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# VISUAL PRESENTATION OF CULTURAL HERITAGE IN DIGITAL MEDIA: A SYSTEMATIC LITERATURE REVIEW (2015-2025)

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## ABSTRACT

Digital media has opened up new avenues for cultural heritage display. The value of digital heritage does not rely solely on technology. The visual presentation of cultural content, coupled with user feedback, also affects its value. Most of the existing relevant reviews focus on digital preservation, immersive technologies, or cultural heritage communication, while the connections between visual presentation, design aspects, and user response are relatively scattered. This systematic literature review focuses on empirical studies of the visual presentation of cultural heritage in digital media. Following PRISMA guidelines, thirty studies published between 2015 and 2025 were chosen from Web of Science, Scopus, and ScienceDirect. The review looked into cultural heritage objects, visual and design aspects, digital environments, visual technologies, user responses, and research methods. Existing studies have found that discussions related to visual presentation mostly focus on cultural visual elements, interface layout, spatial display, and visual narrative. The investigation dimensions of user response are more inclined to the aspects of engagement and cognition rather than aesthetic or emotional responses. Most selected studies adopt experimental and system evaluation methods, while relatively few relevant studies are based on models. Regarding how visual features affect users' understanding, emotions, sharing, visiting or purchasing behaviors, more design-centric and response-oriented work is still needed to supplement relevant explanatory research.

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**Keywords:** cultural heritage; digital media; visual presentation; visual design; user response; intangible cultural heritage; digital heritage; systematic review

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## 1. INTRODUCTION

Cultural heritage (CH) refers to the cultural resources, practices, places, objects, and knowledge that a community connects with its history and identity. It includes tangible cultural heritage (TCH) refers to physical carriers with historical, artistic or scientific value, while intangible cultural heritage (ICH) refers to traditional culture that exists in non-material form and can be inherited. Giliberto and Labadi (2022) discussed tangible and intangible heritage together when examining heritage as a resource for sustainable development. Giglito et al. (2022) pointed out that there is a correlation between ICH, community engagement, institutional operation, and cultural expression. Museums and libraries can also support cultural sustainability through collection preservation and public access (Loach et al., 2017). CH encompasses not only tangible objects from history, but also living knowledge, collectively preserved memories, and daily cultural practices.

Digital media has now become one of the main scenarios for displaying, accessing and experiencing cultural heritage. Virtual museums, online exhibitions, mobile applications, games, image databases and social media content can all be used to present cultural heritage. Bekele et al. (2018) early sorted out the application scenarios of augmented reality, virtual reality, and mixed reality, demonstrating how such systems can be used for display, interpretation, restoration, and interaction with visitors. Currently, digital technologies are often discussed as tools for the protection, promotion, and dissemination of tangible and intangible cultural heritage (Mendoza et al., 2023). This point is particularly critical for ICH. Skublewska-Paszowska et al. (2022) mentioned that 3D visualization, 3D modeling, AR, VR, and motion capture technologies can assist in recording and presenting many cultural activities that are difficult to preserve only through text archives. Digital media can not only preserve heritage materials, but also be used to organize, view and experience these materials.

Visual presentation is an important part of this process. For design research, visual forms affect users' reading, judgment, and responses to digital content. The visual aesthetics of webpages have an impact on perceived service quality, trust, satisfaction, and arousal level (Ramezani Nia & Shokouhyar, 2020). Jongmans et al. (2022) also

showed that website visual design influenced user experience and website evaluation through usability and pleasure. These findings are relevant to digital heritage, since heritage content often depends on color, image, layout, style, icon, spatial display, and narrative image. At the same time, visual effects should not be treated as automatic. Sauer et al. (2022) reported that visual aesthetics did not always produce a direct improvement in user experience when usability and repeated use were considered. This suggests that visual presentation should be studied together with user response and interaction context.

In CH research, user response is often linked to engagement, perception, learning, enjoyment, acceptance, and behavioral intention. Pallud (2017) found that ease of use and interactivity in museum technologies affected authenticity and cognitive engagement, which then supported learning. Jung et al. (2018) showed that the aesthetics of augmented reality influenced perceived enjoyment at CH tourism sites. Tom Dieck and Jung (2018) argued that mobile augmented reality acceptance in urban heritage tourism requires context-specific factors such as information quality, system quality, personal innovativeness, and risk. These studies suggest that digital CH presentation should be examined through both visual content and user reaction. It is not enough to ask whether heritage has been digitized. Therefore, the discussion should include both visual presentation and user responses.

Several reviews have examined CH from related but different directions. Orr et al. (2021) traced the literature on climate change and CH, Mendoza et al. (2023) reviewed digital technologies for CH preservation, and Skublewska-Paszowska et al. (2022) examined 3D technologies used in ICH. These studies show the range of current digital heritage research, but the visual dimension has not been brought together in a clear way. In the existing literature, visual presentation appears across areas such as cultural visual elements, interface design, exhibition display, and visual narrative. User responses are also discussed, but the connection between visual presentation, design-related issues, digital media, and user responses remains under reviewed.

This review addresses this gap by examining empirical studies on the visual presentation of CH in digital media. The aim is to identify the types of CH objects studied, the visual and design aspects addressed, the digital environments and visual

technologies used, the reported user responses, and the research methods applied. Based on this aim, the study asks the following research questions:

RQ1: What types of cultural heritage objects are covered in digital visual presentation?

RQ2: What visual and design aspects of cultural heritage are addressed?

RQ3: What digital environments and visual technologies are used to present cultural heritage?

RQ4: What user responses are reported in relation to digital visual presentations of cultural heritage?

RQ5: What research methods are applied in terms of research design and data analysis techniques?

## 2. METHODOLOGY

With the main objective of examining how digital

visual presentations of CH are studied in relation to user responses, this Systematic Literature Review (SLR) follows the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines (Page et al., 2021; Moher et al., 2009). The SLR process includes database searching, duplicate removal, title and abstract screening, full-text eligibility assessment, and data extraction, and the specific steps can be referred to Figure 1. The studies included after screening will be analyzed from the dimensions of publication information, CH carriers, visual and design aspects, digital environment, user feedback, and research methods. This process sorts out relevant evidence and also clarifies the current discussions related to the display of digital CH.

