with digital content, particularly in areas like art and culture, by merging real and virtual worlds. AR enables audiences to experience artworks interactively, bringing new dimensions to traditional art forms and making exhibitions more immersive and engaging. However, a critical challenge in AR-based exhibitions lies in ensuring the seamless integration of virtual objects into real environments. Accurate tracking of user movements, efficient processing of environmental data, and the synchronization of multiple data sources are key to creating a cohesive and meaningful interactive experience. Multi-source data analysis plays a crucial role here, as it aggregates information from various sensors, cameras, and user interactions to build a comprehensive understanding of the exhibition space. The proposed combined prediction model addresses these challenges by optimizing the system's ability to anticipate user actions and adjust the virtual content accordingly. This predictive capability enhances the responsiveness of the system, improving the overall interaction quality and ensuring that the AR elements are appropriately aligned with the real world.

The influence of digital technology on art is profound and wide-ranging. From the dissemination of information to changes in the creative process and the renewal of aesthetics, art is becoming deeply integrated into everyday life, serving as a vital link between science, technology, and culture. As technology advances, art will continue to grow in diversity and complexity [11, 12]. Augmented reality technology combines the real and virtual worlds to create immersive 3D experiences, allowing users to interact intuitively and enjoy new sensory experiences. This interdisciplinary technology integrates tracking, interaction, graphics, and multimedia to enhance system performance, enabling a seamless fusion of the virtual and natural worlds, making users feel as though they are in a blended reality [13, 14]. In augmented reality systems, tracking technology is crucial. It enables the system to accurately capture the user's perspective and position, thereby adjusting the position and display angle of virtual objects in the real world in real-time [15, 16]. AR has revolutionized the way people engage with digital content, particularly in areas like art and culture, by merging real and virtual worlds. AR enables audiences to experience artworks interactively, bringing new dimensions to traditional art forms and making exhibitions more immersive and engaging. A critical challenge in AR-based exhibitions lies in ensuring the seamless integration of virtual objects into real environments. Accurate tracking of user movements, efficient processing of environmental data, and the synchronization of multiple data sources are key to creating a cohesive and meaningful interactive experience. Multi-source data analysis plays a crucial role here, as it aggregates information from various sensors, cameras, and user interactions to build a comprehensive understanding of the exhibition space. The proposed combined prediction model addresses these challenges by optimizing the system's ability to anticipate user actions and adjust the virtual content accordingly. This predictive capability enhances the responsiveness of the system, improving the overall interaction quality and ensuring that the AR elements are appropriately aligned with the real world [17, 18].

II. Key Technologies of Art Interaction System

A. *Augmented Reality Tracking Registration Technology*

Tracking registration technology is the core of augmented reality. It is widely used to track the dynamics of people and objects in real time and integrate with virtual data to ensure that virtual information is accurately superimposed on real scenes and achieve seamless integration of virtual and real. As shown in Eq. (1) and Eq. (2), these equations define the parameters of feature points used in tracking and registration. Pi represents the position and scale information of the i feature point, where x and y are the coordinates of the feature point in the image, and s is the scale value of the feature point. pt denotes the position at time t, pt−1 is the position at the previous time, v is the velocity, and t1 is the time interval. Its key function lies in precise positioning and dynamic adjustment, so that virtual objects can naturally integrate into reality, presenting highly realistic visual effects both indoors and outdoors.

$$P_i = (x_i, y_i, s_i) \tag{1}$$

$$p_t = p_{t-1} + vt_1 \tag{2}$$

The tracking technology of augmented reality mainly detects objects by various means. As shown in Eq. (3), this equation models the illumination of virtual objects in comparison to real scenes. Ivirtual is the illumination of virtual objects, Ireal is the illumination of real scenes, Iambient is the ambient illumination, and g is the illumination consistency coefficient. These detection means include, but are not limited to, visual tracking, inertial sensors, GPS positioning, and the like. Through these technical means, the augmented reality system can obtain information such as the real-time position, posture and motion state of objects.

$$I_{virtual} = gI_{real} + (1-g)I_{ambient} \tag{3}$$

This transformation not only needs to take into account the three-dimensional spatial position of the object, as shown in Eq. (4), This equation pertains to the consistency of occlusion in augmented reality. Zocclusion is the consistency measure of occlusion, Zreal is the depth value of the real scene, and Zvirtual is the depth value of the virtual object. It is also necessary to combine the motion state of the object and the ambient lighting conditions to ensure that the performance of the virtual object in different scenes can meet the user's expectations.

$$Z_{occlusion} = Z_{real} - Z_{virtual} \tag{4}$$

Tracking technology faces many challenges. First of all, in order to achieve seamless virtual and real fusion, tracking technology needs to have extremely high accuracy and stability. As shown in Eq. (5) and Eq. (6), These equations address the time-sensitive aspects of tracking technology. update is a time interval of real-time update, and fframe is a frame rate. Di is the description vector of the i-th feature point, which contains high-dimensional data describing the local features of the feature point. This means that the system must be able to update the position and pose information of the object in real time within the millisecond level, ensuring that the position of the virtual object in the user's field of view is always consistent with the reference object in the real world.

$$t_{update} = \frac{1}{f_{frame}} \tag{5}$$

$$D_i = \begin{pmatrix} d_{i1} & d_{i2} & \cdots & d_{i16} \end{pmatrix} \tag{6}$$

