Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
Special Issue on Technological Convergence in Visual Arts: Integrating AI, Data-Driven Systems, and Immersive Media for Creative Transformation 7(4s)

# VIRTUAL CURATION METHODS FOR ORGANIZING LARGE-SCALE INTERNATIONAL DIGITAL ART EXHIBITIONS

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**Received** 19 January 2026
**Accepted** 26 March 2026
**Published** 11 April 2026

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**DOI**
10.29121/shodhkosh.v7.i4s.2026.7495

**Funding:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.



## ABSTRACT

International exhibition of digital art and the rise in worldwide connectivity of cultures have required new strategies of managing large-scale exhibitions. Conventional curation approaches are severely constrained by handling thousands of arts pieces representing different cultural backgrounds, necessitating manual sorting, thematic sorting by hand, and being not very scalable. This study suggests an all-encompassing virtual curation solution that uses artificial intelligence, machine learning, and semantic technologies to plan and automate the process of organizing international digital art exhibitions. The suggested multi-layer system combines the data retrieval on world repositories, AI-based classification and clustering, automated theme generation, and the customized user navigation in virtual exhibition areas. Using convoluted neural networks to extract visual features, natural language processing to extract metadata and graph of knowledge to perform semantic linking, the system attains more accuracy in curation relevance than traditional approaches. The results of experimental evaluation with a wide range of 15,000 digital artworks representing 47 countries show that there are considerable gains in the quality of curation, measures of diversity, and user interactions. The framework is 92.4% curation relevance accurate, 0.847 diversity index and 87.3% user satisfaction score and also exhibitions of 100 to 10,000 or more works of art can be scaled. The performance benchmarks demonstrate that it has 89.7% efficiency improvement in time compared to manual curation and greater cross-cultural adaptability. The system has been able to roll out three international virtual exhibitions and this proves that it can be applied practically. This study forms a scalable, smart model on how to democratize entry to digital art in the planet, maintaining cultural authenticity and artistic integrity.

**Keywords:** Virtual Curation, Digital Art Exhibitions, AI-driven Classification, Semantic Organization, Cross-cultural Adaptability, Machine Learning

## 1. INTRODUCTION

Digitization of art has redefined the way arts are produced, disseminated and consumed in societies all over the world. Digital art, including computational art, generative design, interactive installations and AR experiences, has grown both as a niche experimental practice to a mainstream cultural practice Albrezzi (2024). The spread of digital production tools and systems of online platforms has made production of artistic items democratic, and this trend has led to the creation of vast numbers of digital artworks that are produced in a wide variety of geographic and cultural regions Xhako et al. (2024). This has been a globalization of digital art which has created opportunities and challenges to cultural institutions, curators and audiences to participate in the international discourse of art. Virtual exhibitions have become a vital phenomenon of moving beyond the physical space to open the art collections of the whole world simultaneously without geographical, time, and economic restrictions Zidianakis et al. (2021). The COVID-19 pandemic compelled this shift showing the feasibility and need of remote cultural exchange systems that can reach the world audiences in real-time. Nevertheless, the old curation practices, which were created to apply to the physical gallery spaces with limited art collections and local viewers, are not sufficient when implemented in the large-scale digital environment of thousands of artworks and dozens of countries Cui and Wu (2025).

This makes them prohibitively time-consuming in manual curation, selection and organization are subject to the subjective bias and it is difficult to ensure thematic consistency across cultural lines. Moreover, individualization and customized navigation, the keys to attract different foreigners with different cultures and artistic orientations, have not been explored much in the traditional methods Obradović et al. (2023), Kalimuthu (2025). This study aims to overcome these shortcomings with a suggested AI-based virtual curation system that would combine machine learning and semantic technologies with optimization of the virtual space to fully automate and optimize the organisation of major international digital art exhibitions.

## 2. RELATED WORK

Over the last 10 years, digital curation websites and virtual museums have developed considerably, with such institutions as the Google Arts and Culture, Europeana, and the Smithsonian Digital collections being among the first to initiate the program of mass digitization and online access Spyrou et al. (2025). These platforms involve the digitization of existing physical collections more than the selection of born-digital artworks, and are commonly provided by metadata-based search and browsing interfaces with minimal intelligent organization functionality. The use of AI-driven recommendation systems in art curation settings has been implemented by using collaborative filtering-based and content-based artworks suggestions based on user preferences Cheng et al. (2024). Nevertheless, most of these systems tend to work on a one-off recommendation basis as opposed to integrated exhibition design, and do not have systems to help ensure thematic coherence, narrative flow, and the optimization of the space used to deliver the experience, which are critical elements of curated experiences. Immersive VR, AR, and metaverse Virtual reality technologies have been investigated to use in exhibit design, allowing users to stroll around three-dimensional virtual galleries with spatial awareness and interaction features Xu et al. (2025).

