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Cultural expression and interactive development of new media art and design

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SUMMARY: *The current study suggests ways to incorporate the traditional Chinese culture into the design of new media art as well as the conditions to reach the interactivity in these designs. In order to enhance the artistic expression and increase the level of emotional involvement between audience and artwork, an interactive simulation system based on three dimensional gestures was created through Kinect motion sensing technology. Integrating the behavioral interaction and environmental adaptability detection approach, the system allows combined control and simulation of three-dimensional gesture interactions with artworks. It was found that the given approach provides a steady output at low latency of 3D gesture interaction simulation, keeping recognition lag rate under 4.96%. Approbation of the system by users was 66.67%. The developed simulation system is efficient in terms of facilitating cultural expression.*

KEYWORDS: *Kinect; new media art design; behavioral interaction; cultural expression*

1 Introduction

Since the emergence of the digital era, sophisticated technologies have been gradually incorporated into human production and lifestyle, which leads to the constant improvement of the design quality and the growing interest in interactive experience design [1]. In such a context, an innovative form of media art has arisen, and it pushes the boundaries of both the art and technology domains even more [2]. New media art with its high level of technology and unique interactivity provides the audience with unprecedented sensory experiences [3]. Interactive experience design is crucial to the field of new media art, as it not only goes beyond the conventional limits of creative activities but also increases interaction between individuals and works of art [4]. At present, the use of interactive experience design is being extended. More and more designers are using new media art to create intuitive interactive artworks and drive the future development of interactive experience design [5, 6].

The field of interactive experience design on the basis of new media art has received a good amount of interest and has been successful in its achievements. Wang [7] delved into how visual communication technology and art interact with each other in the new media environment. Literature analysis, case studies, and experimental analysis were used to determine the effectiveness of a deep learning-based intelligent visual art design architecture. Guo et al. [8] found through literature review, data analysis, and questionnaire surveys that the interactivity of new media art design facilitates the preservation and dissemination of culture. Interactive experience spaces constructed with new media technologies are the driving forces behind the

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development of new media application in art design. Liu et al [9] discussed the concept of interactive art design methods based on new media technologies and summarized the methods of incorporating such technologies into artistic design. They highlighted the importance of artificial intelligence as a new media tool and platform in the interactive art making process. Gor [10] created an iconic visual topography of art based on mobile touch screens, which is based on the principles of the new media aesthetics theory and demonstrates the interaction between the viewer and the artwork as part of a multisensory space. Ahmedien [11] studied the role of new media technology in art creation as an interactive tool by taking the artwork titled, A Beam of Light as a case study. The research confirmed the value of interactive new media practices, as it stated that they reduce the performers hesitation and help to progress interactive art performances. Lee et al. [12] contended that artistic creation using new media technologies like virtual reality and augmented reality (by combining artworks with real-world locations or putting audiences into virtual worlds) can improve interest in new experiences and remove the gap between observers and works of art. Yin [13] defined the functions of augmented reality, virtual reality, and interactive digital platforms in art design. The technologies enhance the optimalization of visual communication designs of arts, improving the immersive and interactive experiences of audiences and their levels of engagement. Di et al. [14] observe that new media technologies have transformed art design with new media art capturing audience attention through its interactivity. Such experiences enable viewers to engage closely with an artwork creation, which fills their emotional responses.

Moreover, in order to improve the results of artistic design, Zhang et al. [15] used artificial intelligence to build an interactive art design system. The model was experimentally validated, and it proved successful in interactive art design, which can satisfy the requirements of new media era artistic creation. Kun [16] also explained the process of implementing interactive media art design and came up with the model of visual programming. Works of art made under this interactive setting are more intuitive and interactive, and can help the creators of the works engage in personal artwork creation. To sum up, the concept of interactive experience design is becoming more and more important as the new media art keeps changing[17]. Nevertheless, there are still substantial flaws in the form of improper application of the interactive experience design and unsystematic use of the multimedia technologies. More research and practical work needs to be done [18].

The present paper develops the three-dimensional gesture-based interactive simulation system of artworks, which will improve the three-dimensional gesture interaction and cultural expression abilities of new media art designs. Initially, the analysis of the overall system architecture is performed, which includes the following modules: a model of visual imaging feature analysis in the context of simulating 3D gesture interaction, a base database, an optimal transmission protocol, and simulation control through interaction. Following that, simulation testing proves the superiority of the given approach in improving the 3D gesture interaction simulation abilities of artworks. At last, a survey questionnaire on the basis of real user experience examines cultural expression and interactive properties of the system.