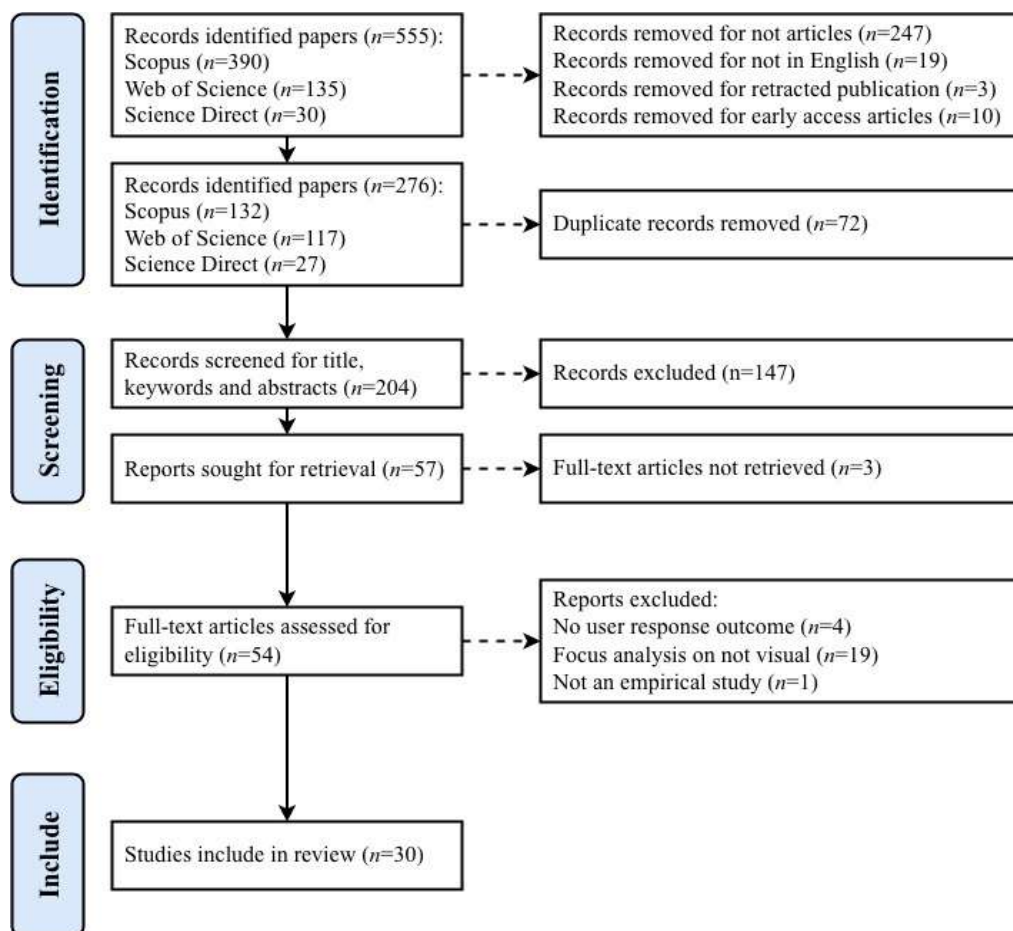


Figure 1: PRISMA flow diagram

### 2.1. Identification: Search Strategy and Sources

This SLR focuses on four connected concepts: cultural heritage, digital media, visual presentation, and user response. These concepts were used to develop the search strategy. Searches were conducted in three databases: Web of Science, Scopus, and ScienceDirect. The search was restricted to

English-language articles published between 2015 and 2025. The detailed search process and search criteria are shown in Table 1. During the identification stage, records that were not articles, not written in English, retracted publications, and early access articles were removed. After removing 72 duplicate records, 204 records remained for the next

screening stage.

**Table 1: Database search strategy and search criteria**

Database	Search Terms	Search Criteria
WOS	TS=(( "traditional culture" OR "cultural heritage" OR "folk art" OR "traditional craft" ) AND ( digital OR media OR platform OR game OR website ) AND visual AND ( experience OR engagement OR response OR perception ) ) AND PY=(2015-2025)	Field: Searches title, abstract, keyword plus, and author keywords; (SCI-EXPANDED) & (SSCI) & (A&HCI)
SCOPUS	TITLE-ABS-KEY ( ( "traditional culture" OR "cultural heritage" OR "folk art" OR "traditional craft" ) AND ( digital OR media OR platform OR game OR WEBSITE ) AND visual AND ( experience OR engagement OR response OR perception ) ) AND PUBYEAR > 2015 AND PUBYEAR < 2025	Field: Title, abstract or author-specified keywords
Science Direct	"cultural heritage" AND (digital OR media) AND visual AND (experience OR engagement OR response OR perception)	Field: Title, abstract or author-specified keywords; Publication dates: 2015-2025

**2.2. Screening and Eligibility Criteria**

This stage focused on screening the remaining records against the review scope and eligibility criteria. Records were first screened by title, keywords, and abstract. Studies were retained when they were related to CH, digital media, visual presentation, and user response. Records that did not match the review focus were excluded at this stage. After screening, 57 reports were sought for retrieval, and 3 full-text articles could not be obtained. The remaining 54 full-text articles were assessed for

eligibility. During full-text assessment, studies were excluded if they did not report user response outcomes, did not focus on visual analysis, or were not empirical studies. Finally, 30 studies were included in the review.

**2.3. Final Selected Studies**

The screening and full-text eligibility assessment resulted in 30 studies for the final review. Each selected study was assigned a code from S1 to S30. Table 2 lists the final selected studies with their study codes, titles, and authors.