No delay and no jitter are also important indicators of augmented reality tracking technology. Any tiny delay or jitter will destroy the coordination between the virtual object and the real scene. As shown in Eq. (7) and Eq. (8), these equations focus on the metrics for evaluating feature point matching. Matchi,j is the matching measure of the i-th feature point and the j-th feature point, and b is the standard deviation, which is used to control the width of the Gaussian function. dij is the Euclidean distance between the i-th feature point and the j-th feature point, which is used to measure their similarity. Causing discomfort to the user when using the augmented reality system. Advanced tracking technology often relies on high-performance hardware support and optimized algorithm design to minimize delay and jitter and improve system response speed and stability.

$$Match_{i,j} = exp\left(-\frac{\|D_i - D_j\|^2}{2b^2}\right) \tag{7}$$

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{8}$$

B. *Feature Analysis Related Technologies*

In image processing and computer vision, feature analysis is very important. As shown in Eq. (9) and Eq. (10), these equations delve into feature point analysis, Thresholdfeature is the threshold of feature points, N is the total number of feature points, and di is the description measure of each feature point. L(x,y,c) is the image of the scale space, G(x,y,c) is the Gaussian filter, and I(x,y) is the original image. Feature points carry location, scale and high-dimensional description vectors to uniquely identify each point like a "fingerprint".

$$Threshold_{feature} = \frac{1}{N}\sum_{i=1}^{N} d_i \quad (9)$$

$$L(x,y,c) = G(x,y,c) \times I(x,y) \quad (10)$$

High-dimensional description promotes efficient recognition and matching, and supports key tasks such as image registration, stitching, recognition and 3D reconstruction. As shown in Eq. (11) and Eq. (12), These equations describe the characteristics of feature points, Fi is the description vector of the i-th feature point, which contains local information of the feature point, f is the eigenvalue. Ti is the extraction result of the I-th feature point, Extract is the extraction algorithm, and I is the image. Feature point matching is its core, ensuring accurate matching of similar points between images.

$$F_i = \left(f_{i1} \quad f_{i2} \quad \cdots \quad f_{iN} \right) \quad (11)$$

$$T_i = Extract(I, x_i, y_i, s_i) \quad (12)$$

In the actual operation of feature point matching, how to improve the accuracy and speed of matching is one of the technical difficulties. At present, the popular matching method is to compare the feature points by using the trace of Hessian matrix and Euclidean distance similarity. As shown in Eq. (13), Correcti is the result of correcting the i-th feature point, Align() is the correction function, and Ref is the reference model, T is the time for updating. The Hessian matrix is a second derivative matrix, which can capture the curvature rate information in the image, thus helping to locate feature points more accurately.

$$Correct_i = Align(T_i, Ref) \quad (13)$$

By calculating the trace of the Hessian matrix, we can obtain the change information of the local area around the feature point, and the Euclidean distance is used to measure the similarity between the two feature points. As shown in Eq. (14), this equation highlights the importance of filtering feature points based on similarity metrics. Ffiltered is a filtered feature point, and FilterType is a filter type. When the Euclidean distance between two feature points is smaller, the higher the similarity between them, so it can be considered that the two feature points are matched.

$$F_{filtered} = Filter(F_i, FilterType) \quad (14)$$

This method, which combines the similarity of Hessian matrix and Euclidean distance, not only performs well in the matching accuracy of feature points, but also significantly improves the matching speed. As shown in Eq. (15) and Eq. (16), these equations quantify matching performance. Precisionmatch is the matching accuracy, TP is the true example, and FP is the false positive example. Stabilityfeature is the stability of the feature point, and Variance() is the Variance of the description vector. This is because Hessian matrix provides a more direct curvature information, which makes irrelevant feature points more quickly filtered out in the process of feature point matching, thus reducing the amount of calculation and improving the overall matching efficiency.

$$Precision_{match} = \frac{TP}{TP + FP} \quad (15)$$

$$Stability_{feature} = Variance(D_i) \quad (16)$$

III. Interactive System Under Multi-Source Data Fusion and Analysis Technology

A. AR-Based Interaction Design and Optimization

AR technology has become popular with the development of computers and multimedia, and its core lies in the integration of virtual and honest, which promotes the interaction between users' reality and virtual reality. Optimizing interaction design is the key. It is necessary to pay attention to user experience and pursue intuitive and natural interaction [19]. Natural behaviors such as postures, expressions, and voices have become a trend to manipulate virtual objects, which are more humane than touch screens and handles and enhance convenience and immersion. Using human postures and gestures to interact with virtual objects is one of the most natural and intuitive ways at present [20, 21]. In this interactive mode, it is first necessary to monitor the user's body position and movements in real-time through accurate tracking and registration technology. According to this information, the system will determine the user's position in three-dimensional space and judge his intention by analyzing his actions [22, 23]. According to the preset action definition, the system will associate the user's action with specific operation instructions to realize virtual object control. Optimizing interaction design is particularly critical to make this interaction mode easier for users [24, 25]. The movements are designed to be ergonomic, ensuring that users do not experience discomfort or fatigue while performing them. The association between actions and operations should have precise semantics so that users can intuitively understand and remember them. Users can zoom in or out of virtual objects through simple gestures or close virtual windows by waving their hands. These designs must be finely optimized based on user habits [26, 27]. Table I shows the results of interactive system response test data. Voice interaction is also a natural interaction method widely used in augmented reality.