2 Cultural Expression and Interactivity in New Media Art Design

New media art design is a form of art that involves the use of modern technologies and the digital media platforms to produce and exhibit artworks. Incorporating traditional Chinese cultural factors into new media art design is not only an indication of the inheritance and innovation of China traditional culture, but also the harbinger of the future development and further investigation of new media art. Interactivity in new media art design means that there is a capability to engage and participate together between the artwork and the audience.

2.1 Strategies for Cultural Expression in New Media Art Design

2.1.1 Understanding Historical Culture and Core Ideologies

The long history of civilization in China has produced priceless cultural assets, such as the timeless texts of the Book of Songs, the Analects, and the Tao Te Ching, and the three great philosophical schools of Confucianism, Taoism, and Buddhism. These cultural heritages are not merely a reflection of traditional Chinese culture, but also valuable resources to inspire new media artworks. Exploring these time-honored writings and intellectual artifacts will reveal the roots and principles of traditional Chinese culture and thus serve as an endless source of creative inspiration in new media art design.

2.1.2 Appreciating Traditional Art Forms

Conventional art is an important way to access the deep roots of Chinese traditional culture. Chinese painting, calligraphy, music, and theater all have their own special features. The art forms are not merely displays of distinct aesthetic sensitivity and expression but rather reflect the deep cultural essence and emotional richness. Artists incorporate the aesthetic language and expressive technique of Chinese traditional culture into the creation of digital media art through studying and valuing traditional artistic techniques and aesthetics in detail, which gives their works the special qualities and charm of Chinese traditional culture [19].

2.1.3 Exploring Traditional Cultural Elements

Chinese traditional culture includes symbols, patterns, and narratives including the dragon, phoenix, and qilin as traditional totems and literary classics such as Dream of the Red Chamber and Journey to the West that all contain deep cultural implications and symbolic meanings. Exploring the cultural implications behind these symbols and narratives may enrich the cultural value and emotional impact of digital media artworks. The artists may use scholarly research strategies to perform an extensive interpretation of these symbols and narratives based on their cultural aspect, which would bring out greater levels of cultural depth to the audience.

2.2 Manifestations of Interactivity in New Media Art Design

The study of the interactivity of new media art design is important to learn about the modern tendencies in the sphere of contemporary artistic production. The thorough investigation of the immersive synthesis of user involvement shows how the combination of technology and sensory experience adds extra interpretative levels to works of art. The examination of the usage of gamification features and the way game mechanics may drive audience participation promotes interaction and emotional attachment between audiences and artworks. By way of theme-driven interactive narratives, reflection and contemplation on the part of audiences during engagement is directed by the consideration of how artwork can convey deep themes through storytelling.

2.2.1 Participatory

The new media art must be designed in such a way that it can be finished with the help of audience participation, as it is what fundamentally defines its interactive nature. Interaction is based on participation it is one of the main features of the interactivity of new media art and the most important element in the realization of its value. New media art has absolutely no value without audience participation. Viewers become engaged with any artist piece when they come across it, and the piece attracts them to the point where they want to become involved. The mutual influence between them and their active engagement in the interactive aspects of the work generates a two-way flow between the two entities; this dynamic interaction is exactly the mechanism that brings out the value of new media art.

2.2.2 Gameplay

The audience engagement tendencies or interactions are largely influenced by their gaming psychology. The quality of a new media art piece is defined by how the visual, auditory, and linguistic components affect the audience. Of all these, visual impact is the most important- it is used as a focus and a priority in artistic design, and it continues to be the most popular form of expression in gaming and entertainment. Over the past few years augmented reality (AR) technology has become a novel trend in the interactive media art design. It combines data about the real and virtual worlds, and inserts virtual objects into a three-dimensional space and allows the real-time interaction between the viewer and those objects. AR provides a level of realism that no other technology can. The visual and auditory simulations have reached lifelike fidelity and the tactile and olfactory simulation technologies are now available.

2.2.3 Thematic

Artists focus on interactivity and playfulness in their new media designs as an expression of the thematic essence of new media art. Accepting the idea of participation and playfulness helps to make the process of spreading the work more efficient and enables conveying the themes that are embedded in new media art. Hence, such concepts of participation and playfulness can be perceived as a kind of more abstract means of communication. In the context of new media art, the thematic dimension is mostly related to the feelings of the artist conveyed through the work and it constitutes the very essence of new media art.