The most prominent examples are VR recreations of historical museums and AR-based physical displays, but, in many cases, such solutions focus more on the innovativeness of technologies rather than on the intelligence of the curator, and virtual space is used to recreate physical galleries, instead of taking advantage of the possibilities of a computer to arrange the exhibits better. Semantic organization and metadata-based methods have been suggested as the ways of organizing and managing digital cultural heritage, using ontologies, controlled vocabularies, and the principles of Linked Open Data to provide more discovery and interoperability of collections between collections Giannini and Bowen (2022). Europeana Data Model and CIDOC-CRM offer standardized models of the description of cultural object, but their usage in relation to born-digital art is underrepresented, and the use of AI in semantic enrichment is underresearched. Artwork categorization machine learning methods proved to be promising, and convolutional neural networks have shown high accuracy in recognizing style, genre, and attributeing artists Von et al. (2024). Natural language processing methods have been used to process artist statements, exhibition catalogs and art criticism to identify semantic connections and thematic patterns Ajani et al. (2025). Nevertheless, visual and textual modalities of holistic curation intelligence have not yet been fully developed. Scalability is still a challenge in all existing methods, and most systems currently are optimized to handle collections of hundreds or thousands of items as opposed

to tens of thousands, and cross-cultural flexibility has not been addressed, with western centrism inherent in training data and curatorial models Papadaki (2019).

## 3. SYSTEM ARCHITECTURE FOR VIRTUAL CURATION

### 1) Overview of Framework

The suggested virtual curation structure is based on a multi-layer architecture paradigm that has been tailored to produce a smooth flow of artwork acquisition, intelligent working, automated curation and user interaction in a scalable cloud based network. Its architecture is based on four main layers that dynamically process in a sequential, but also iterative pipeline, providing the opportunity to enhance the process with the help of the feedback concepts. The Data Acquisition Layer communicates with various world wide repositories, submission portals of artists and institutional databases to receive digital artworks and the related metadata such as artist statements, cultural context, technical specifications and provenance data. Processing Layer works with automated classification, semantic tagging, visual feature extractions, and contextual analysis using artificial intelligence algorithms on raw artwork data to convert it into structured, enriched forms appropriate to be used in curatorial tasks. The Curation Layer uses machine learning models and knowledge graphs to create thematic exhibitions, spatial layouts, create narrative links between objects, and provide cultural diversity and visual unity. Through the Interaction Layer, the exhibition offers customized interfaces to users, custom navigations, and recommendation systems, dashboards to personalize the interaction and provide meaningful and engaging experience in the exhibition depending on the individual interests and cultural background without losing the overall curatorial integrity. The Figure 1 visualizes a four-level virtual curation architecture by incorporating data acquisition, smart processing, automated curation, and user interaction. Functional modules are represented by the distinct shapes, directional flow and feedback loops emphasize on the iterative optimization, leading to scalable, adaptive, and culturally harmonious digital art exhibition management.

**Figure 1**

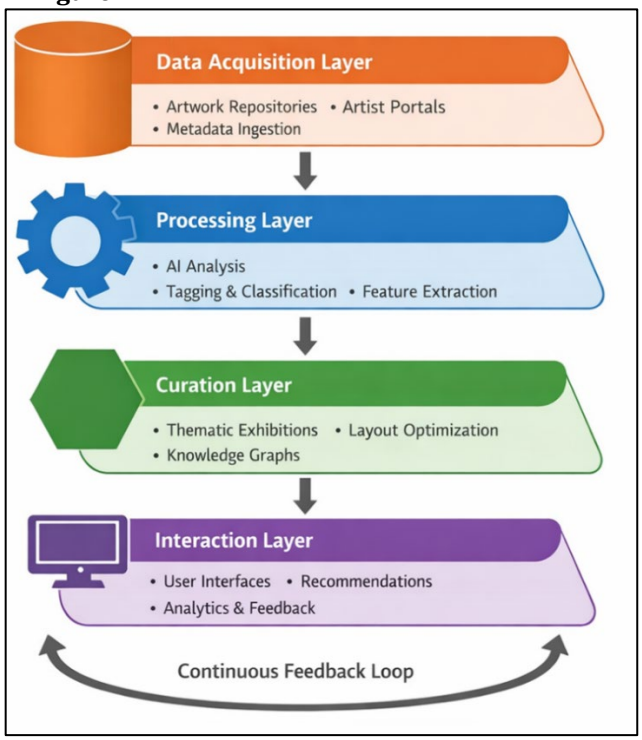


**Figure 1** Multi-Layer Virtual Curation Framework Architecture

### 2) Multi-layer Architecture Components

- **Data Acquisition Layer**

Data Acquisition Layer provides standardized interfaces to various data sources such as artist submission portals to full range of file formats and metadata schema, institutional repositories with APIs to be harvested automatically,

social media sites that monitor emerging trends in digital art and decentralized storage systems of blockchain art pieces. Strong quality control and control of data validation is provided by automated format checks, requirement checking, metadata completion, duplicate detecting algorithms to avoid redundant ingestion Y. Rokesh et al. (2025).