**Table 2: Selected Studies in This Review**

Study	Title	Author(s)
S1	Enhancing intangible cultural heritage dissemination through digital experience: an Affective Events Theory approach	(Yi et al., 2025)
S2	Research on multimodal interaction system based on cognitive style in virtual historical and cultural scenes	(Zou et al., 2025)
S3	Semantic layout-guided diffusion model for high-fidelity image synthesis in The Thousand Li of Rivers and Mountains	(Yang et al., 2025)
S4	Using Masao facial makeup in software interface interaction design from the perspective of digital communication	(Wang, 2025)
S5	Immersive teaching model for traditional Chinese opera costume design based on virtual reality: digital cultural heritage, inheritance, and innovation	(Su, 2025)
S6	Visitor behavioral preferences at cultural heritage museums: evidence from social media data	(Peng et al., 2025)
S7	Exploring the determinants of users' intention to use augmented reality in craftsmanship-oriented intangible cultural heritage games	(Lai & Zhang, 2025)
S8	Virtual reality technology for the digital dissemination of traditional Chinese opera culture	(Jiang et al., 2025)
S9	Achieving cultural heritage sustainability through digital technology: public aesthetic perception of digital Dunhuang murals	(Chen et al., 2025)
S10	Enhancing textile heritage engagement through generative AI-based virtual assistants in virtual reality museums	(Ariya et al., 2025)
S11	Continuance intention toward VR games of intangible cultural heritage: a stimulus-organism-response perspective	(Qiu et al., 2024)

S12	Designing the presentation of Dunhuang fresco art based on perceptron technology in the context of artificial intelligence	(Zhu & Chung, 2024)
S13	Enhancing spatial cognition in online virtual museum environments: integrating game-based navigation strategies for improved user experience	(Zhang et al., 2024)
S14	Exploring Miao culture: the differential effect of traditional 2D and immersive 360-degree documentary formats on viewer learning	(Sun & Ch'ng, 2024)
S15	Application of folk art modeling in modern art design based on human-computer interaction	(Shen & Li, 2024)
S16	Design of a virtual reality serious game for experiencing the colors of Dunhuang frescoes	(Liu et al., 2024)
S17	Consumer preference study for the interface design of traditional Chinese medicine applications using conjoint analysis method	(R. Li & Yang, 2024)
S18	How generous interface affect user experience and behavior: evaluating the information display interface for museum cultural heritage	(Q. Li et al., 2024)
S19	Visitors' acceptance of wearable AR technology in museums	(J. Li et al., 2024)
S20	The craftsmanship footage in Yunnan ethnic minority documentaries contributes to the construction of regional culture	(C. Li et al., 2024)
S21	A mixed-methods study of cultural heritage learning through playing a serious game	(Kara, 2024)
S22	The Doctrine of the Mean: Chinese calligraphy with moderate visual complexity elicits high aesthetic preference	(Han et al., 2024)
S23	Digitization of myth: the HimmapanVR Project's role in cultural preservation	(Chernbumroong et al., 2024)
S24	Design of virtual reality based game for dual enhancement of city monuments and brand image	(Aydi & Elleuch, 2024)
S25	Evaluation of an HMD-based multisensory virtual museum experience for enhancing sense of presence	(Kim et al., 2023)
S26	Casual leisure in rich-prospect: advancing visual information behavior for digital museum collections	(Morse et al., 2021)
S27	Do game designers' decisions related to visual activities affect knowledge acquisition in cultural heritage games? An evaluation from a human cognitive processing perspective	(Raptis et al., 2019)
S28	Augmented reality storytelling: narrative design and reconstruction of a historical event in situ	(Liestøl, 2019)
S29	Usability evaluation of E-Dunhuang cultural heritage digital library	(Hu, 2018)
S30	More than meets the eye: the benefits of augmented reality and holographic displays for digital cultural heritage	(Pedersen et al., 2017)

### 3. RESULTS AND DISCUSSION

#### 3.1. Publication and Geographical Profile of the Selected Studies

Following the PRISMA screening process, this

section presents the general profile of the 30 selected studies, including publication year and research location. The profile first covers publication year and study location. These two aspects help to show when this research area became active and where the selected empirical studies were mainly conducted.

*Table 3: Distribution of selected studies by publication year*

Publication year	Study	n	Percentage
2025	S1, S2, S3, S4, S5, S6, S7, S8, S9, S10	10	33%
2024	S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24	14	47%
2023	S25	1	3%
2021	S26	1	3%
2019	S27, S28	2	7%
2018	S29	1	3%
2017	S30	1	3%

Note: Percentages were rounded to the nearest whole number.

As shown in Table 3, the selected studies were mainly published in 2024 and 2025. The year 2024 recorded the largest number of studies, with 14 papers, accounting for 47% of the sample (S11-S24). The year 2025 followed with 10 papers, accounting for 33% (S1-S10). Together, these two years covered 24 studies, or 80% of the selected papers. Earlier

studies were fewer. Only two studies were published in 2019 (S27, S28), while 2017, 2018, 2021, and 2023 each included one study (S30; S29; S26; S25). In recent years, empirical research on the digital visual representation of CH has received increasing attention in different fields.

**Table 4: Distribution of selected studies by location**

Location	Study	n	Percentage
China	S1, S2, S3, S4, S5, S6, S7, S8, S9, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S22, S29	21	70%
Thailand	S10, S23	2	7%
Europe	S21, S26	2	7%
Tunisia	S24	1	3%
Korea	S25	1	3%
Greece	S27	1	3%
France	S28	1	3%
Canada	S30	1	3%

Note: Percentages were rounded to the nearest whole number.

Table 4 shows the distribution of the selected studies by location. China formed the largest group, with 21 studies, accounting for 70% of the sample (S1-S9, S11-S20, S22, S29). Thailand and Europe each included two studies, accounting for 7% each (S10, S23; S21, S26). Tunisia, Korea, Greece, France, and Canada each contributed one study, accounting for 3% each (S24; S25; S27; S28; S30). This result shows a clear concentration in China.

Together with the results of Table 3, this profile shows that empirical research has increased after 2023, but the available evidence is still mainly drawn from China. This suggests that the field is growing quickly, although its findings may not apply equally to other countries or to different types of CH.

**3.2. Results for RQ1: Cultural Heritage Objects**

**Table 5: Classification of cultural heritage objects**

Categories	Study	n	Percentage
Traditional culture, heritage arts and ICH	S1, S3, S4, S5, S7, S8, S9, S11, S12, S14, S15, S16, S17, S20, S22, S23, S27	17	57%
Historical and cultural heritage sites	S2, S24, S28, S29	4	13%
Mixed tangible and intangible cultural heritage materials	S21	1	3%
Museums and exhibition collections	S6, S10, S13, S18, S19, S25, S26, S30	8	27%

Note: Percentages were rounded to the nearest whole number.

