Human Factors in Design, Engineering, and Computing, Vol. 238, 2026, 164–174
https://doi.org/10.54941/ahfe1008251

SPARC: An Interactive Virtual Environment for Eliciting and Organizing Place-Based Memories in Historic Districts

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ABSTRACT

Memories of residents connect historic districts with everyday activities, social relationships, and change. Changing uses, names, and landmarks, however, complicate the identification and organization of places and periods in oral accounts. Developed for Lingshui Old Street, China, SPARC (Spatial Platform for Assisted Recollection and Collection) combines a high-fidelity street-block environment, spatiotemporal slices, and information entry and processing. Interviews and guided trials with 12 current or former residents and feedback from four researchers were analyzed qualitatively. Discussion in the virtual environment elicited memories and recognition cues. Residents identified discrepancies for historical verification, while researchers clarified locations, floors, and uses and compared accounts. SPARC thus provided a shared spatial reference connecting recollection with information organization. Linking accounts to places, times, uses, and people, while retaining sources and unresolved information, provides a foundation for investigating heritage value.

Keywords: Place-based memories, Historic districts, Interactive virtual environments, Oral interviews, Participatory conservation

INTRODUCTION

Memories of residents connect the physical spaces of historic districts with everyday activities, social relationships, and change. These experiences enrich urban landscape documentation (Hayden, 1995) and reveal the social value of heritage through use, memory, and identification (Jones, 2017). Recording them requires locating unfamiliar names and landmarks and distinguishing historical change from differences in places or experiences. Oral history and historical geographic information systems provide foundations for relating such experiences to location, attributes, and time (Selvi Ünlü, 2019; Gregory and Ell, 2007).

Spatial references help participants communicate and interpret these experiences. Go-along interviews situate discussion in familiar environments (Kusenbach, 2003), while geo-narrative methods link accounts with spatiotemporal information (Kwan and Ding, 2008). Virtual reconstruction supports recollection of lost environments (Di Giuseppantonio Di Franco et al., 2025). Baker et al. (2021) emphasized reminiscence through 3D scenes

Received November 2, 2026; Revised November 17, 2026; Accepted November 20, 2026; Available online December 1, 2026

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and objects; Yang et al. (2026) emphasized expression through collaborative scene creation. Building on these approaches, this study examines how shared viewing connects the recollection and spatial expression of residents with the work of researchers in clarifying and organizing accounts.

SPARC (Spatial Platform for Assisted Recollection and Collection) addresses this connection in Lingshui Old Street, where shop turnover and alterations complicate identification. Its three modules connect browsing, period-specific viewing, and building-linked records. Interviews, trials, and researcher feedback examine memory elicitation, historical checks, and information organization for participatory historic district conservation.

RELATED WORK

The Complexity of Place-Based Memory Information in Historic Districts

Place-based memory records must connect where experiences occurred with when they occurred and what they meant. Such memories include perceptions, emotions, and experiences beyond coordinates (De Nardi, 2014). Recording formats influence their expression (Brown and Kyttä, 2014), while interviews and shared discussion develop and clarify accounts (Stein, 2014; Cantillon et al., 2024). These complexities motivate a framework connecting time (events and change), space (places and relationships), and culture (uses, people, activities, and meanings). Original wording, photographs, recognition cues, approximate dates, candidate locations, and corrections preserve sources and interpretive processes when accounts remain uncertain or differ.

Virtual Environments as a Medium for Memory Elicitation and Recollection

Virtual environments can connect memory elicitation with participation and data collection. Reconstructed places support recollection (Di Giuseppantonio Di Franco et al., 2025), while collaborative creation supports expression (Yang et al., 2026). Deng et al. (2026) reviewed physiological, spatiotemporal, and interaction data, subjective feedback, and contextual information collected in interactive virtual environments. SPARC applies this approach to assisted historic district interviews: residents browse prebuilt 3D scenes and contribute through identification, narration, and comparison, while researchers link accounts to places and organize temporal, spatial, and cultural information.