TABLE I. Results of Interactive System Response Test Data

Test Items	Average time to detect and track new users	User gesture detection average time	Average time of initialization and correction of artwork interaction system	Average time to obtain artwork location
Test Results (ms)	0.62	3.38	276.78	26.58

Through speech recognition technology, the system can recognize the user's voice commands and convert them into operation commands, thus realizing the control of virtual objects. Voice interaction has the advantages of no touch and easy remote operation, and it is especially suitable for scenarios that require multitasking or when hands are inconvenient [28]. "Occlusion consistency" refers to the ability of an AR system to realistically handle the overlapping or covering of virtual and real-world objects. When a virtual object is placed in a scene, it must appear as though it interacts naturally with real-world objects, meaning that parts of the virtual object should be hidden or "occluded" by physical objects if they overlap in space. Maintaining occlusion consistency is critical for enhancing the realism of AR experiences. "Virtual objects" are computer-generated 3D models that are projected into the real-world environment through AR devices, such as headsets or mobile screens. These objects appear as though they exist within the physical space, and users can view and interact with them through the AR system. The seamless integration of virtual objects with the physical world is one of the defining characteristics of effective AR systems. "Feature points" are specific, easily recognizable points within a digital image or physical environment that are used by AR algorithms to map, track, and understand spatial relationships. Fig. 1 is the AR interaction design algorithm's principle and implementation flow chart. After passing the threshold screening, the system performs non-maximum suppression on each remaining feature point. This step ensures that the selected feature point is a prominent feature in its scale space. Fig. 1 demonstrates the AR interaction design algorithm's principle and the step-by-step implementation flowchart. This flowchart is essential as it outlines how the system processes real-time user interactions with virtual objects in an augmented reality environment. It emphasizes key steps, such as detecting and tracking the user's gestures, accurately registering virtual objects in the real world, and ensuring smooth interaction through algorithms that optimize real-time performance.

SURF-64 uses a 64-dimensional descriptor, which makes it faster but less detailed compared to SURF-128, which employs a 128-dimensional descriptor for capturing more information about feature points. In this research, these algorithms were implemented to detect and match distinctive feature points between real-world images and virtual elements. The system extracts feature from images of artwork or the exhibition space, and SURF is used to generate a set of keypoints, such as corners or edges, that are invariant to changes in scale, rotation, or lighting. These algorithms are integrated into the interactive exhibition system by first preprocessing the input data to detect feature points in real-time, followed by the matching of these feature points to align virtual objects with the physical environment. SURF-64 and SURF-128 are configured based on the exhibition's needs, where SURF-64 offers faster computation for real-time tracking, while SURF-128 provides more detailed feature matching when precision is critical. This means that the final position and scale value of feature points can be more accurate than the original pixel grid, thereby improving the accuracy and reliability of feature point matching. Fig. 2 is the architecture diagram of the multi-source data fusion algorithm. Accurate detection and matching of feature points is crucial to the performance of augmented reality systems. Fig. 2 focuses on the multi-source data fusion algorithm architecture, which is critical for integrating diverse data inputs from various sources, such as sensors, images, and spatial data, into a cohesive system.

B. Feature Extraction of Artworks Based on Machine Learning

Augmented reality requires realistic modeling of virtual objects, considering shape, material, light and shadow, and environmental interaction. The key challenges are lighting, occlusion consistency, and shadow casting. Lighting consistency is the most important. It is necessary to simulate natural lighting, adjust the lighting effect of virtual objects, and calculate actuarially based on scene geometry and reflection attributes to match natural light sources and enhance visual reality and immersion. Occlusion consistency is another crucial factor involving the mutual occlusion between virtual and natural objects. In the real world, the occlusion relationship between objects is essential for judging the spatial relationship. In augmented reality, virtual objects should have an occlusion relationship with natural objects as if they exist in the same space. Table II shows the test data of the augmented reality natural feature point tracking and registration module of the artwork interactive system. The system must accurately calculate the occlusion relationship between the virtual object and each object in the natural environment and render it in real-time. In this field, Bauhaus University in Germany took the lead in achieving the consistent effect of virtual and real occlusion, which made the occlusion effect of virtual scenes reach a highly realistic level. This technological breakthrough significantly improves the realism of augmented reality systems, allowing virtual objects to be more naturally integrated into actual scenes.

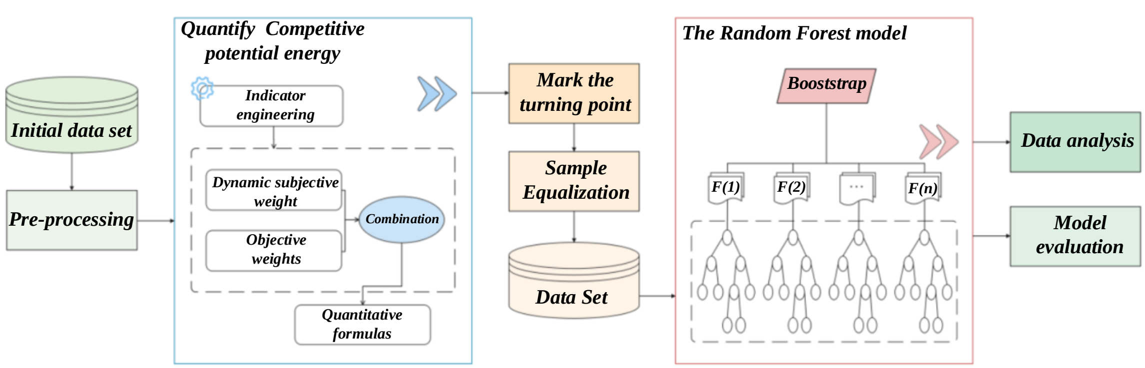

Fig. 1. Principle and implementation flowchart of AR interaction design algorithm.