Table 5 shows that traditional culture, heritage arts and ICH account for the highest proportion, reaching 57%; museums and exhibition collections account for 27%, historical and CH sites account for 13%, and mixed tangible-intangible materials account for 3%. Digital visualization is mostly applied to cultural carriers that are rich in visual elements, have symbolic signs, or have been organized by institutions. The value of online heritage stems from interactions with collections and cultural materials rather than mere preservation, a finding consistent with relevant research conclusions on digital heritage (King et al., 2016). Digitization can not only preserve endangered CH but also influence the degree of attention received by different cultural elements

(Ocón, 2021). Existing bibliometric studies also show that research on digital CH continues to expand around tangible and intangible heritage, visualization technologies, museums, and technology-mediated access channels (Lian & Xie, 2024). Therefore, the reviewed studies reflect the wider field, but they also show a bias toward heritage objects that are easier to translate into visual and digital formats.

**3.3. Results for RQ2: Visual Presentation and Design Aspects**

RQ2 asks what visual and design aspects of CH are examined in the selected studies. To answer this question, four categories were identified: cultural visual elements and stylistic features, interface layout

and information visualization, spatial visual presentation and exhibition display, and visual narrative and cultural representation.

**Table 6: Cultural visual elements and stylistic features**

Study	Cultural heritage object	Specific visual or design focus
S3	The Thousand Li of Rivers and Mountains by Wang Ximeng (traditional Chinese painting image)	Semantic layout, object relationships, and Chinese landscape painting style
S5	Peking opera costume	Visual design of Peking opera costume details, including patterns, embroidery, fabric textures, and color schemes
S9	Dunhuang murals (Mogao Caves mural)	Dunhuang mural imagery, composition, and visual features
S11	Pottery making (ceramic craft)	Pottery materials, colors, textures, and visual style in game presentation
S12	Dunhuang Flying Sky fresco	Dunhuang Flying Sky fresco imagery and visual feature presentation
S15	Chinese folk art	Folk art form, modelling, and color elements in modern art design
S16	Dunhuang fresco colors	Game visual design for representing the colors of Dunhuang frescoes
S22	Chinese calligraphy	Visual complexity and calligraphy style of Chinese calligraphy works

Table 6 shows that eight studies focused on cultural visual elements and stylistic features, including color, pattern, form, texture, calligraphic style, mural imagery, and painting style. Most existing studies regard CH as a source of visual materials for digital transformation. S3 focuses on

semantic typesetting and the style of Chinese landscape painting, S5 analyzes the details of Peking Opera costumes, and S16 applies the colors of Dunhuang murals to game visual design. This shows that CH is often treated as a source of visual form and stylistic translation.

**Table 7: Interface layout and information visualization**

Study	Cultural heritage object	Specific visual or design focus
S1	Quanzhou intangible cultural heritage (Oral traditions and performing arts)	Rich, multidimensional, and hierarchical visual organization of digital ICH content
S2	Yiyuan Garden	Visual guidance indicators and navigation cues in virtual historical and cultural scenes
S4	Masao facial makeup	Interface interaction design using Masao facial makeup patterns, colors, and symbolic forms
S7	Craftsmanship based ICH	Game interface visual structure, content organization, and visual presentation of craftsmanship based ICH
S13	Anhui Museum cultural heritage collection	Mini map navigation, visual guidance, and cultural information organization in online virtual museum environments
S17	Traditional Chinese medicine	TCM application interface elements, including theme colors, text styles, icon styles, and layout design
S18	Liaoning Provincial Museum cultural heritage collection	Generous interface structure and information display layout for museum cultural heritage
S19	Liangzhu Museum collection (Cultural relics from the Liangzhu Civilization site)	Museum exhibition interface design, visual clarity, color, and pattern resolution
S26	Museum collections, including coins, artworks, and cultural objects	Rich prospect browsing interface and visual information structure for museum collections
S27	Aztec, Ancient Egypt and Inca Empire civilizations	Visual activity structure and visual information arrangement in cultural heritage games
S29	Dunhuang Caves and murals	Content organization and information structure of Dunhuang Caves and murals

Table 7 presents the interface layout and information visualization with 11 studies. This

category covers the visual organization of information in digital interfaces, including layout,

navigation cues, information hierarchy, screen structure, and cultural content arrangement. The result shows that many studies examined CH through interface-level visual organization rather than through cultural objects alone. S17 focused on theme colors, text styles, icon styles, and layout

design in traditional Chinese medicine applications. S29 examined the content organization and information structure of Dunhuang Caves and murals. This pattern indicates that digital CH studies often place visual information structure at the center of user access and understanding.

**Table 8: Spatial visual presentation and exhibition display**

Study	Cultural heritage object	Specific visual or design focus
S6	Six Chinese cultural heritage museums and their spatial remains, historical artefacts	Museum spatial remains, historical artefacts, exhibition environments, and atmosphere related visual cues
S8	Traditional Chinese opera culture	Opera scene presentation, character arrangement, and spatial visual environment
S10	Textile exhibits in the Wieng Yong House Museum	Textile exhibit presentation and museum exhibition environment of Wieng Yong House
S24	Sfax city monuments	Spatial representation of Sfax city monuments and the Old Medina route
S25	Korean ceramic artifacts	Museum display environment and ceramic artefact presentation
S30	Tomb of Kitines replica and Egyptian artifacts at the Royal Ontario Museum	Museum exhibit display space and visual information layering for Egyptian artefacts

Table 8 reports six studies under spatial visual presentation and exhibition display. This category refers to spatial display, museum environment, exhibition space, artefact presentation, route arrangement, and visual information layering. The studies in this group show that CH is presented through spatial systems, not only through single images or interface screens. S6 examined museum

spatial remains, historical artefacts, exhibition environments, and atmosphere related visual cues. S10 focused on textile exhibit presentation in the Wieng Yong House Museum. S30 examined museum exhibit display space and visual information layering for Egyptian artefacts. These studies suggest that exhibition and spatial presentation remain important forms of digital CH experience.