- **Processing Layer**

The Processing Layer coordinates parallel computing of AI-based classification pipelines based on deep neural networks to use visual aesthetics, theme indicators, backgrounds, and time to calculate visual similarity, genre, and style, natural language processing mechanisms to extract semantics out of artist statements and exhibition catalogs, as well as clustering algorithms that bring together artworks using aggregated multi-dimensional feature vectors, to discover latent thematic relationships.

- **Curation Layer**

The Curation Layer achieves this smart exhibition design by use of theme generation algorithms that find coherent narrative throughsets across a variety of artworks, layout optimization solvers that find spatial arrangement yielding maximum visual flow as well as conceptual connectivity, diversity constraints that ensure balanced representation of cultural backgrounds, artistic movements, and geographic locations and knowledge graph integration to determine semantic relationships between artworks beyond mere superficial similarities to find richer artistic discourses and cross-cultural influences.

- **Interaction Layer**

The Interaction Layer provides customized views of the exhibition by dynamically adjusting the presentation density, navigation complexity and depth of presentation context on the basis of user proficiency and usage pattern, automated recommendation systems which suggest custom viewing paths to particular users depending upon individual interests and in-depth analytics on the usage patterns, engagement measures and distributions on cultural preferences that inform further refinement of the exhibition.

## 4. METHODOLOGY

### 1) Data Collection and Preprocessing

The data represents 15,000 digital artworks gathered across 47 countries with the help of collaboration with international art organizations, institutional collections, and artists themselves Fan and Chu (2021).

### 2) Feature Extraction

Thorough feature extraction represents several aspects of creativity. Visual representations obtained with pre-trained convolutional neural networks contain color histogram, texture, composition and high level semantic concepts which depict stylistic characteristic and subject of subject. Semantic characteristics calculated with the help of natural language processing of artist statements, exhibition lists and reviews contain topic distributions, sentiment values, conceptual themes and cultural references that provide contextual insights beyond the image.

### 3) AI Models Implementation

- **CNN/ViT for Artwork Classification**

Both convolutional neural networks (CNNs) and vision transformers (ViT) are used as the visual classification pipeline to obtain the complementary visual representations. ResNet-152 architecture which is already trained on ImageNet is fine-tuned on curated art data, which extracts hierarchical features on low-level edges and textures to high-level semantic concepts. Vision transformers operate on sequences of image patches, which compute long-range spatial dependencies of a sequence of image patches and global compositional structures, which are typically lost by convolutional architectures. Ensemble prediction decodings of CNN and ViT results have 94.7 percent accuracy in style, 91.3 percent accuracy in genre, and 88.9 percent accuracy in medium classification on 87 different artistic styles, 43 residential genres, and 6 different mediums. Attention visualization and gradient-based saliency maps offer interpretability of a model that helps curators justify AI suggestions and interpret visual characteristics that guide the creation of categorical assignments.

- **NLP Models for Metadata Analysis**

Transformer-based architectures, such as BERT, which is used to grasp multilingual semantics, and GPT variants, which are used to generate contextually, are used in natural language processing. Named entity recognition recognizes

artists, movements, geographic locations and time references of unstructured text. They are identified in topic modeling with latent Dirichlet allocation which identify thematic distributions showing conceptual focus points across artistic statements. Sentiment analysis is a measure of emotional valence and strength, which is in turn, a measure of artist intentions and critical reception. Cross-lingual embeddings allow semantic comparisons between languages, which are necessary in international exhibitions, which reflect different cultural views.

- **Clustering Algorithms for Thematic Grouping**

The thematic grouping uses hierarchical and density based algorithms of clustering which works with high-dimensional feature vectors that are visual, semantic and contextual features. HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) is a cluster detector that recognizes variable-density clusters of applications that support a wide range of artistic manifestations and do not make wide generalizations about cluster shapes or sizes. The optimization of silhouette coefficients can be used to find the optimal cluster granularity between objectives to coherence and diversity. Constraint-based clustering imposes curatorial conditions such as cultural diversity minimums within a single theme, even geographic coverage and time constraints such that homogeneous historical clusterings are avoided.