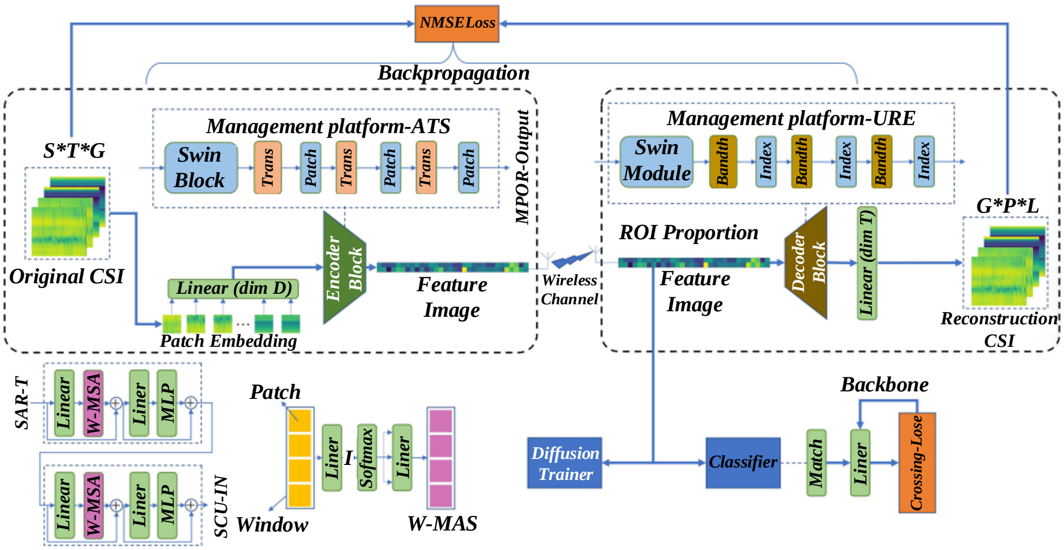

Fig. 2. Architecture diagram of multi-source data fusion algorithm.

TABLE II. TEST DATA OF AUGMENTED REALITY NATURAL FEATURE POINT TRACKING REGISTRATION MODULE OF ARTWORK INTERACTION SYSTEM

Test Items	Run Results
Number of feature points detected	65
Feature point detection time (ms)	75.37
Number of successful feature point matches	27
Number of successful tracking feature points	22
Tracking match time (ms)	13.14
Number of feature points detected after tracking failure	49
Feature point detection time (ms) after tracking failure	61.5

In augmented reality, to keep the shadow of the virtual object consistent with the direction and intensity of the light source in the actual scene, the system needs to accurately calculate the position and intensity of the light source and the geometry of the virtual object. In this way, the shadows of virtual objects can seamlessly blend with shadows in natural scenes, thus further enhancing the realism of augmented reality. Machine learning techniques have been widely used in augmented reality systems to achieve these complex effects. Through machine learning algorithms, the system can automatically learn illumination rules, occlusion relationships, and shadow projection rules from a large amount of accurate scene data, thereby generating more realistic visual effects in augmented reality. This reduces the workload of manual debugging and improves the system's automation level, making augmented reality technology more widely used in various scenarios. In augmented reality and computer vision, feature point extraction and matching are the keys to fusion. Fig. 3 is the application evaluation diagram of a multi-source data fusion algorithm in art information processing, with machine learning assistance, Fast-Hessian quick detection of feature points, and SURF completion description to ensure accuracy and stability. Fast-Hessian efficiently locates scales but lacks direction description; SURF makes up for this shortcoming and provides detailed feature data. The SURF descriptor uses Haar wavelet to extract the direction information of the feature points, thus realizing the rotation invariance of the feature points. In image processing, rotation invariance means that no matter how the image is rotated, the description information of feature points can still be consistent, thus ensuring the matching accuracy of feature points.

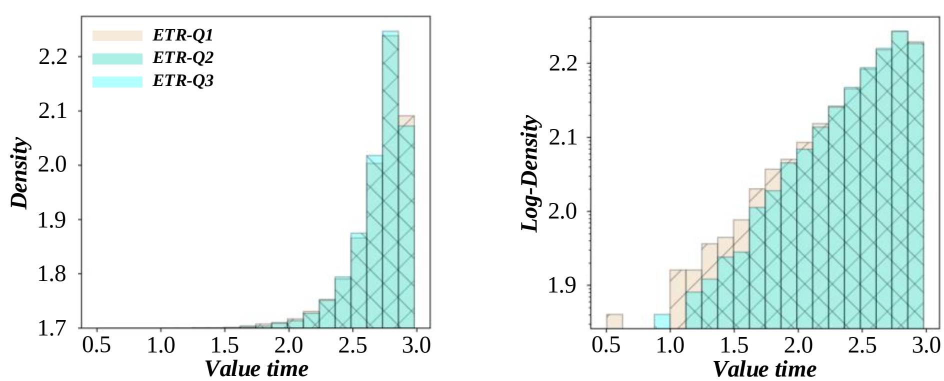

Fig. 3. Application evaluation diagram of multi-source data fusion algorithm in art information processing.