Organizing Spatial and Temporal Information in Virtual Environments

Virtual environments can organize historical information through spatial relationships and period-specific representations. Heritage modeling integrates spatial evidence (Remondino, 2011), while historical images support reconstruction of past states (Stefani et al., 2011). Such representations also require traceable sources and explicit uncertainty (Zuk et al., 2005; The London Charter, 2009). SPARC links building-based records

with period-specific scenes, retaining event times, sources, and unresolved information to support comparison of the accounts of residents and subsequent verification.

SPARC DESIGN AND IMPLEMENTATION

Case Introduction

Lingshui Old Street in Jinjiang, Fujian, was built in 1929–1931 under Wu Liangshi, an overseas Chinese resident in the Philippines. Its arcaded shophouses (qilou) combined commerce, residence, and storage along Quan'an Road. Compiled materials document commercial decline, post-1949 expansion and cooperative use, and trade shifting to a new market after 2000. The surviving layout includes altered entrances, subdivisions, and facades; shops, a gateway, and an overhead passage have disappeared. Historical materials and surveys supported four period models. Users included merchants, households, shoppers, school and township-office users, cooperative staff, and retailers. Some proprietors closed or sublet; others remained. Overseas Chinese-owned properties are vacant or rented to vendors for accommodation, preparation, and processing. These changing uses make the complementary memories of residents relevant to interpreting surviving spaces.

Research Requirements and System Architecture

SPARC connects recognition and recording through three modules: (1) a high-fidelity street-block environment for viewing; (2) spatiotemporal slices representing four historical stages; and (3) information entry and processing for temporal, spatial, and cultural records. Building selection and scene period link the modules.

Residents recount experiences, identify places, and report differences; researchers assist operation, clarify accounts, and record information. Building-linked records and a supporting materials register retain sources, media, and unresolved information for comparison.

High-Fidelity Street-Block Environment Module

The environment module combines 3D scenes with browsing controls. Scenes represent street alignment, building adjacency, shopfronts, arcades, entrances, and everyday objects. Rhino models based on historical materials were refined in Blender with ChatGPT assistance. Photograph-derived textures, components, furniture, and signs populate scenes (Figure 1). Godot implements lighting, environmental settings, browsing, selection, entry, and period switching.

Controls provide overview, first-person, and third-person modes (Figure 2). Overview supports rotation, zooming, and panning; navigation provides pedestrian or third-person views of position and surroundings. Both navigation modes support movement and collision constraints, retaining position when switching. These views enable street- and building-scale inspection.

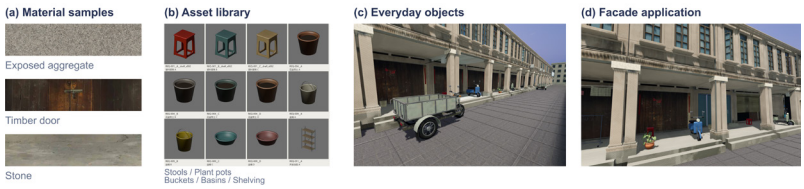


Figure 1: Materials, asset samples, and scene applications: (a) material samples; (b) asset library; (c) everyday objects; (d) facade application.



Figure 2: Street-block overview with surrounding context, first-person navigation, and third-person navigation. Surroundings are present-day contextual representations.

Spatiotemporal Slices Module

Spatiotemporal slices provide four scene states: the mid-Republican period, late Republican period, post-1949 to the late 20th century, and post-2000 (Figure 3). Selecting a labeled period loads the corresponding scene for navigation and building selection.

Scene period and event time remain distinct because an account may describe experiences outside the viewed period. Text records and supporting materials retain years, approximate dates, and sequences. Researchers manually organize correspondences between changing names, uses, and relocated shops.