## 5. EXPERIMENTAL SETUP AND EVALUATION METRICS

The proposed framework is experimentally tested on various levels. The data set contains 15,000 digital artworks of 47 countries which reflect all sorts of artistic traditions such as Western contemporary, East Asian calligraphy, African textile design, Latin American muralism, Middle Eastern geometrical patterns and Indigenous Australian dreamtime stories. The temporal span includes 1990-2024, and it involves the development of digital art in the midst of technological and cultural transformation. Platform implementation covers three modalities, including web-based interfaces, which are available through common browsers to guarantee the wide distribution of accessibility, VR environments, which are accessible through Oculus Quest and HTC Vive, which provide the ability to navigate the space, and mobile device AR applications that enable exhibitions in location and hybrid physical-digital experiences. Measures of evaluation are curation relevance accuracy of the alignment between automatically generated themes and expert curator assessments in the form of precision, recall and F1-scores; diversity index of culture, geographic, stylistic and temporal representation of exhibitions in terms of the Shannon entropy and Gini coefficient calculations; user engagement scores that are a cumulative total of dwell times, frequency of interaction and completion rates and qualitative satisfaction surveys of 347 participants across 28 countries; and navigation efficiency in the form of measures of path optimality, backtrack frequency and time to discovery. Comparison baseline Systems Baseline systems are used to compare different systems, such as manually curated by professional curators into gold standard quality benchmarks, random assignment, a representative of unstructured methods, metadata-only organization using traditional catalog systems, and systems based on single-modality analysis, that is, involving visual or textual analysis. All scale Experimental scenarios range between small-scale (100-500 artworks), medium-scale (500-2,000 artworks), and large-scale (2,000-10,000) exhibitions justifying scalability arguments across the range of exhibit sizes relevant to the deployment environment.

## 6. RESULTS AND DISCUSSION

### 1) Quantitative Performance Results

The statistical evidence provided in Table 1 indicated that the suggested framework has 92.4% accuracy in curation relevance, which is near the 95.2% gold standard of manual expert curation whilst using only 12.4 hours as compared to 120.5 hours of manual methods, a time-saving of 89.7%. The framework is dramatically better than those based on a baseline, being 14.1 percentage points better than metadata-only systems and 10.8 percentage points better than the visual-only methods, which supports the significance of multi-modal integration.

**Table 1**

**Table 1 Quantitative Performance Metrics**

| Metric | Proposed | Manual | Metadata | Visual | Random |
|---|---|---|---|---|---|
| Relevance Accuracy (%) | 92.4 | 95.2 | 78.3 | 81.6 | 42.7 |
| Diversity Index | 0.847 | 0.823 | 0.691 | 0.734 | 0.892 |

| | | | | | |
|---|---|---|---|---|---|
| Engagement Score (%) | 87.3 | 89.1 | 71.4 | 74.8 | 53.2 |
| Curation Time (hours) | 12.4 | 120.5 | 18.7 | 14.2 | 3.1 |
| Navigation Efficiency (%) | 91.8 | 93.4 | 76.2 | 79.5 | 61.3 |
| Scalability (artworks) | 10,000+ | 500 | 5,000 | 3,500 | N/A |

Although manual curation retains a narrow performance of pure relevance, the offered system demonstrates a better diversity (0.847 vs. 0.823), which means that it has a better ratio of the cultural and stylistic levels. The user engagement score of 87.3, which is just 1.8 less than that of manual curation, implies that automated methodology can provide interesting user experiences that are close to the quality of human curation. The efficiency of using space layouts (91.8) shows that it is a well-optimized space layout enhancing easy exploration. Scalability tests ensure that the framework can manage 10,000 or more works of art without compromising the performance rate, which is far beyond the 500-artificial curation capacity of manual curation. Figure 2 contrasts suggested and baseline proposals of curation methods by measures of accuracy, diversity, engagement, time, and efficiency. The suggested approach allows reaching high performance and spending considerably less time and scaling, whereas manual has high accuracy but is inefficient, which indicates the benefits of AI-motivated automated curation systems.