IV. Multi-Source Data Analysis and Analysis Design of Art Interactive Exhibition System Under Augmented Reality Technology

A. *Implementation of Augmented Reality Technology in Art Exhibitions*

Response time refers to the system's ability to register and process interactions in real-time, ensuring a seamless user experience. In an interactive exhibition, any noticeable lag or delay in responding to user inputs can disrupt the flow and diminish the immersive quality of the experience. Therefore, a faster response time is essential for maintaining engagement and enhancing the system's usability. Feature point detection is crucial for the accurate placement and movement of virtual objects in augmented reality. By increasing the number of detected feature points through algorithms like SURF-64 and SURF-128, the system ensures more precise tracking and overlay of virtual content, providing a more coherent integration of real and virtual elements. This is particularly important in art exhibitions where accuracy in object alignment can directly affect how well users perceive the interaction. User interaction accuracy measures how well the system interprets and responds to gestures, voice commands, or touch inputs, which is vital for creating an intuitive and engaging experience. If the system fails to accurately interpret user inputs, it could lead to frustration and disengagement. System stability ensures that the exhibition runs smoothly without crashes or significant performance degradation, which is critical in public settings. Immersive experience is an overall measure of user satisfaction and engagement, assessing how well the system integrates AR technology to create an engaging and interactive environment. Fig. 4 is an accuracy evaluation diagram of an art style recognition algorithm based on multi-source data analysis. This method has the advantages of high accuracy and fast recognition speed and is especially suitable for complex exhibition environments. Its limitation lies in the need to add additional signage in the exhibition venue, which may affect the aesthetics of the exhibits and the audience experience. Natural feature point tracking technology based on no identification is more flexible and natural.

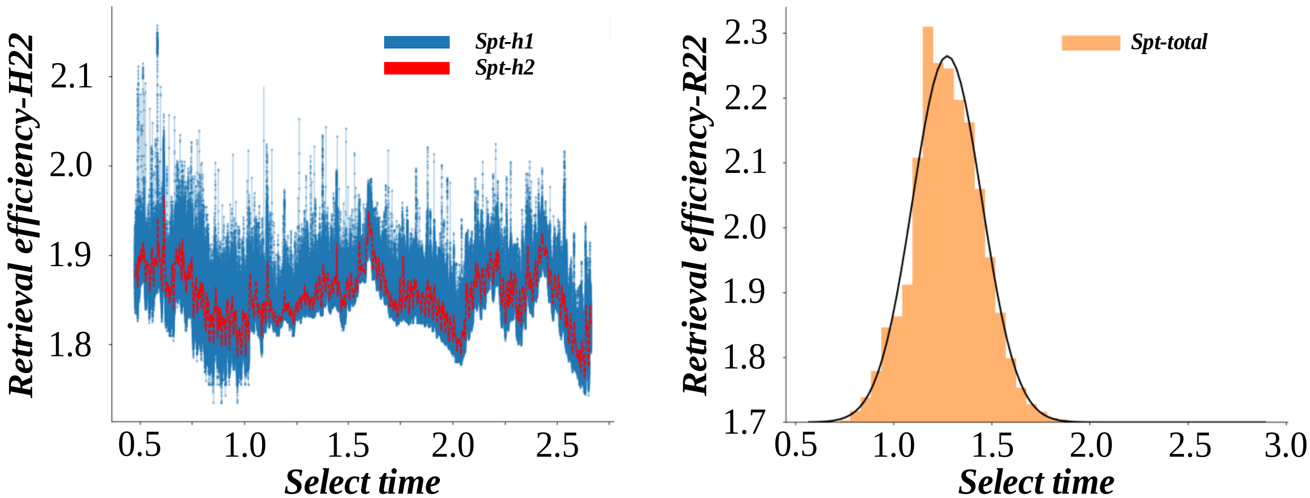

Fig. 4. Accuracy evaluation chart of art style recognition algorithm based on multi-source data analysis.

The application of augmented reality technology in art exhibitions can provide richer information display forms for the audience and enhance the interaction between the audience and the artworks through virtual guides and interactive experiences. When watching a famous painting, the audience can see the creative story behind the painting and the artist's life through augmented reality technology and even interact with virtual artists to gain an in-depth understanding of the connotation of the artwork. This novel exhibition method dramatically enhances the interest and sense of participation, making the audience a passive appreciator and a part of the exhibition. After the direction calculation, the SURF descriptor uses the integral graph to quickly calculate the rectangular area where the feature points are located. The advantage of the integral graph is that it can efficiently calculate the sum of pixels in any rectangular area in the image, which is widely used in fast image processing algorithms. In the feature extraction process of the SURF descriptor, the integral graph is used to define the region of interest, that is, the critical area near the feature points. Fig. 5 is an evaluation diagram of the audience behavior data analysis algorithm for exhibition route optimization. The SURF descriptor can generate detailed feature point description information by calculating the feature vector based on the Haar wavelet in this region of interest. This description information not only contains the location and direction of feature points but also includes rich data about the local structure of feature points, which is very important for the matching and subsequent processing of feature points.