3 Application of Kinesthetic Interaction Technology in New Media Art Design

The future media art works will be more immersive and emotionally engaging due to the use of haptic interaction technology. The combination of these technologies will not only increase the cultural manifestations of art but also enhance the emotional relationship between art works and their audiences, driving further innovation and creation of art in the digital era.

3.1 Kinect Motion-Sensing Interaction Technology

Kinect device is now a major element to facilitate the augmented reality interaction technology. Structural analysis of this project will be based on its infrared projector, infrared CMOS camera and color camera. Both of the infrared cameras mainly work with the computer to do depth sensing of the human body, sending color images and depth information to the computer. They code the measurement space and sensors read information and provide light data to the chip, which decodes it and produces depth images. The Kinect device uses sensors to acquire data in its input part, namely, color video stream, depth data stream, and audio data stream. It is based on this that facial recognition, skeleton tracking, and speech recognition can be done. Skeleton tracking is especially important since it forms the basis of interaction implementation. When designing systems, the higher the amount of skeleton abstraction points, the more the recognition outcomes tend to be realistic.

3.1.1 Kinesthetic Interaction

Application of Kinect motion-sensing interaction is based upon gesture and voice signals to activate switches and start interactions. .NET technology is used to detect the movements and associate them with their respective semantic meanings. The first step involved using the embedded motion-sensing technology in the Kinect device to identify the gesture nodes, where extensive preprocessing was performed. After that, there is a training of gestures and voice. The processed information stream is kept in the training library, which triggers real-time recognition of states. Lastly, the trained gestures and voices are matched with the inputted information by the backend, which results in command control and allows the escort functionality.

3.1.2 Audio and Video Acquisition

Image acquisition has strong dependence on sensor capabilities of the Kinect sensor to offer skeletal tracking information and record RGB and depth image data to recognize scenes and gestures. Raw audio signals captured by the microphone array are subjected to echo cancelling, noise suppression, and localization in audio processing. Voice commands make the interaction between humans and computers better and acquire three dimensional state information.

3.1.3 Action Recognition

The hybrid approach that combines dynamic and static elements is used whereby static gestures are being dynamically converted. Dynamic modeling algorithms enrich gesture commands. Relevant gesture definitions must be grounded in users' actual habits to ensure operational consistency with outcomes and reduce cognitive load. Specific gesture planning is detailed in Section 4.1 (Table 1).

3.2 Architectural Design of a Three-Dimensional Gesture-Based Interactive Simulation System for Artworks

To realize a behavior-based 3D gesture interaction simulation system for artworks, this study integrates visual parameter analysis with environmental and physical parameter acquisition to construct a visual imaging analysis model for 3D gesture interaction with artworks. Integrating 3D visual information interaction with multi-parameter combination control, we establish the underlying database for the artwork 3D gesture interaction system. Utilizing Kinect gesture interaction technology [20], we design automated assembly control for the simulation system and optimize the transmission protocol for its energy-saving control system. Through methods of 3D model reconstruction and multidimensional parameter fitting for artworks, we perform simulation control for 3D gesture interaction with artworks. This yields the overall structural model of the 3D gesture interaction system for artworks, as shown in Figure 1. It includes modules such as 3D model reconstruction, model slicing and filling, model output control, and human-computer interaction.

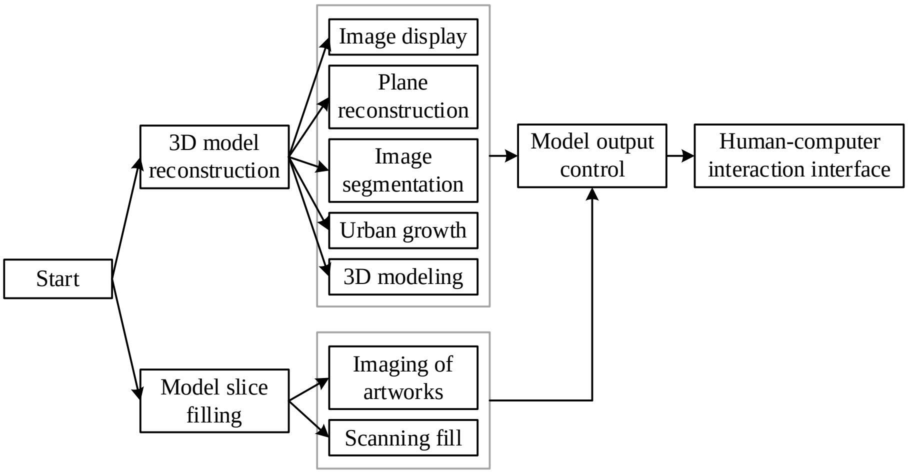

Figure 1: The three-dimensional body sense interaction simulation system structure