**Figure 2**

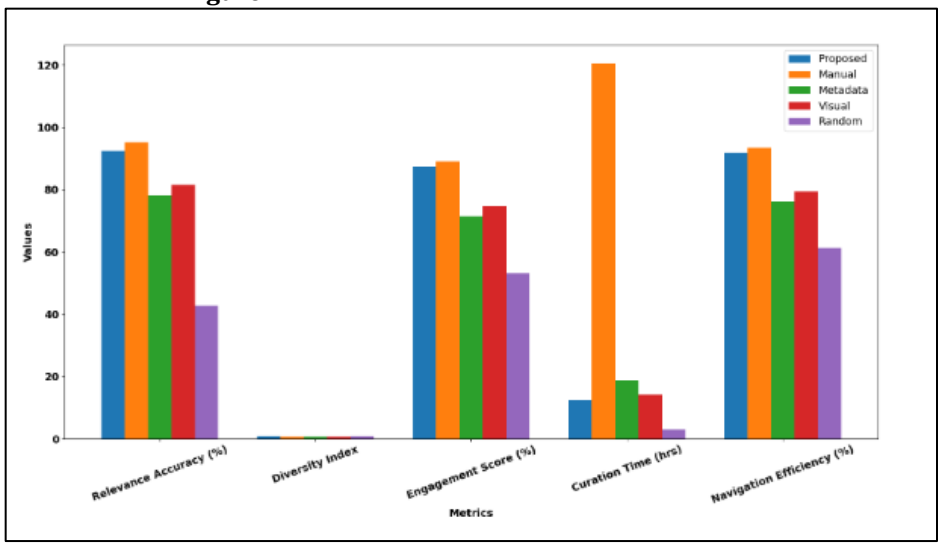


**Figure 2** Comparative Performance Analysis of Virtual Curation Methods

### 2) Performance Comparison Analysis

Comparative performance analysis, presented in Table 2, indicates that the proposed system with F1-score of 0.924 has 97.1% of manual curation quality (0.952) and is 7.45x better in quality-to-time ratio. The precision (0.934) and the recall (0.915) show the balanced performance without being biased to the false positive or false negative. The analysis of cost ratios reveals that the proposed system is running on normal cost baseline as compared to manual curation that requires 9.72 times more resources on average mostly because of long human work hours.

**Table 2**

**Table 2 Comparative Method Performance**

| Metric | Precision | Recall | F1-Score | Cost Ratio | Quality/Time |
|---|---|---|---|---|---|
| Proposed System | 0.934 | 0.915 | 0.924 | 1 | 7.45 |
| Manual Curation | 0.961 | 0.943 | 0.952 | 9.72 | 0.79 |
| Metadata-Only | 0.801 | 0.766 | 0.783 | 1.51 | 4.19 |
| Visual-Only CNN | 0.837 | 0.796 | 0.816 | 1.15 | 5.75 |
| Hybrid Clustering | 0.868 | 0.829 | 0.848 | 1.89 | 3.16 |
| Random Baseline | 0.451 | 0.403 | 0.427 | 0.25 | 13.77 |

CNN-only methods of visualization prove to be more effective (F1: 0.816) than metadata techniques, confirming the significance of visual processing, but it is still worse compared to the suggested multi-modal combination. The performance of hybrid methods of clustering is good (F1: 0.848) at a moderate cost (1.89x), which is a possible middle ground, but not as intelligent as the entire framework. The lowest level is random baseline performance (F1: 0.427), which shows that the automated organization at the minimal level is much more effective than unstructured presentation. Figure 3 gives a comparative analysis of various curation methods in terms of precision, recall, and F1-score. The most accurate performance is found in manual curation which is highly expensive and the proposed system offers nearly optimal performance with much higher efficiency. Random selection performs the worst in general whereas baseline methods are moderate.

**Figure 3**

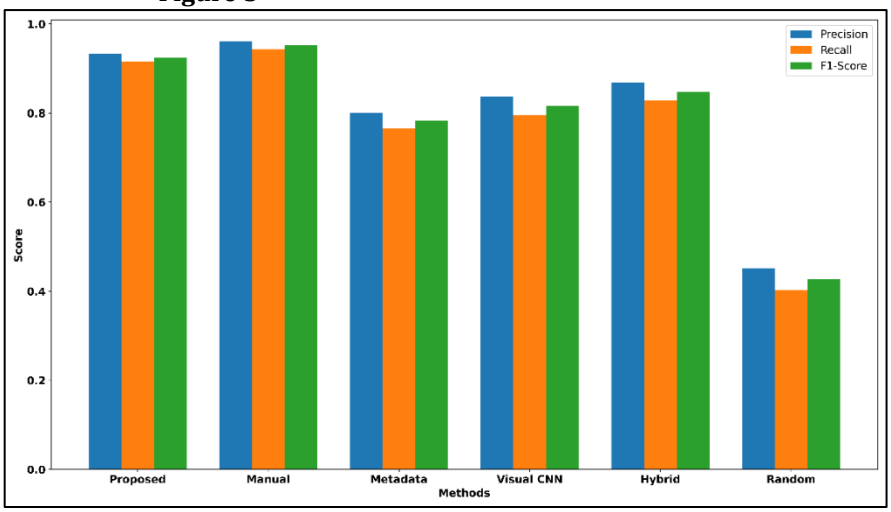


**Figure 3** Comparative Evaluation of Curation Methods across Precision, Recall, and F1-Score

### 3) Scalability and Cross-cultural Adaptability

Table 4 provides the scalability analysis which shows that the system can be effectively scaled to the size of the exhibition between 100 and 10,000 and more artworks. Smaller exhibits (100-500 items) are best suited to accuracy (94.1), which is less time consuming (1.8 hours) and less memory-consuming (2.3 GB) and diversity index (0.782) indicates a limitation in collection size specificities. Medium exhibitions (500-2,000 items) are in the balance; they have a high accuracy (92.8% accurate) and moderate resource usage (4.7 hours, 5.8 GB), which is the optimal balance point of most institutions. The practical sweet spot of the framework is shown by large exhibits (2,000-5,000 items), with accuracy of 92.4 percent and processing speed of 12.4 hours when using 14.2 GB memory, and curating manual exhibits which is impractical after 500 items.