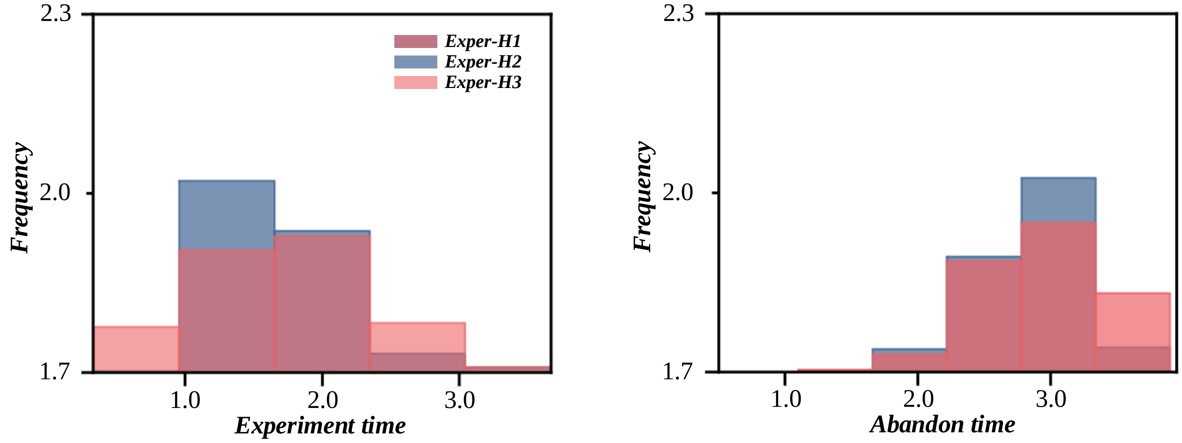

Fig. 5. Evaluation diagram of exhibition route optimization by audience behavior data analysis algorithm.

B. Architecture and Performance Evaluation of Art Interactive Exhibition System

In the interactive art exhibition system, feature point matching affects the overall performance. The SURF algorithm is efficient in recognition, but there are mismatches. Random Sample Consensus (RANSAC) algorithm improves the accuracy by random sampling to eliminate mismatches. First, the model parameters are determined, the samples are randomly selected to calculate the model, and the correct point set is screened according to the geometric distance. To improve the algorithm's accuracy, the RANSAC algorithm will randomly sample multiple times and find the most extensive set of consistent points. These point sets are divided into inner and outer points. This way, the algorithm can effectively screen out the matching points and determine the final model parameters. Finally, these maximum consistent point sets are used to re-estimate the model to output the optimal result. Fig. 6 is the evaluation diagram of the audience behavior data analysis algorithm for optimizing the exhibition route. The RANSAC algorithm shows high efficiency and stability when dealing with feature point matching. It can accurately identify and remove mismatched feature points in complex matching environments, improving the matching accuracy and robustness of the whole system.

The successful application of the RANSAC algorithm can significantly improve the performance of the interactive exhibition system of artworks, making the integration of virtual and reality more natural and realistic. In the architecture of an interactive exhibition system of artworks, accurately matching feature points is the key to realizing the perfect integration of virtual content and artworks. Using the RANSAC algorithm, the system can effectively reduce mismatches and ensure users' interactive experience in the exhibition is smoother and more realistic. Combined with other optimization techniques, such as image preprocessing, feature point enhancement, and multi-view fusion, the system's overall performance can be further improved. The architecture and performance evaluation of interactive art exhibition systems must comprehensively consider feature point detection, matching algorithms, and overall stability. As an efficient mismatch processing technology, the RANSAC algorithm provides strong support for accurate system matching. In the interactive exhibition system of artworks, the brightness of images concentrates on the details. Fig. 7 is an experimental data evaluation diagram of the AR interaction design algorithm to improve the audience's immersion. The histogram averages and stretches the gray distribution, enhances contrast, shows details, and helps subsequent processing, such as binarization. The basic principle of histogram averaging is to map the brightness histogram of the input image into a new histogram so that the brightness value distribution of the new histogram is more uniform.

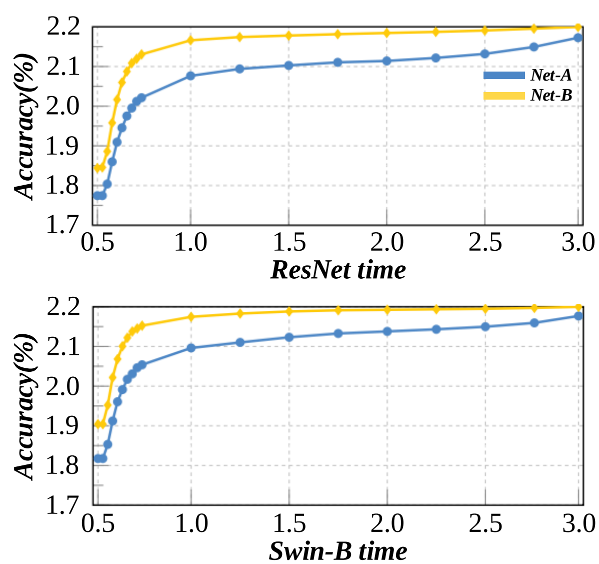

Fig. 6. Evaluation diagram of exhibition route optimization by audience behaviour data analysis algorithm.