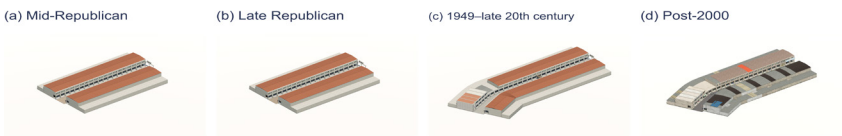


Figure 3: Four historical stages from matched aerial viewpoints. Post-2000 roof colors follow the aerial photograph.

Information Entry and Processing Module

This module links scene selection to information entry and retrieval. Ray casting identifies and highlights a building, retrieves its ID, and opens the panel (Figure 4). Floor selection specifies the vertical scope of the account. Building ID, floor, and scene period follow selection; other details are narrated, entered, and confirmed. Fixed fields and free text retain experiences and differing interpretations (Table 1), alongside records of contributors, sources, and consent.

Table 1: Main fields in the information entry and processing module.

Category	Field
Time	Scene period
Space	Building ID, Floor, Actual street address (optional)
Culture	Building / shop / memory title, Use (optional), Content

Note: Scene period identifies the viewed stage; event dates and sequences remain in accounts and supporting materials.

Binding records to buildings, floors, and periods supports display and retrieval through scenes and panels. The supporting materials register links recordings, videos, and photographs through filenames and timestamps, allowing researchers to consult original evidence during verification (Figure 5).

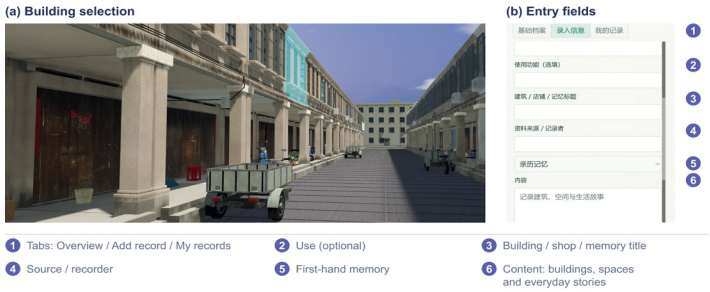


Figure 4: Building selection and original Chinese entry fields, with numbered English translations.

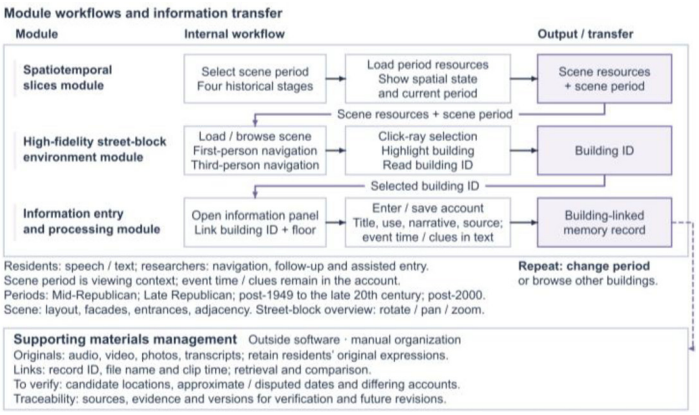


Figure 5: Module workflows and information transfer in SPARC, with supporting materials management. Dashed arrows indicate manual linkage.

USER FEEDBACK STUDY

Study Setting and Participants

Twelve current or former residents participated in one-to-one guided use, group discussion, or individual trials; four project researchers provided feedback (Figure 6). Community contacts and visits recruited residents with

residential, business, or everyday connections. Interviews established familiar periods and places. Resident feedback concerned recognition, discrepancies, and expression; researcher feedback concerned operation, questioning, information location, and organization. These perspectives were analyzed separately. Interviewees consented to research use. The professional roles of community staff were distinguished from personal experiences; cited materials were coded.