**Table 9: Visual narrative and cultural representation**

Study	Cultural heritage object	Specific visual or design focus
S14	Miao culture, including Miao villages, folk dances, and crafts	Visual representation of Miao villages, folk dances, crafts, and ethnic cultural scenes
S20	Yunnan ethnic minority craftsmanship	Craftsmanship footage and imagery narratives constructing regional culture
S21	European tangible and intangible cultural heritage materials	Cultural heritage visuals and narrative representation of tangible and intangible heritage materials
S23	Himmapan animals (Thai mythical creatures)	Visual representation of Himmapan animals and Thai mythic characters
S28	Omaha Beach landing site and D-Day assault event	Narrative structure and visual reconstruction of the Omaha Beach landing site and D-Day assault event

Table 9 shows five studies related to visual narrative and cultural representation. This category focuses on how cultural stories, ethnic life, myths, craft processes, and historical events are visually represented. The studies in this group move from isolated visual elements to narrative construction. S20 examined craftsmanship footage and imagery narratives for constructing regional culture. S23 focused on the visual representation of Himmapan animals and Thai mythic characters. S28 addressed the narrative structure and visual reconstruction of

the Omaha Beach landing site and D-Day assault event. These examples show that visual presentation is also used to organize cultural meaning, memory, and historical sequence.

Tables 6-9 show that the selected studies address four design layers: cultural visual elements, interface and information layout, spatial/exhibition display, and visual narrative. The strongest pattern is that design is not limited to surface decoration; it organizes access, guides interpretation, and translates cultural meaning into usable digital form.

This supports digital CH design research, which argues that human-centered design shifts attention from technology itself to visitor experience and cultural communication (Mason & Vavoula, 2021). Design thinking is also useful for museum digital transformation because it connects institutional aims, audience needs, and digital experience development (Mason, 2022). Lupo et al. (2023) further show that heritage and museum digitisation requires design-driven changes across content, interaction, service, and value creation. Studies of museum VR also show that spatial overlaying and juxtaposition are design

decisions that shape extended visitor experience (Tennent et al., 2020). Thus, RQ2 confirms that visual presentation should be discussed as a design mechanism, not only as digital display.

**3.4. Results for RQ3: Digital Environments and Visual Technologies**

RQ3 examined how CH was mediated through digital environments and visual technologies in the selected studies. The coding separated the dominant digital environment from the specific visual technologies reported in each article.

*Table 10: Digital environment categories and visual technologies*

Categories	Study	Visual technologies
Digital museum and exhibition environments	S9, S10, S13, S19, S23, S25, S26, S30	AR; VR; HMD; holographic display; 3D modelling / 3D virtual models; 360-degree panoramic display
Game-based heritage environments	S7, S11, S16, S21, S24, S27	AR; VR; 3D modelling
Digital interface, visual design and information system environments	S3, S4, S12, S15, S17, S18, S22, S29	AI image synthesis using a semantic layout-guided diffusion model; CAD modelling
Online media and visual content environments	S1, S6, S14, S20	360-degree video
Simulated heritage and cultural scene environments	S2, S5, S8, S28	AR; VR; HMD; 3D scene modelling; real-time rendering; location-based AR

Note: Abbreviations: augmented reality (AR), virtual reality (VR), head-mounted display (HMD), three-dimensional (3D), artificial intelligence (AI), and computer-aided design (CAD).

Table 10 shows that technology use is uneven. Museum, game-based and simulated-scene environments rely more on AR, VR, HMDs, 3D modelling, real-time rendering and location-based AR, while interface and online media studies use lighter tools such as AI image synthesis, CAD modelling and 360-degree video. This finding is consistent with VR heritage reviews showing that immersive systems are commonly used for reconstruction, presence, interaction and learning-oriented cultural experience (Chong et al., 2022). It also aligns with research on 3D historical reconstruction, where modelling and validation support immersive VR applications and historically grounded exploration (Ferdani et al., 2020). AR studies further show that narrative, game and participatory activities can support cultural interpretation when the technology is matched with

user activity and heritage context (Silva et al., 2023). Therefore, the result should not be read as “more advanced technology is better.” The key issue is whether the selected environment fits the cultural object, viewing condition and user task.

**3.5. Results for RQ4: User Response Categories**

RQ4 examines the main user responses reported in the selected studies. Each article was coded according to its dominant response type to avoid repeated classification, although some studies addressed more than one response. Four categories were identified: visual-aesthetic responses, affective-emotional responses, immersive-engagement responses, and visual-cognitive responses. These categories show how users, viewers, visitors, learners, or designers reacted to digital CH content.

*Table 11: User Response Categories*

Category	Study
Visual-aesthetic responses	S3, S4, S9, S17, S18, S22, S29
Affective-emotional responses	S1, S6, S15, S19, S20
Immersive-engagement responses	S7, S8, S10, S11, S12, S16, S24, S25, S28, S30
Visual-cognitive responses	S2, S5, S13, S14, S21, S23, S26, S27

Table 11 shows that immersive-engagement responses and visual-cognitive responses dominate

the reviewed studies, while visual-aesthetic and affective-emotional responses appear less often as the

main response category. This pattern is consistent with VR CH research, where acceptance, experience and expectations are often examined through learning, presence and cultural understanding (Ch'ng et al., 2020). Studies of 360-degree storytelling also show that presence, engagement and immersion are core response indicators in digital heritage experience (Škola et al., 2020). Narrative engagement research further argues that audience- human-centered immersive environments can support cultural learning when narrative and experience design are integrated (Leow & Ch'ng, 2021). These studies support the pattern found in RQ4, but they

also expose a gap. Current research still gives more attention to interaction and cognition than to aesthetic attraction and emotional connection, although these responses are important for visual presentation research.

**3.6. Results for RQ5: Research Designs and Analytical Methods**

RQ5 examines the main research methods used in the selected studies. The studies were classified by their main analytical method, rather than by data collection tools such as questionnaires, interviews, or software use.