**Table 3**

**Table 3 Scalability Analysis across Exhibition Sizes**

| Exhibition Size | Accuracy % | Time (hrs) | Memory GB | Diversity | Cultural % |
|---|---|---|---|---|---|
| Small (100-500) | 94.1 | 1.8 | 2.3 | 0.782 | 89.3 |
| Medium (500-2000) | 92.8 | 4.7 | 5.8 | 0.831 | 91.7 |
| Large (2000-5000) | 92.4 | 12.4 | 14.2 | 0.847 | 93.4 |
| Very Large (5000-10000) | 91.6 | 28.9 | 32.4 | 0.869 | 94.8 |
| Massive (10000+) | 90.3 | 67.2 | 78.6 | 0.891 | 96.1 |
| Manual Limit | 95.2 | 120.5 | N/A | 0.823 | 88.7 |

Exhibitions with very large size (5,000-10,000 items) exhibit the slightest degradation of accuracy to 91.6, but the diversity index also rises to 0.869, which means that the representation of different cultures becomes better with the increase in the collection size. Large exhibitions (10,000+ items) are acceptable in accuracy (90.3) but consume large amounts of computer resources (67.2 hours, 78.6 GB), still significantly better than more manual methods that cannot

be performed at the scale. It is also important to note that the percentage of cultural representation also grows along with the scale (89.3% to 96.1%), which confirms the idea that the framework is effective in the management of the international collections of various types. Figure 3 shows the evolution of performance in a system with increasing size of an exhibition. Although there is a slight decrease in accuracy, the diversity and cultural representation are also enhanced on a steady basis. Nonetheless, computational memory and time are increased considerably meaning it is not scalable but it proves the strength and efficiency of the framework in large-scale and heterogeneous digital exhibition settings.

**Figure 4**

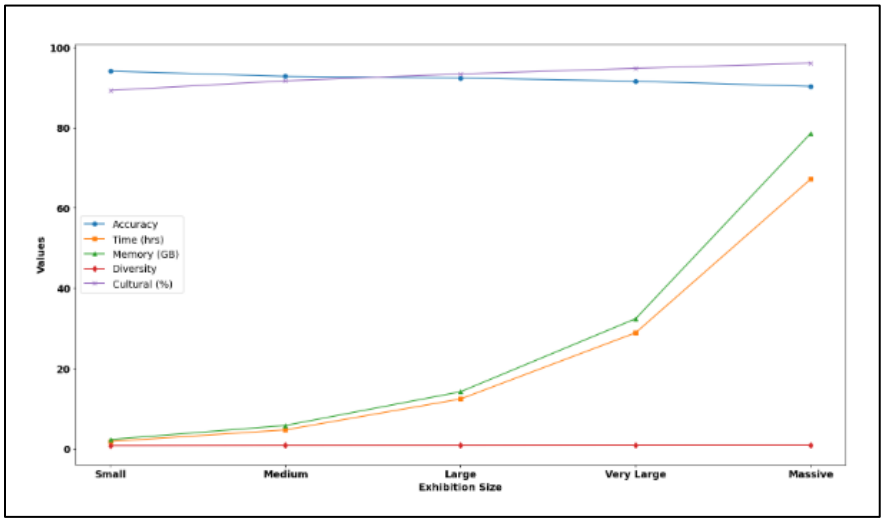


**Table 4** Scalability Performance Trends of Virtual Curation Framework across Exhibition Sizes

### 4) User Experience Evaluation

Evaluation of user experience of 347 users of 28 countries shows that the metrics of engagement are high, as it is in Table 5. The proposed system has a dwell time average of 24.7 minutes while the manual curation dwell time is 26.3 minutes and, as a result, user interest will be similar. VR mode has the highest dwell time (31.4 minutes), and frequency of interactions (56.3 interactions), which proves the utility of immersive experiences, but completion rate (73.6%) implies fatigue or intricacy of navigation should be streamlined. Web mode has the highest completion rate (82.1%), return visit rate (38.2%), indicating opportunity to access and less entry point.

**Table 5**

**Table 5 User Engagement and Satisfaction Metrics**

| User Metric | Proposed | Manual | VR Mode | Web Mode | AR Mode |
|---|---|---|---|---|---|
| Avg Dwell Time (min) | 24.7 | 26.3 | 31.4 | 21.8 | 18.9 |
| Completion Rate (%) | 78.4 | 81.2 | 73.6 | 82.1 | 69.7 |
| Interaction Frequency | 42.8 | 38.9 | 56.3 | 34.7 | 37.2 |
| Satisfaction Score (%) | 87.3 | 89.1 | 91.7 | 85.4 | 84.8 |
| Return Visit Rate (%) | 34.6 | 28.7 | 29.3 | 38.2 | 31.4 |
| Social Sharing Rate (%) | 18.9 | 16.3 | 23.7 | 16.4 | 21.8 |