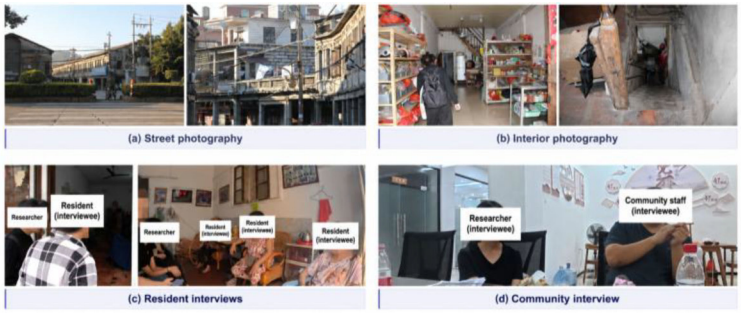


Figure 6: Fieldwork methods and participant roles: (a) street photography; (b) interior photography; (c) resident interviews; (d) community interview. Faces are obscured for privacy.

Study Methods

Sessions followed three stages: semi-structured interviews, scene viewing, and feedback. Before viewing, residents described their connections, familiar periods, places, and activities; researchers recorded locations, relationships, changes, and unresolved points. Residents then identified previously discussed places in SPARC, elaborated accounts, and suggested candidate locations or discrepancies. Researchers assisted navigation and operation and adapted follow-up questions to the responses of residents.

Feedback addressed the recognition, perceived discrepancies, and expression difficulties of residents, alongside the experiences of researchers in navigation, interpretation, recording, and comparison. Audio recordings, photographs, and some videos documented these exchanges. Field use centered on browsing and identification; oral contributions were organized from field records and transcripts. Information entry and processing were implemented prototype functions rather than the focus of the field evaluation. Analysis therefore examined recorded interactions in context, accounting for differences in viewing time and questioning.

Data Analysis

Analysis used 31 transcripts, including continuous and parallel recordings, linked through filenames, timestamps, and context. Episodes of identification, spatial discussion, or feedback retained the wording, questions, places, temporal cues, and sources of participants. Comparing accounts before and

during viewing distinguished confirmed or candidate locations, additional details, corrections, and unresolved disagreements; categories could overlap. Resident feedback was organized around recognition, details, discrepancies, and experience; researcher feedback around clarification, comparison, navigation, language, and recording. Cases included clear and unresolved identifications, distinguishing existing from added information and prompted from spontaneous contributions.

SPARC USE AND USER FEEDBACK

Source codes denote materials (S), comparison excerpts (K), quotations/excerpts (E), feedback (V), historical/everyday themes (H), and verification items (Q), not separate participants.

SPARC Elicits Memories and Discovers Landmarks for Recollection

SPARC prompted discussion of familiar places and the landmarks underlying the recollections of residents. One resident clarified direction by stating, "*The hotpot restaurant was on North Street,*" using a familiar shop to locate other places [S01; K01; E01–E03].

Building details prompted comparison with personal memories. A barbershop proprietor asked, "*Is this my home?*" After mentioning a glass door and upstairs security grilles and changing viewpoint, the resident stated, "*This one is my home*" [S11; K10; E38–E39]. Another resident, who had approximately located a watch shop before viewing, added, "*There was a walkway you could go down,*" extending the account to entrance–street level differences [S10; K09; E29–E32].

Recollections also connected places with recurring activities. Accounts of Pudu vendors and a stage cleared of stored items for performances revealed time-dependent uses [H08; E22, E25; S09]. Together, these cases show how discussion in the virtual environment elicited personal details and clarified relationships between places and activities that drawings or present-day observation alone may overlook.

Residents Use SPARC to Check Historical Information

SPARC enabled residents to check represented conditions against their memories. Remembered "*five units*" contrasted with the "*four units*" of the model, prompting discussion of sizes, drainage, and neighboring uses. This exposed both a possible discrepancy and ambiguity over whether jian meant bays, premises, or businesses [K15; E51–E54]. Comments about "*modernization,*" "*stone slabs,*" and a scene that "*looks a little too new*" questioned materials and apparent age [S09, S12/S30; E27, E46]. Such spontaneous checks identified possible omissions and inconsistencies that, once verified, could inform corrections to historical records and reconstructed scenes.