3.3 Three-Dimensional Gesture-Based Visual Image Acquisition and Preprocessing for Artworks

To achieve three-dimensional tactile-visual interaction and information processing for artworks, it is necessary to first construct a three-dimensional tactile-visual image analysis model for artworks. By integrating fuzzy information enhancement and information fusion methods, a three-dimensional tactile-interactive visual feature analysis of artworks is conducted. Employing edge contour feature analysis methods [21], a three-dimensional tactile-visual image detection and analysis model for artworks is obtained, as shown in Figure 2.

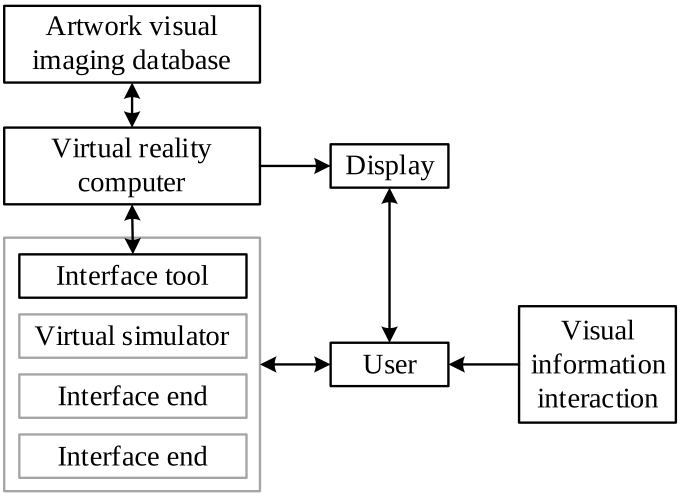

Figure 2: Art 3D image analysis model

Based on the three-dimensional sensory visual feature analysis model for artworks shown in Figure 2, a spatial three-dimensional visual simulation method is employed to enhance the three-dimensional sensory visual experience of artworks. The similarity feature metric for the three-dimensional sensory interactive visual images of pictorial artworks is defined as:

$$F_i = \frac{\sum_{i=1} F + |x_i, u_i|}{g^k} + n \tag{1}$$

In the equation, n represents the similarity index coefficient for the three-dimensional tactile-interactive visual images of artworks, g^k denotes the characteristic function of the three-dimensional tactile interaction of artworks, and $x_i \in R^n$ represents the edge feature distribution vector of the artwork's 3D haptic-interactive visual image, and $u_i \in R^m$ denotes the edge feature distribution vector. Employing a linear feature space parameter fusion method, a visual space fusion model for the artwork's 3D haptic-interactive visual is constructed. The fuzzy feature set for the artwork's 3D haptic-interactive visual is obtained as m is obtained. Let $A_j(L)$ serve as the joint feedback coefficient for the artwork's 3D haptic interaction. Employing a fuzzy distributed detection method, the feature optimization extraction for the artwork's 3D haptic interaction visual image is performed. Using an image detail parameter fusion method, the preprocessing distribution for the artwork's 3D haptic interaction is obtained as:

$$K_u = \frac{\alpha x^i + \sum_n g^k}{m} + F_i(\varphi) \tag{2}$$

In the formula, α represents the lateral feature point of the artwork's three-dimensional gestural interaction, while φ denotes the longitudinal feature point. By calculating the correlation feature values of the artwork's three-dimensional gestural interaction visual images, combined with statistical feature analysis and edge pixel reconstruction, the visual information of the three-dimensional gestural interaction is reorganized and feature matching is performed. This yields a joint parametric distribution model for the artwork's three-dimensional gestural interaction, expressed as:

$$Team(z) = \left|\frac{K_u}{g^k}\right| + (fk.z + lk_{k=1,2,\cdots,R}) - n \tag{3}$$

In the formula, fk represents the three-dimensional tactile visual feature quantity of the artwork, z denotes the three-dimensional tactile visual distribution coefficient of the artwork, and lk signifies the statistical feature quantity. By employing multi-scale fusion, a three-dimensional tactile interactive visual feature matching model for artworks is constructed, yielding the following preprocessing distribution set for three-dimensional tactile visual images of artworks:

$$Kikl(r) = \frac{\sqrt{Team(z)} - m + F_i}{(g^k \cdot z + f^k + r)} A_j(L) \tag{4}$$

In the formula, r represents the three-dimensional tactile visual scale coefficient of the artwork. Based on the above analysis, a distributed linear reconstruction method is employed to construct a model for capturing and preprocessing three-dimensional tactile interactive visual images of the artwork.