Because of the uniformity of gray value distribution, the setting of the binarization threshold is more accurate in the image after the histogram means, thus improving the accuracy and effect of binarization. Histogram averaging often needs to be implemented in combination with specific mapping functions. These mapping functions are used to convert the original gray value of the image into a new gray value to enhance contrast and uniform distribution. Standard mapping functions include linear mapping and nonlinear mapping. By selecting appropriate mapping functions, the effect of histogram averaging can be adjusted according to specific application requirements and image characteristics. Besides histogram averaging, other aspects of image processing, such as feature point extraction, matching algorithm, and image fusion, must be comprehensively considered to ensure the performance of the interactive exhibition system of works of art. By optimizing and improving these technologies, the system can achieve a more efficient and accurate artwork display and interactive experience. The performance evaluation of the system is also a critical link. Through the comprehensive review of the image processing effect, the stability and performance of the system can be continuously improved to meet the high requirements of users for art exhibitions. Fig. 8 is an evaluation diagram of the accuracy changes of the audience feedback prediction algorithm based on machine learning. Histogram averaging plays an essential role in the interactive exhibition system of artworks. It improves the contrast and detail performance of images and provides a reliable foundation for subsequent binarization processing.

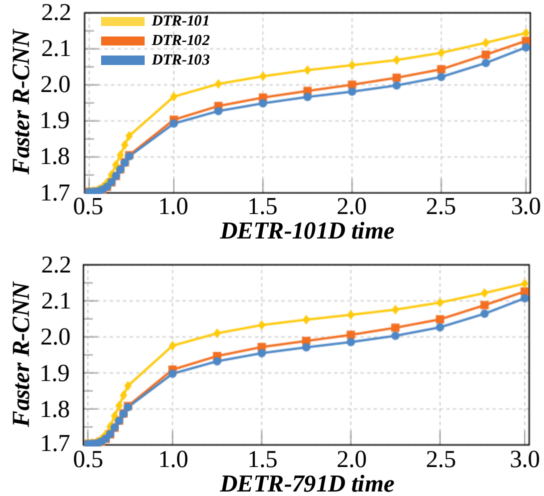

Fig. 7. Experimental data evaluation diagram of AR interaction design algorithm to improve audience immersion.

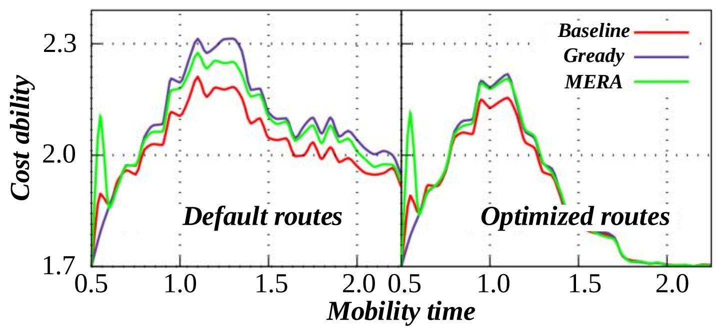

Fig. 8. Accuracy change evaluation diagram of audience feedback prediction algorithm based on machine learning.

V. Experimental Analysis

Finding and matching feature points is incredibly time-consuming when the target image is large. In this case, many feature points may increase the computational complexity and time consumption, which cannot meet the real-time requirements. Especially in real-time application scenarios, such as dynamic scenarios in augmented reality systems, fast processing, and response are required, so finding and matching many feature points may lead to system performance degradation. Fig. 9 is the evaluation diagram of the response time of the system performance evaluation algorithm on the interactive exhibition system of artworks. Although we may find many feature points in the target image, only some of them are feature points that need to be matched.

Some optimization strategies are usually employed. Using more accurate feature point detection algorithms improves the quality of feature points instead of just increasing the number. Through the feature point selection and screening algorithm, the feature points that have the most significant influence on the final calculation result are matched first, thus reducing the interference of irrelevant points. Fig. 10 is an application evaluation diagram of the security policy design algorithm in art data protection, especially in augmented reality systems. It is necessary to determine the quantity and quality of feature points according to specific needs to achieve the best system performance and user experience.

According to the size of the image, it needs to be cropped to reduce the processing amount and improve efficiency. Video dynamics require strategic cropping and efficient matching. The setting of the cropping area also needs to be adjusted according to the actual situation. If the motion in the image is too fast, it may cause the target object or feature point to move out of the cropped area. Fig. 11 is the evaluation diagram before and after improving the AR interactive interface based on the user interface design optimization algorithm. The system must re-detect the entire image to ensure that essential feature points are not missed. Although this scenario increases the computational burden, by clipping within this neighborhood according to the last detected feature point location, the system can reduce the size of the area to be looked up.

The system's performance can be further improved by optimizing the selection of cropping areas. The cropping area can be intelligently adjusted based on the movement trajectory of the target object and the known feature point position in the image, thereby reducing the frequency of re-detection and further improving processing efficiency. The strategy of cropping images significantly impacts the efficiency of augmented reality systems. By setting the cropping area reasonably and reducing the size of the image to be searched, the speed of feature point extraction and matching can be effectively improved, thus improving the overall running efficiency of the system. Fig. 12 is the application efficiency evaluation diagram of feature extraction and matching algorithm in art image recognition. When dealing with dynamic scenes, it is necessary to consider the motion of target objects to ensure the accuracy and real-time performance of the feature point detection and matching process.

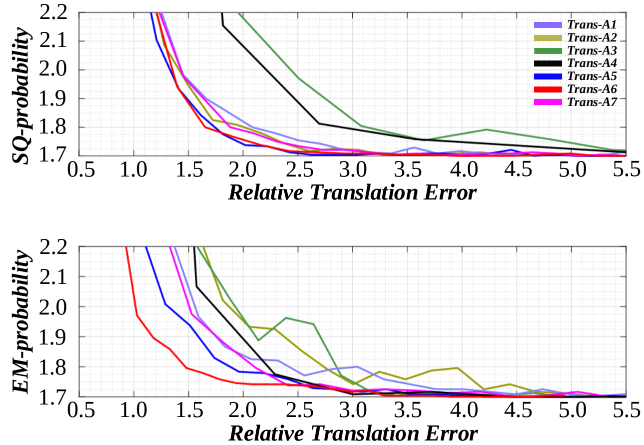

Fig. 9. Evaluation diagram of system performance evaluation algorithm on the response time of art interactive exhibition system.