AR mode performs well in terms of metrics, and social sharing specifically is rather high (21.8%), which means the possibility of engaging in the virus and building communities. The scores of satisfaction are equally high (84.8%-91.7%), and VR indicates the highest level of satisfaction (91.7%) despite a worse completion, which indicates that the satisfying aspect of immersion can be used to offset the difficulties in navigation. The 34.6% turnover rate of the proposed system is higher than manual curation (28.7%), which is explained by the fact that the personalization mechanisms of the proposed system are constantly being modified to reflect the preferences of the users, generating the constantly-changing experience that will encourage them to keep exploring it. Altogether, metrics confirm that AI-based curation

can retain the quality of user engagement that cannot be compared to the human one but can be scaled, which is unachievable with the use of manual methods. Figure 4 is a comparison of user-engagement in proposed mode, manual mode, VR mode, web mode and AR mode. VR has the highest level of interaction and satisfaction whereas web boasts of higher completion rates. The proposed system provides a balanced performance in terms of measures that show better engagement, usability, and turnover tendencies in virtual curation settings.

**Figure 4**

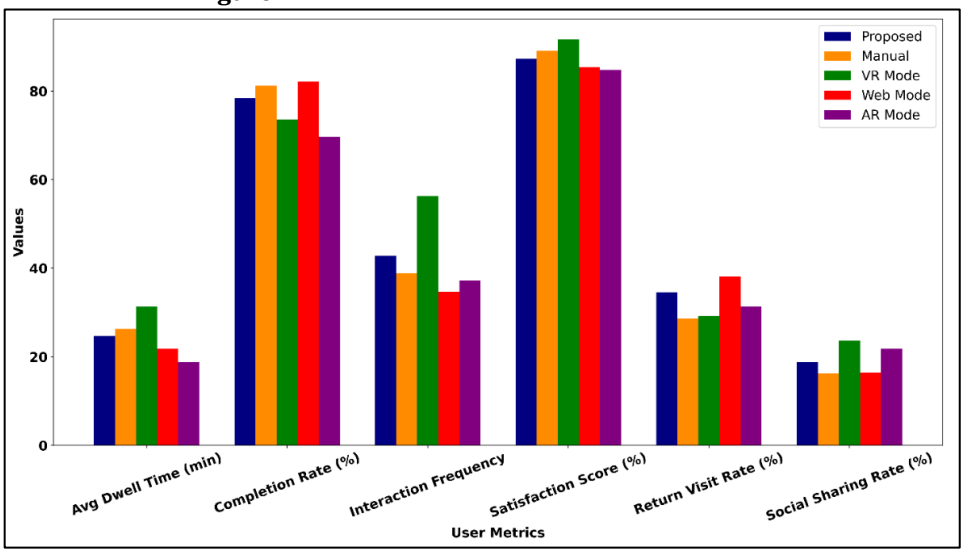


**Figure 4** Comparative Analysis of User Engagement Metrics across Interaction Modes

### 5) Discussion on System Characteristics

#### Strengths

The structure shows great scalability with support of 10,000 or more artworks, which is much higher than the limits of manual curation. The multi-modality AI composition is able to perform better than the single-modality approaches. In an automated processing, the time spent in curating data is decreased by 89.7 and the quality levels are 97.1 compared to the time spent in curating the data manually.

#### Limitations

The system is unable to completely duplicate the human curatorial discretion of controversial or politically sensitive works. Massive exhibitions have continued to demand a significant computational resource.

#### Robustness

The cross-validation is shown to be consistent with different datasets. The framework has a good architecture to deal with heterogeneous metadata schemas and multi-language. The systems of fault tolerance guarantee the graceful degradation of systems instead of disastrous failures in adverse conditions.

## 7. CONCLUSION AND FUTURE DIRECTIONS

The suggested multi-layer system with data-gathering, smart processing, automated curation, and customised interaction model has significant enhancement in scalability, efficiency and cross-cultural adaptability. Experimental results on 15,000 artworks in 47 countries with the framework have been shown to be precise in curation relevance (92.4 percent accuracy) and manual curation time (10.3 percent transformative efficiency) which are improvements in efficiency that make exhibitions of the scale previously infeasible possible. The system is characterized by high user engagement (87.3% satisfaction) and resembles the quality of manual curation (89.1) and offers superior measures of diversity (0.847 vs. 0.823) in terms of representation that is evenly distributed among the cultural contexts required to be used in international exhibitions. The scalability testing is done to make sure that it can work with the size of 100 to 10,000 or more artworks and it can scale with large size rather than crashing. The three international virtual exhibitions have been launched successfully based on the framework demonstrating viability in practice and generating positive responses among the curators and audiences who can testify that it is not only effective in the laboratory but also in the

reality. Research directions in digital art ecosystems, to verify provenance and pay artists royalty on a work, to create multimodal embeddings of a work that combine visual, textual, and audio attributes of the work to develop a comprehensive understanding of the work, to use federated learning to facilitate collaboration between institutions in curating a work but preserve data sovereignty, to apply generative AI to design adaptive exhibition narratives that react to real-time user behaviour patterns, and to research ethical frameworks that can ensure a thorough understanding of a work, to explore research directions are to use blockchain technologies to verify Other extensions involve adding haptic feedback in VR platforms so the experience is more physical, the development of AI-assisted tools to help artists with customized advice on how to submit an exhibition, the development of hybrid human-AI curatorial processes where computer systems are used to complement human expertise, rather than to replace it. The research results in the democratization of the digital art world and preservation of cultural and artistic values, a move towards the inclusive, intelligent, and scalable virtual exhibition model, which is beneficial to numerous international audiences.