3.4 Three-Dimensional Gesture Integration and Behavioral Interaction in Artworks

Based on the aforementioned construction of a three-dimensional tactile visual imaging and feature recognition model for artworks, we proceed to reconstruct the three-dimensional tactile visual representation of artworks. Employing a single-frame vector fusion method, the fusion distribution function for the three-dimensional tactile interactive visual distribution of artworks is obtained as follows:

$$H(x) = c_j(\vec{x}) + l^2 + \frac{4\pi}{g_x}(| f_j(\vec{x}) \quad |) \tag{5}$$

In the formula, l represents the number of learning iterations for the three-dimensional haptic interaction of the artwork, $f_j(\vec{x})$ denotes the feature reconstruction attribute set for the three-dimensional haptic interaction of the artwork, and $c_j(\vec{x})$ signifies the pixel feature distribution set. Based on fuzzy rough set theory, the visual image structure of the artwork's 3D haptic interaction is restructured to derive a joint feature parameter matching model for the interaction. The resulting pheromone distribution matrix is expressed as:

$$W_u = \left[f_j(\vec{x}) + a \right] \frac{m}{| x_i, u_i |} - g^k \cdot z(H(x)) \tag{6}$$

In the formula, a denotes the super-distribution reconstruction similarity coefficient of the image. By employing the Retinex algorithm for high-resolution visual information reconstruction and integrating fuzzy information detection methods, while considering the feature distribution set of low-illumination images, a super-resolution fusion technique for three-dimensional tactile-interactive visual images of artworks is established. This yields a feature analysis model for the fusion of three-dimensional tactile-interactive visual parameters of artworks:

$$M_{i,j} = \begin{cases} \dfrac{W_u}{f_j(\vec{x})} \times X \\ \dfrac{1 - H(x)}{1 - g_x} \times T \end{cases} \tag{7}$$

In the formula, X represents the information sampling points for the three-dimensional physical interaction of the artwork, while T denotes the feature segmentation threshold for the three-dimensional physical interaction of the artwork. An information fusion model for the three-dimensional physical interaction of the artwork is established to obtain a set of control parameters for simulating the interaction parameters, thereby achieving the three-dimensional physical fusion and behavioral interaction of the artwork.

4 Simulation Testing

4.1 Action Recognition Function Verification

The interactive functions of the 3D gesture-based simulation system for artworks are primarily realized through Kinect. This study employs six hand gestures—right hand open, arms together, right hand pull down, left hand open, arms open, and right hand raise—to control the movement, rotation, and scaling of artistic images. Gesture recognition uses 13 bone points: left hand, left wrist, left elbow, left shoulder, left hip, head, shoulder center, right shoulder, right elbow, right wrist, right hand, right hip, and hip center. The particular settings according to the keyboard key mappings specified by the Unity3D 4.0 virtual software are presented in Table 1.

Table 1: Interactive posture definition table

Action	Keyboard response	Object action
Right hand open (A1)	A	Amplification
Double arms (A2)	B	Narrow down
Pull down (A3)	C	Right-hand rotation
Left hand open (A4)	D	Left rotation
Open arms (A5)	E	Left shift
Right hand (A6)	F	Right shift

Afterwards, the system assesses the quality of gesture capture based on the data output generated by the Kinect sensor. In Figure 3 the changes in the angular velocity signal due to movement of the arm are displayed. The Kinect sensor of the system is effective at capturing the movements of the user as the users arm move.