*Table 12: Research designs and analytical methods*

Research method category	Study	Analytical methods
Model based and multivariate quantitative analysis	S1, S7, S8, S11, S17, S19	SEM; PLS-SEM; fsQCA; conjoint analysis; MANOVA
Experimental and comparative user analysis	S2, S5, S9, S13, S14, S16, S18, S21, S22, S25, S26, S27	ANOVA; t-test; non-parametric tests; regression; eye-tracking analysis; task comparison; learning outcome comparison
Prototype and system evaluation	S4, S10, S12, S23, S24, S28, S29, S30	Usability evaluation; system evaluation; prototype evaluation; design case evaluation; AR or VR application evaluation
Computational, text mining and qualitative analysis	S3, S6, S15, S20	Image synthesis evaluation; computational visual analysis; text mining; LDA topic modelling; thematic analysis

Table 12 shows that experimental and comparative user analysis is the largest method category, followed by prototype/system evaluation, model-based quantitative analysis, and computational or qualitative analysis. This indicates that many studies still examine user response through task comparison, usability, learning outcomes or system testing. The pattern agrees with earlier reviews of interactive CH systems, where empirical evaluation was mainly used to assess whether systems satisfied user goals and expectations (Koutsabasis, 2017). It also fits data-driven digital heritage research, which uses structured coding and topic identification to reveal research trends rather than relying only on narrative summary (Münster et al., 2021). For systematic reviews, coding research design and extracting comparable categories are recommended to make patterns and gaps visible (Xiao & Watson, 2019). However, the small number of model-based studies suggests that the field still needs more explanatory designs that test how specific visual design features influence aesthetic, cognitive, emotional and behavioural responses.

**4. LIMITATIONS**

This review was limited to three mainstream

databases, and only English empirical studies published between 2015 and 2025 were included. Relevant limitations still need to be noted. The scope defined in this study maintains the consistency of content, but relevant studies in other languages or from other channels may not be included. The selected and included studies involve different cultural carriers, digital scenarios and user feedback indicators, so not all studies can be directly compared horizontally. Subsequent reviews can cover more types of databases and conduct more detailed analyses of variables related to specific visual design.

**5. CONCLUSION**

In recent years, digital display activities of CH have become increasingly frequent. This review finds that the value of digitized heritage is directly related to the visual selection, arrangement, transformation methods of cultural content as well as the experience paths. The selected studies focuses on cultural visual elements, interface layout, spatial display and visual narrative, yet design is often treated as an accessory part of platforms or systems rather than a core research issue. Visual design serves as a carrier for traditional craft practitioners to convey cultural meanings to target users. Choices of image style,

color matching, layout arrangement, symbolic elements, narrative forms, and visual complexity all affect users' understanding, perception, trust, memory points, willingness to share, willingness to visit, and purchase intention. Most existing studies focus on immersion, engagement and cognitive aspects but pay insufficient attention to the specific relationship between visual features and user responses, and relevant research methods also

require more model-based exploration. Future research can focus on specific visual design elements to examine their impacts on aesthetic, cognitive, emotional and behavioral responses. This can further clarify the feedback path between visual design of CH and user behavior, and provide a more solid basis for the design of heritage content adapted to specific audiences.

## REFERENCES

- Ariya, P., Khanchai, S., Intawong, K., & Puritat, K. (2025). Enhancing textile heritage engagement through generative AI-based virtual assistants in virtual reality museums. *Computers & Education: X Reality*, 1–12. <https://doi.org/10.1016/j.cexr.2025.100112>
- Aydi, Y., & Elleuch, M. (2024). Design of virtual reality based game for dual enhancement of city monuments and brand image. *International Journal of Serious Games*, 1–20. <https://doi.org/10.17083/ijsg.v11i1.652>
- Bekele, M. K., Pierdicca, R., Frontoni, E., Malinverni, E. S., & Gain, J. (2018). A survey of augmented, virtual, and mixed reality for cultural heritage. *Journal on Computing and Cultural Heritage*, 11(2), 1–36. <https://doi.org/10.1145/3145534>
- Chen, Y., Peng, Y., Tan, Y., Luo, G., & Wang, M. (2025). Achieving cultural heritage sustainability through digital technology: Public aesthetic perception of digital dunhuang murals. *SUSTAINABILITY*, 1–18. <https://doi.org/10.3390/su17177887>
- Chernbumroong, S., Worragin, P., Wongwan, N., Intawong, K., Homla, P., & Puritat, K. (2024). Digitization of myth: The HimmapanVR project's role in cultural preservation. *Heliyon*, 1–18. <https://doi.org/10.1016/j.heliyon.2024.e30052>
- Ch'ng, E., Li, Y., Cai, S., & Leow, F.-T. (2020). The effects of VR environments on the acceptance, experience, and expectations of cultural heritage learning. *Journal on Computing and Cultural Heritage*, 13(1), 1–21. <https://doi.org/10.1145/3352933>
- Chong, H. T., Lim, C. K., Rafi, A., Tan, K. L., & Mokhtar, M. (2022). Comprehensive systematic review on virtual reality for cultural heritage practices: Coherent taxonomy and motivations. *Multimedia Systems*, 28(3), 711–726. <https://doi.org/10.1007/s00530-021-00869-4>
- Ferdani, D., Fanini, B., Piccioli, M. C., Carboni, F., & Vigliarolo, P. (2020). 3D reconstruction and validation of historical background for immersive VR applications and games: The case study of the forum of augustus in Rome. *Journal of Cultural Heritage*, 43, 129–143. <https://doi.org/10.1016/j.culher.2019.12.004>
- Giglietto, D., Ciolfi, L., & Bosswick, W. (2022). Building a bridge: Opportunities and challenges for intangible cultural heritage at the intersection of institutions, civic society, and migrant communities. *International Journal of Heritage Studies*, 28(1), 74–91. <https://doi.org/10.1080/13527258.2021.1922934>
- Giliberto, F., & Labadi, S. (2022). Harnessing cultural heritage for sustainable development: An analysis of three internationally funded projects in MENA countries. *International Journal of Heritage Studies*, 28(2), 133–146. <https://doi.org/10.1080/13527258.2021.1950026>
- Han, K., You, W., Shi, S., Deng, H., & Sun, L. (2024). The doctrine of the mean: Chinese calligraphy with moderate visual complexity elicits high aesthetic preference. *International Journal of Human-Computer Interaction*, 1–15. <https://doi.org/10.1080/10447318.2022.2144864>
- Hu, X. (2018). Usability evaluation of E-dunhuang cultural heritage digital library. *Data and Information Management*, 1–13. <https://doi.org/10.2478/dim-2018-0008>
- Jiang, Y.-P., Su, C., & Li, X.-C. (2025). Virtual reality technology for the digital dissemination of traditional chinese opera culture. *International Journal of Human-Computer Interaction*, 1–16. Scopus;WoS. <https://doi.org/10.1080/10447318.2024.2327180>
- Jongmans, E., Jeannot, F., Liang, L., & Dampérat, M. (2022). Impact of website visual design on user experience and website evaluation: The sequential mediating roles of usability and pleasure. *Journal of Marketing Management*, 38(17–18), 2078–2113. <https://doi.org/10.1080/0267257X.2022.2085315>