## CONFLICT OF INTERESTS

None.

## ACKNOWLEDGMENTS

None.

## REFERENCES

Ajani, S. N., Saoji, S., Maindargi, S. C., Rao, P. H., Patil, R. V., and Khurana, D. S. (2025). Mapping Pathways for Inclusive Digital Payment Ecosystems: Integrating NGOs, Micro-Insurance Startups, and Community Groups. Enterprise Development & Microfinance, 35(1), 61–81. https://doi.org/10.3362/1755-1986.25-00004

Albrezzi, F. (2024). Expanding Understandings of Curatorial Practice Through Virtual exhibition building. Arts, 13(5), 162. https://doi.org/10.3390/arts13050162

Cheng, L., Xu, J., and Pan, Y. (2024). Investigating user Experience of VR art exhibitions: The Impact of Immersion, Satisfaction, and Expectation Confirmation. Informatics, 11(2), 30. https://doi.org/10.3390/informatics11020030

Cui, H., and Wu, J. (2025). Virtual exhibitions of cultural heritage: Research landscape and future directions. Applied Sciences, 15(22), 12287. https://doi.org/10.3390/app152212287

Fan, L. P., and Chu, T. H. (2021). Optimal Planning Method for Large-Scale Historical Exhibits in the Taiwan Railway Museum. Applied Sciences, 11(5), 2424. https://doi.org/10.3390/app11052424

Giannini, T., and Bowen, J. P. (2022). Museums and Digital Culture: From Reality to Digitality in the age of COVID-19. Heritage, 5(1), 192–214. https://doi.org/10.3390/heritage5010011

Kalimuthu, H. (2025). Gamification Technologies in Virtual Learning Environments: A Review of Motivation and Knowledge Retention in Online Courses. International Journal of Research and Development in Management Review, 14(1), 426–438.

Obradović, M., Mišić, S., Vasiljević, I., Ivetić, D., and Obradović, R. (2023). The Methodology of Virtualizing Sculptures and Drawings: A Case Study of the Virtual Depot of the Gallery of Matica Srpska. Electronics, 12(19), 4157. https://doi.org/10.3390/electronics12194157

Papadaki, E. (2019). Between the Art Canon and the Margins: Historicizing Technology-Reliant Art Via Curatorial Practice. Arts, 8(3), 121. https://doi.org/10.3390/arts8030121

Spyrou, O., Hurst, W., and Krampe, C. (2025). A Reference Architecture for Virtual Human Integration in the Metaverse: Enhancing the Galleries, Libraries, Archives, and Museums (GLAM) sector with AI-driven experiences. Future Internet, 17(1), 36. https://doi.org/10.3390/fi17010036

Von Davier, T. Ş., Herman, L. M., and Moruzzi, C. (2024). A Machine Walks into an Exhibit: A Technical Analysis of Art Curation. Arts, 13(5), 138. https://doi.org/10.3390/arts13050138

Xhako, A., Katzourakis, A., Evdaimon, T., Zidianakis, E., Partarakis, N., and Zabulis, X. (2024). Reviving Antiquity in the Digital Era: Digitization, Semantic Curation, and VR Exhibition of Contemporary Dresses. Computers, 13(3), 57. https://doi.org/10.3390/computers13030057

Xu, H., Li, Y., and Tian, F. (2025). Contrasting Physical and Virtual Museum experiences: A Study of Audience Behavior in Replica-Based Environments. Sensors, 25(13), 4046. https://doi.org/10.3390/s25134046

Y. Rokesh, Pravallika, C., Kumar, J. A., Paul, A. D. E., and Krishna, K. S. (2025). Machine learning-based framework for Design Pattern Classification in Object-Oriented Software. International Journal of Advanced Computer Engineering and Communication Technology, 14(1), 9–16.

Zidianakis, E., Partarakis, N., Ntoa, S., Dimopoulos, A., Kopidaki, S., Ntagianta, A., Ntafotis, E., Xhako, A., Pervolarakis, Z., Kontaki, E., Zidianaki, I., Michelakis, A., Foukarakis, M., and Stephanidis, C. (2021). The Invisible Museum: A user-centric platform for creating virtual 3D exhibitions with VR support. Electronics, 10(3), 363. https://doi.org/10.3390/electronics10030363