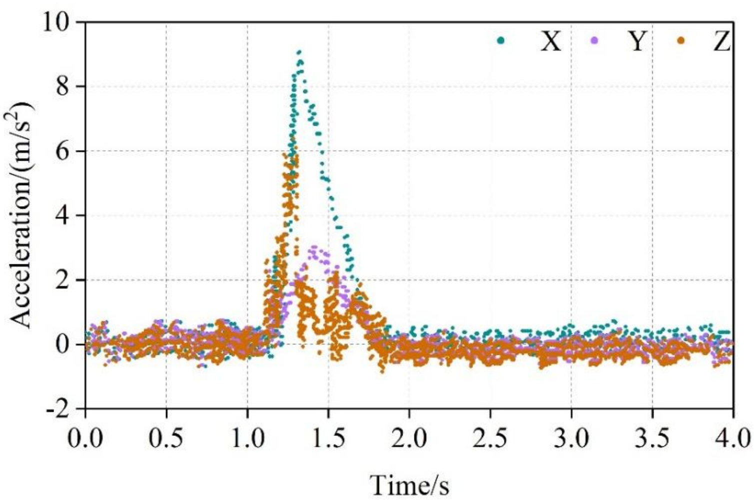

Figure 3: The results of the angular velocity of the arm

The evaluation of the latency effects of any action recognition was performed through interactive demonstration testing on the training set. They are represented in Figure 4. The highest value of the action recognition latency achieved with six actions is 15.5ms, which indicates a good performance of the application. It confirms that the suggested technique is efficient at recording user actions in real time.

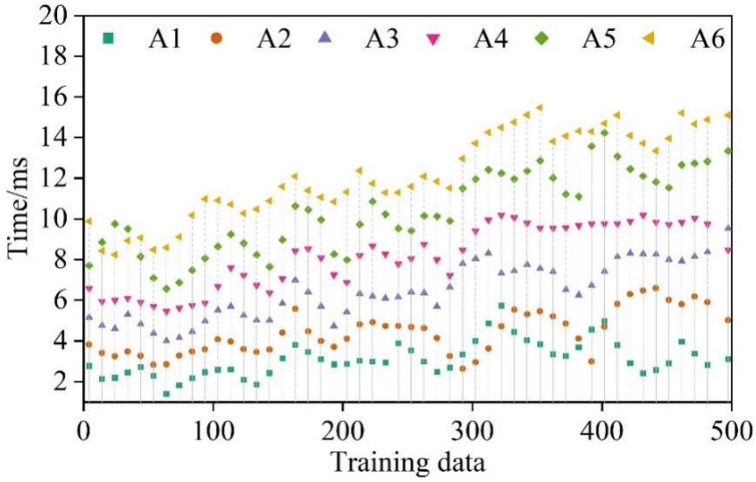

Figure 4: Various action recognition delay results

Following the training, the present study carried out recognition testing on six sequential sequence inputs. Figure 5 shows action recognition accuracy rates. Recognition accuracy The accuracy rates for action recognition are shown in Figure 5. The recognition accuracy for the six actions ranged from 82% to 93%, demonstrating that the Kinect sensor performed well in the validation set. Among these, the highest recognition accuracy was achieved for the "right hand pulling down" action, while the lowest accuracy was observed for the "right hand opening" action. This latter action is easily confused with both the "right hand raising" and "right hand pulling down" actions.

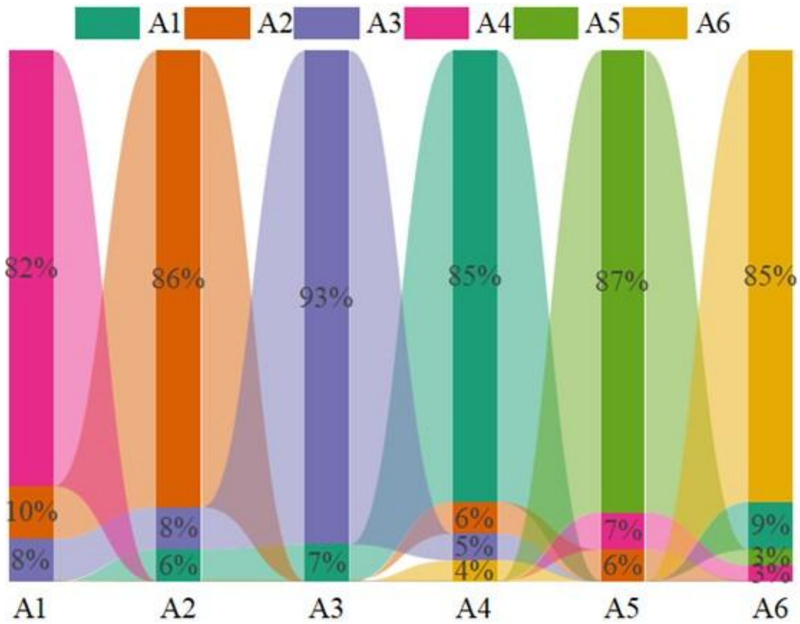

Figure 5 Accuracy of action recognition

4.2 Comparative Test Analysis

Augmented Reality (AR) [22] and OpenGL technology [23] were selected as comparison methods to conduct performance testing of the proposed method. Three systems were constructed, and the aforementioned six actions were selected, with each action repeated 100 times to form the test set. Multiple recognition attempts were performed using the three methods, yielding the action recognition latency rates shown in Figure 6. As indicated by the data, the proposed method achieved recognition latency rates below 4.96% for user interaction actions. Conversely, the AR method was always higher than 7.53% and the OpenGL method was greater than 13.03%. It shows that the suggested approach is superior in terms of the performance of interaction gesture recognition. The benefit is based on the fact that the method uses the Kinect sensor to record the images of the users and applies the template matching algorithm to accurately determine the posture of the human body, which leads to high accuracy and low latency.