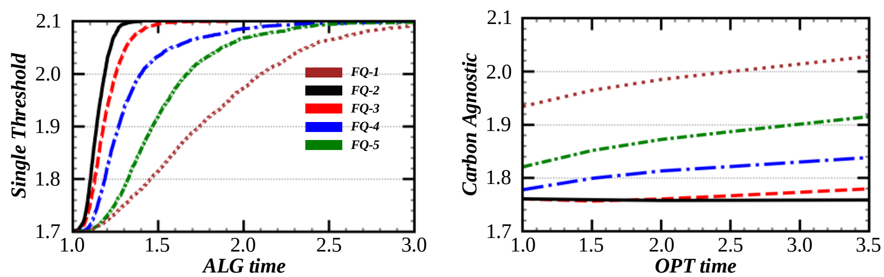

Fig. 10. Application evaluation diagram of security policy design algorithm in art data protection.

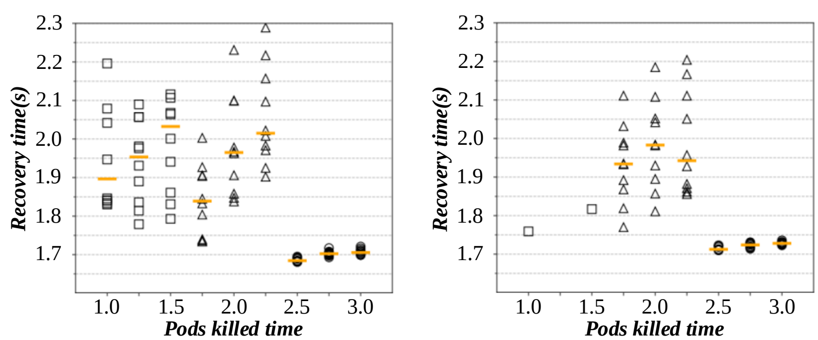

Fig. 11. Evaluation diagram before and after improvement of AR interactive interface based on user interface design optimization algorithm.

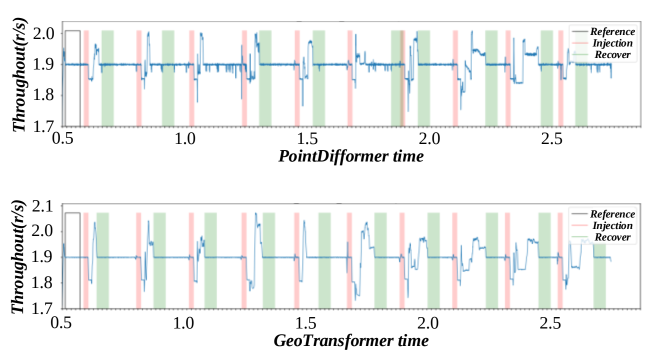

Fig. 12. Application efficiency evaluation diagram of feature extraction and matching algorithm in art image recognition.

VI. CONCLUSION

This paper focuses on the application of computer vision and augmented reality technologies in artwork interaction systems, where feature point extraction and matching, as a key step in image recognition, significantly improves the accuracy of recognition. Although multi-feature point extraction can increase the accuracy, it is not always necessary because too many feature points may instead lead to a heavier processing burden on the system. In AR applications, feature points not only assist in calculating transformations between images, such as the solution of a single response matrix requires at least four matching points, but increasing the number of feature points does not always bring additional benefits, but may instead increase computational complexity and resource consumption.AR technology, with its powerful interactivity and integration of multi-sensory experiences such as visual and auditory sensations, is gradually revolutionizing the way art is viewed.

In this paper, the consistency of occlusion illumination in virtual object interaction is essential for experience, but the research needs to be stronger and needs a breakthrough in the future. The study focuses on the analysis and prediction of Internet multi-source data characteristics, efficiently integrates data to predict realistic indicators, such as the number of interactive systems of artworks, and verifies it in predicting tourist volume, showing the potential of wide application of the model. One key area for future research is enhancing the precision and responsiveness of the AR system, particularly in terms of improving the real-time interaction between virtual and real-world objects. This could involve exploring more advanced algorithms for feature extraction, tracking, and data fusion, ensuring a seamless integration of virtual objects into the physical exhibition space. Another area worth exploring is optimizing the system's performance under various environmental conditions, such as changes in lighting, user movement, or large crowds. While the current model focuses on integrating multi-source data, future research could investigate how to make the system more adaptable and resilient in these dynamic settings, enhancing its robustness and versatility in different exhibition environments.

This paper studies the multi-source data collection and feature analysis of the Internet. It takes the art interaction system as an example to design a scheme to screen relevant data effectively. Aiming to solve the problem of data clutter, comprehensive index optimization is calculated by keyword screening and calculation. The number of mismatches for SURF-64 is 49 at threshold 500 and 22 at threshold 1000, 11, and 7 for SURF-128 under the same conditions, respectively. This shows that a higher threshold and a more significant dimension can help reduce the number of false matches and improve the matching accuracy.

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