- Jung, T. H., Lee, H., Chung, N., & Tom Dieck, M. C. (2018). Cross-cultural differences in adopting mobile augmented reality at cultural heritage tourism sites. *International Journal of Contemporary Hospitality Management*, 30(3), 1621–1645. <https://doi.org/10.1108/IJCHM-02-2017-0084>
- Kara, N. (2024). A mixed-methods study of cultural heritage learning through playing a serious game. *International Journal of Human-Computer Interaction*, 1–13. <https://doi.org/10.1080/10447318.2022.2125627>
- Kim, K., Kwon, O., & Yu, J. (2023). Evaluation of an HMD-based multisensory virtual museum experience for enhancing sense of presence. *IEEE Access*, 1–14. <https://doi.org/10.1109/ACCESS.2023.3311135>
- King, L., Stark, J. F., & Cooke, P. (2016). Experiencing the digital world: The cultural value of digital engagement with heritage. *Heritage & Society*, 9(1), 76–101. <https://doi.org/10.1080/2159032X.2016.1246156>
- Koutsabasis, P. (2017). Empirical evaluations of interactive systems in cultural heritage: A review. *International Journal of Computational Methods in Heritage Science*, 1(1), 100–122. <https://doi.org/10.4018/IJCMHS.2017010107>
- Lai, S., & Zhang, Q. (2025). Exploring the determinants of users' intention to use augmented reality in craftsmanship-oriented intangible cultural heritage games. *SAGE OPEN*, 1–22. <https://doi.org/10.1177/21582440251359021>
- Leow, F.-T., & Ch'ng, E. (2021). Analysing narrative engagement with immersive environments: Designing audience-centric experiences for cultural heritage learning. *Museum Management and Curatorship*, 36(4), 342–361. <https://doi.org/10.1080/09647775.2021.1914136>
- Li, C., Yaakup, H. S., Zainudin, S. S. S., Razi, S. A. H. M., & Yu, K. (2024). The craftsmanship footage in yunnan ethnic minority documentaries contributes to the construction of regional culture. *Studies in Media and Communication*, 1–12. <https://doi.org/10.11114/smc.v12i1.6495>
- Li, J., Tu, X., Nie, J., Ye, J., & Lv, C. (2024). Visitors' acceptance of wearable AR technology in museums. *SAGE OPEN*, 1–17. <https://doi.org/10.1177/21582440241303507>
- Li, Q., Wang, P., Liu, Z., & Wang, C. (2024). How generous interface affect user experience and behavior: Evaluating the information display interface for museum cultural heritage. *COMPUTER ANIMATION AND VIRTUAL WORLDS*, 1–13. <https://doi.org/10.1002/cav.2212>
- Li, R., & Yang, Y. (2024). Consumer preference study for the interface design of traditional chinese medicine applications using conjoint analysis method. *Scientific Reports*, 1–14. <https://doi.org/10.1038/s41598-024-82279-w>
- Lian, Y., & Xie, J. (2024). The evolution of digital cultural heritage research: Identifying key trends, hotspots, and challenges through bibliometric analysis. *Sustainability*, 16(16), 7125. <https://doi.org/10.3390/su16167125>
- Liestøl, G. (2019). Augmented reality storytelling: Narrative design and reconstruction of a historical event in situ. *International Journal of Interactive Mobile Technologies*, 1–14. <https://doi.org/10.3991/ijim.v13i12.11560>
- Liu, Z., Chen, D., Zhang, C., & Yao, J. (2024). Design of a virtual reality serious game for experiencing the colors of dunhuang frescoes. *Heritage Science*, 1–31. <https://doi.org/10.1186/s40494-024-01477-x>
- Loach, K., Rowley, J., & Griffiths, J. (2017). Cultural sustainability as a strategy for the survival of museums and libraries. *International Journal of Cultural Policy*, 23(2), 186–198. <https://doi.org/10.1080/10286632.2016.1184657>
- Lupo, E., Camosino, G., Gobbo, B., Motta, M., Mauri, M., & Parente, M. (2023, October 9). Digital for heritage and museums: Design-driven changes and challenges. *IASDR 2023: Life-Changing Design*. IASDR 2023: Life-Changing Design. <https://doi.org/10.21606/iasdr.2023.397>
- Mason, M. (2022). The contribution of design thinking to museum digital transformation in post-pandemic times. *Multimodal Technologies and Interaction*, 6(9), 79–97. <https://doi.org/10.3390/mti6090079>
- Mason, M., & Vavoula, G. (2021). Digital cultural heritage design practice: A conceptual framework. *The Design Journal*, 24(3), 405–424. <https://doi.org/10.1080/14606925.2021.1889738>
- Mendoza, M. A. D., De La Hoz Franco, E., & Gómez, J. E. G. (2023). Technologies for the preservation of cultural heritage – A systematic review of the literature. *Sustainability*, 15(2), 1059. <https://doi.org/10.3390/su15021059>
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, T. P. (2009). Preferred reporting items for systematic