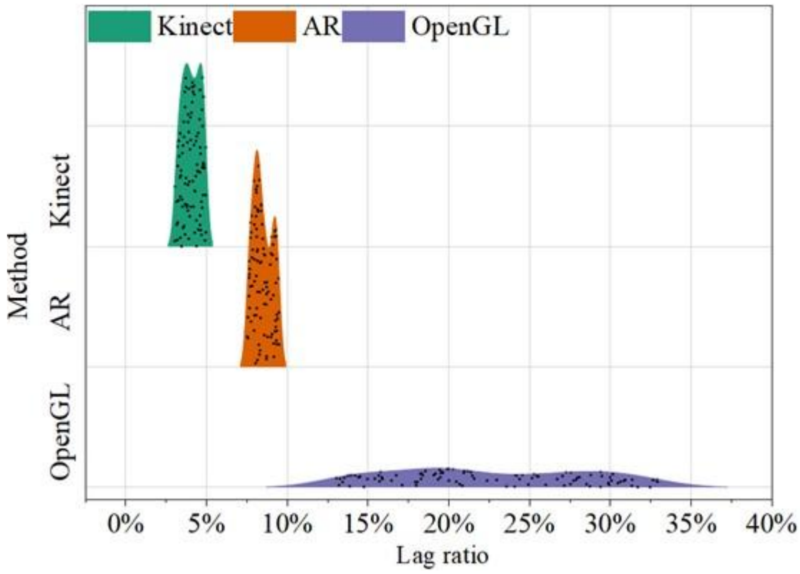

Figure 6: Three methods of action recognition lag ratio

The subsequent series of trials performed in three ways produced the values of recognition accuracy which are presented in Figure 7. The use of the proposed approach produced an average human motion recognition rate of over 92.97% (highest at 95.99%). On the other hand, the approach based on AR achieved the highest average accuracy of 89. 08%, whereas the one based on OpenGL had a maximum accuracy of 90.95%. This indicates that the proposed method can provide a higher level of performance of motion-based interactions, and this provides better satisfaction to the users. The benefit is due to the fact that the method takes into consideration various important factors when designing and implementing the method. Particularly, it applies effective preprocessing on the input images when preprocessing images, which involves reducing noise and detecting edges, in order to reduce effects of interference and noise on the recognition of motion. Then, the visual feature extraction algorithm correctly depicts the main features that the media imagery conveys. Lastly, user image data is obtained through the Kinect sensor and template matching algorithm is used to accurately determine user movement. All these factors have made the interaction recognition highly accurate.