SPARC Supports Researchers in Clarifying and Comparing Accounts

Shared viewing helped researchers clarify what accounts referred to. A grocery proprietor corrected an interpretation of raised ground as a higher building: *"It wasn't the shop that was higher than these. It was the ground. The foundation, the foundation was a little higher"* [S03; K03; E07–E08]. Activities mistaken for neighboring shops were distinguished by floor: *"No, it was downstairs. They sold oyster omelets downstairs."* Subsequent explanation clarified upstairs uses [S11; K11; E40–E41].

Comparing accounts also distinguished successive carpentry-shop and photography-studio uses. Conversely, questions about the neighbors and alterations of a video arcade left its identification unresolved [K07, K12; E20, E44]. Alongside oral explanations and paper references, shared 3D views provided concrete objects for follow-up questions, helping researchers separate spatial misunderstandings, temporal changes, and information requiring further verification.

Usability Issues and Desired Features

Feedback identified gaps in scene coverage and navigation. Residents requested Sanwangfu and the performance stage [V04; E27]. After unsuccessful zooming, *"Save a few more scenes"* indicated a need to return to useful viewpoints. A shutdown interrupted another session, which continued orally [V10–V11; E43, E65].

Submission and temporal organization also required support. Residents wanted convenient photograph uploads and chronological display [V08; E24]. *"Although we divided it into four periods, their memories don't have these four periods."* Schooling, business, and relocation required event-based records with approximate or relative dates [S04; V14; E61]. Dialect comprehension also affected questioning and organization, indicating a need for language assistance alongside spatial references [S27; E60].

DISCUSSION

SPARC as a Shared Spatial Reference in On-Site Interviews

The role of SPARC as a shared spatial reference connects the memory expression of residents with the interpretation of researchers. Residents can explain recognition cues and challenge how their accounts are understood, as the ground-level and floor-use exchanges illustrate. Researchers can then clarify what was meant before organizing records. Preserving this dialogue alongside locations helps distinguish misidentification, historical change, and unresolved disagreement. The resulting records retain both the knowledge of residents and the reasoning through which it was interpreted.

Digital Archives of Places Embody Heritage Value

For digital archives of places that embody heritage value, linking scenes, accounts, buildings, floors, periods, and sources provides a foundation. Such records connect spatial appearance with when, how, and by whom places were used, retaining relationships with commerce, social life, and public activities.

For research, the carpentry/photography and festive-stage accounts show why temporal context matters when interpreting uses and activities. Linking such accounts with period-specific scenes could support comparisons across periods and recognition of layered heritage value, rather than judgments based on the appearance of one period.

For communities, completed archives could become exhibition and information-retrieval tools combining scenes, accounts, and photographs. Former addresses and residential histories could also help overseas community members and descendants locate ancestral homes and family connections.

Limitations

Findings concern researcher-assisted interviews; independent use requires evaluation. Web distribution would require checks of unaided usability, verification, duplicate submissions, and sustained participation at scale. Sequential interviewing, repeated recall, follow-up questions, additional time, and positive assumptions may affect later accounts, so additional information cannot be attributed solely to SPARC. Audio did not always identify unique buildings, leaving candidate locations unresolved. Limited records of slice use mean temporal interpretation rests on accounts and system capabilities, rather than independently established effects of period switching.

Future Development Informed by User Feedback

Feedback on scene coverage and navigation points to better spatial references and easier viewpoint recovery. Landmarks, facades, steps, and arrangements should be checked against materials and interviews; fixed viewpoints and return controls could reduce interruptions. Linking scene periods with event dates, including construction, relocation, and reletting, would support further evaluation of cross-period comparison.

Requests for easier contributions motivate web-based photograph and oral submissions. Speech/text parsing could assist researchers by proposing places, times, uses, and people for confirmation while retaining wording, sources, and uncertainty. Linking parsing with asset retrieval and editing could enable rapid scene previews for resident–researcher review, with versions and evidence retained. Evaluation should examine whether these functions support fuller expression and continued contributions.