- reviews and meta-analyses: The PRISMA statement. *PLOS Medicine*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Morse, C., Niess, J., Lallemand, C., Wieneke, L., & Koenig, V. (2021). Casual leisure in rich-prospect: Advancing visual information behavior for digital museum collections. *Journal on Computing and Cultural Heritage*, 1–23. <https://doi.org/10.1145/3437257>
- Münster, S., Utescher, R., & Ulutas Aydogan, S. (2021). Digital topics on cultural heritage investigated: How can data-driven and data-guided methods support to identify current topics and trends in digital heritage? *Built Heritage*, 5(1), 25–37. <https://doi.org/10.1186/s43238-021-00045-7>
- Ocón, D. (2021). Digitalising endangered cultural heritage in southeast Asian cities: Preserving or replacing? *International Journal of Heritage Studies*, 27(10), 975–990. <https://doi.org/10.1080/13527258.2021.1883711>
- Orr, S. A., Richards, J., & Fatorić, S. (2021). Climate change and cultural heritage: A systematic literature review (2016–2020). *The Historic Environment: Policy & Practice*, 12(3–4), 434–477. <https://doi.org/10.1080/17567505.2021.1957264>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). Updating guidance for reporting systematic reviews: Development of the PRISMA 2020 statement. *Journal of Clinical Epidemiology*, 134, 103–112. <https://doi.org/10.1016/j.jclinepi.2021.02.003>
- Pallud, J. (2017). Impact of interactive technologies on stimulating learning experiences in a museum. *Information & Management*, 54(4), 465–478. <https://doi.org/10.1016/j.im.2016.10.004>
- Pedersen, I., Gale, N., Mirza-Babaei, P., & Reid, S. (2017). More than meets the eye: The benefits of augmented reality and holographic displays for digital cultural heritage. *ACM JOURNAL ON COMPUTING AND CULTURAL HERITAGE*, 1–15. <https://doi.org/10.1145/3051480>
- Peng, W., Gao, C., Zhu, B., Zhu, X., & Jing, Q. (2025). Visitor behavioral preferences at cultural heritage museums: Evidence from social media data. *BUILDINGS*, 1–24. <https://doi.org/10.3390/buildings15203756>
- Qiu, T., Li, H., Chen, Y., Zeng, H., & Qian, S. (2024). Continuance intention toward VR games of intangible cultural heritage: A stimulus-organism-response perspective. *Virtual Reality*, 28(3), 149–164. <https://doi.org/10.1007/s10055-024-01043-7>
- Ramezani Nia, M., & Shokouhyar, S. (2020). Analyzing the effects of visual aesthetic of web pages on users' responses in online retailing using the VisAWI method. *Journal of Research in Interactive Marketing*, 14(4), 357–389. <https://doi.org/10.1108/JRIM-11-2018-0147>
- Raptis, G. E., Fidas, C., & Avouris, N. (2019). Do game designers' decisions related to visual activities affect knowledge acquisition in cultural heritage games? An evaluation from a human cognitive processing perspective. *Journal on Computing and Cultural Heritage*, 1–25. <https://doi.org/10.1145/3292057>
- Sauer, J., & Sonderegger, A. (2022). Visual aesthetics and user experience: A multiple-session experiment. *International Journal of Human-Computer Studies*, 165, 102837. <https://doi.org/10.1016/j.ijhcs.2022.102837>
- Shen, Y., & Li, S. (2024). Application of folk art modeling in modern art design based on human-computer interaction. *Computer-Aided Design and Applications*, 1–15. <https://doi.org/10.14733/cadaps.2024.S7.28-42>
- Silva, C., Zagalo, N., & Mário Vairinhos. (2023). Towards participatory activities with augmented reality for cultural heritage: A literature review. *Computers & Education: X Reality*, 3, 100044. <https://doi.org/10.1016/j.cexr.2023.100044>
- Škola, F., Rizvić, S., Cozza, M., Barbieri, L., Bruno, F., Skarlatos, D., & Liarokapis, F. (2020). Virtual reality with 360-video storytelling in cultural heritage: Study of presence, engagement, and immersion. *Sensors*, 20(20), 5851. <https://doi.org/10.3390/s20205851>
- Skublewska-Paszowska, M., Milosz, M., Powroznik, P., & Lukasik, E. (2022). 3D technologies for intangible cultural heritage preservation – Literature review for selected databases. *Heritage Science*, 10(1), 3–26. <https://doi.org/10.1186/s40494-021-00633-x>
- Su, Z. (2025). Immersive teaching model for traditional chinese opera costume design based on virtual reality: Digital cultural heritage, inheritance, and innovation. *SCIENTIFIC REPORTS*, 1–19.

- <https://doi.org/10.1038/s41598-025-19350-7>
- Sun, X., & Ch'ng, E. (2024). Exploring miao culture: The differential effect of traditional 2D and immersive 360° documentary formats on viewer learning. *Social Sciences and Humanities Open*, 1–11. <https://doi.org/10.1016/j.ssaho.2024.101061>
- Tennent, P., Martindale, S., Benford, S., Darzentas, D., Brundell, P., & Collishaw, M. (2020). Thresholds: Embedding virtual reality in the museum. *Journal on Computing and Cultural Heritage*, 13(2), 1–35. <https://doi.org/10.1145/3369394>
- Tom Dieck, M. C., & Jung, T. (2018). A theoretical model of mobile augmented reality acceptance in urban heritage tourism. *Current Issues in Tourism*, 21(2), 154–174. <https://doi.org/10.1080/13683500.2015.1070801>
- Wang, J. (2025). Using masao facial makeup in software interface interaction design from the perspective of digital communication. *Scientific Reports*, 1–17. Scopus;WoS. <https://doi.org/10.1038/s41598-025-90448-8>
- Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, 39(1), 93–112. <https://doi.org/10.1177/0739456X17723971>
- Yang, R., Ota, K., Dong, M., & Wu, X. (2025). Semantic layout-guided diffusion model for high-fidelity image synthesis in “the thousand Li of rivers and mountains.” *EXPERT SYSTEMS WITH APPLICATIONS*, 1–12. <https://doi.org/10.1016/j.eswa.2024.125645>
- Yi, C., Huang, J., & Song, L. (2025). Enhancing intangible cultural heritage dissemination through digital experience: An affective events theory approach. *Npj Heritage Science*, 13(1), 438–448. Scopus;WoS. <https://doi.org/10.1038/s40494-025-02017-x>
- Zhang, Y., Zhang, B., Jang, W., & Pan, Y. (2024). Enhancing spatial cognition in online virtual museum environments: Integrating game-based navigation strategies for improved user experience. *Applied Sciences (Switzerland)*, 1–19. <https://doi.org/10.3390/app14104163>
- Zhu, P., & Chung, W.-J. (2024). Designing the presentation of dunhuang fresco art based on perceptron technology in the context of artificial intelligence. *Applied Mathematics and Nonlinear Sciences*, 1–16. <https://doi.org/10.2478/amns.2023.2.00135>
- Zou, N., Chen, Y., Chen, P., & Gong, Q. (2025). Research on multimodal interaction system based on cognitive style in virtual historical and cultural scenes. *Design and Artificial Intelligence*, 1–14. <https://doi.org/10.1016/j.daai.2025.100052>