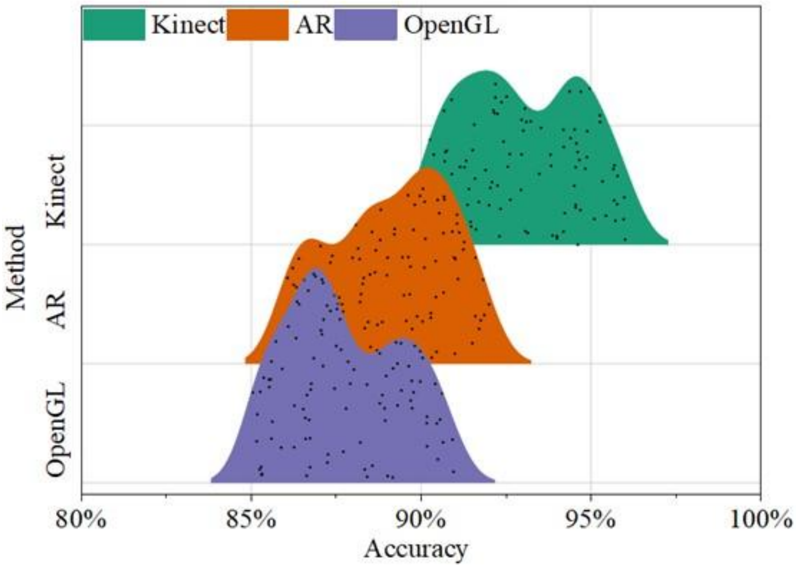

Figure 7: The three methods were compared with the accuracy of interaction

5 User Experience Analysis

The choice of ten target users was made to assess the 3D gesture interaction experience. User data was gathered and user experience measures were rated based on a 5-point Likert scale. Results were analyzed using data analysis with additional interviews on all three test parts to be sure and reveal possible hidden problems. The process is used to guide the iteration and optimization of 3D gesture interaction products. We have sent 10 questionnaires to our participants and received 10 valid responses in this user experience assessment. All 10 user evaluation scores were inputted into SPSS to undergo statistical analysis. SPSS revealed that the user experience questionnaire has a Cronbach alpha coefficient of 0.963, indicating high reliability.

Based on the two dimensions of cultural expression and interactivity, the 3D gesture interaction experience was evaluated using a questionnaire containing six questions as follows:

I think that this 3D gesture interaction system is very effective in communicating the cultural stories and meanings of artworks (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree).

Gesture-based interaction (such as hand gestures, body language) enables me to better engage in learning about cultural context behind artworks compared to conventional presentation methods (i.e. text/audio guides) (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree).

The response time to gestures of the system is slow and there are significant gaps between my actions and the responses that I receive through the artwork (1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, 5-Strongly Disagree).

I can explore actively various cultural layers of art works (e.g. symbols, history, dimensions), not passively accepting the information (5-strongly agree, 4-agree, 3-neutral, 2-disagree, 1-strongly disagree).

This experience of embodied culture contributed to increased emotional resonance and memorability with the artwork (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree).

I would suggest this system to other people who are keen on culture and art since it is a balance between cultural richness and interactivity (5-Strongly Agree, 4-Agree, 3-Neutral, 2-

Disagree, 1-Strongly Disagree).

The scores on user experience are presented in Figure 8. The findings showed that all the metrics on the 3D motion-sensing interactive product scored between 4 and 5 points, which is 66.67 percent of the respondents. It indicates its capability to offer a positive user experience..

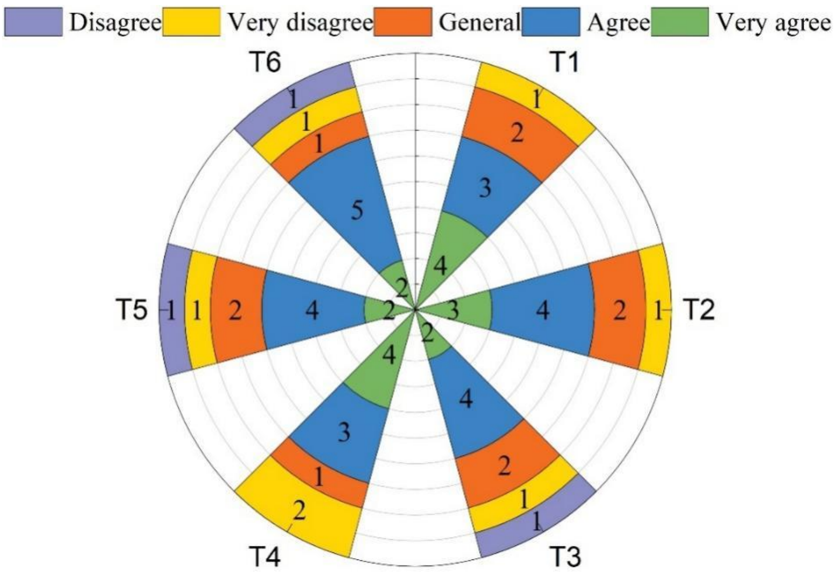

Figure 8: User experience score

6 Conclusion

To enrich the three-dimensional gesture interaction and cultural communication features of artwork, this paper suggests a design approach to a gesture-based interactive simulation system. Experimental findings prove that the developed system has good motion recognition, high output stability, and low latency, which contributes to the increase in the quality of visual presentation of artworks. The recognition rate of its motion is less than 4.96 percent with an average accuracy rate of 92.97 percent. It performs better than both augmented reality and OpenGL technologies, which leads to positive application results. After the assessment of user experiences, 66.67% of the users found the cultural expression and interactivity of the 3D gesture-based interaction product to be either quot; satisfactoryquot; or quot; very satisfactoryquot;. It means that the 3D gesture-based interaction simulation system enlarges the artistic expression forms, intensifies emotional involvement between audiences and artworks, and encourages constant innovation and advancement of art in the digital age.

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