CONCLUSION

SPARC connects recollection and spatial expression through a high-fidelity street-block environment, spatiotemporal slices, and information entry and processing. Interviews and trials with 12 current or former residents and feedback from four researchers showed its role in assisted information collection. The virtual environment elicited memories, residents checked representations, and researchers clarified and compared accounts. Linking these accounts to places, times, uses, and people provides a foundation for heritage archives. Further development will address scene coverage, navigation, temporal organization, submission, semantic assistance, and rapid updates, alongside evaluation of independent and sustained participation.

ACKNOWLEDGMENT

This study is supported by the Tsinghua University Initiative Scientific Research Program (Student Academic Research Advancement Program, Grant No. 20267020002), the Tsinghua University Undergraduate Teaching Reform Project (2025, Grant No. DX08_06), and the Foundation for Cultivated Young Talents of Fujian Province, China (Grant No. 2025350253).

Prof. Huishu Deng serves as the corresponding author, and Prof. Quhang Wu serves as the co-corresponding author of this study.

REFERENCES

Baker, S., Kelly, R. M., Waycott, J., Carrasco, R., Bell, R., Joukhadar, Z., Hoang, T., Ozanne, E. and Vetere, F. (2021). School's back: Scaffolding reminiscence in social virtual reality with older adults. Proceedings of the ACM on Human-Computer Interaction, 4(CSCW3), Article 267, pp. 1–25. https://doi.org/10.1145/3434176.

Brown, G. and Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Applied Geography, 46, pp. 122–136. https://doi.org/10.1016/j.apgeog.2013.11.004.

Cantillon, Z., Baker, S. and Evans, C. (2024). Cartography, conversation, and critical cultural justice inquiry: Participatory mapping and the reimagining of Kingston and Arthur's Vale Historic Area, Norfolk Island. Cultural Studies ↔ Critical Methodologies,24(6),pp.471–486.https://doi.org/10.1177/15327086241279819.

De Nardi, S. (2014). Senses of place, senses of the past: Making experiential maps as part of community heritage fieldwork. Journal of Community Archaeology & Heritage, 1(1), pp. 5–22. https://doi.org/10.1179/2051819613Z.0000000001.

Deng, H., Zhang, L. and Wang, X. (2026). Interactive 3D digital environments as ergonomic data collection platforms: A cross-immersion analysis. Metaverse, Virtual Environments and Game Design, 217, pp. 230–239. AHFE International. https://doi.org/10.54941/ahfe1007670.

Di Giuseppantonio Di Franco, P., Dolcetti, F., Baraldo, M. and Dey, S. (2025). Can immersive technologies rebuild heritage and sense of place? Examining Virtual Reality's role in fostering community resilience in post-disaster Italy. International Journal of Heritage Studies, 31(7), pp. 956–977. https://doi.org/10.1080/13527258.2025.2520760.

Gregory, I. N. and Ell, P. S. (2007). Historical GIS: Technologies, methodologies, and scholarship. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511493645.

Hayden, D. (1995). The power of place: Urban landscapes as public history. Cambridge, MA: MIT Press.

Jones, S. (2017). Wrestling with the social value of heritage: Problems, dilemmas and opportunities. Journal of Community Archaeology & Heritage, 4(1), pp. 21–37. https://doi.org/10.1080/20518196.2016.1193996.

Kusenbach, M. (2003). Street phenomenology: The go-along as ethnographic research tool. Ethnography, 4(3), pp. 455–485. https://doi.org/10.1177/146613810343007.

Kwan, M.-P. and Ding, G. (2008). Geo-narrative: Extending geographic information systems for narrative analysis in qualitative and mixed-method research. The Professional Geographer, 60(4), pp. 443–465. https://doi.org/10.1080/00330120802211752.

Remondino, F. (2011). Heritage recording and 3D modeling with photogrammetry and 3D scanning. Remote Sensing, 3(6), pp. 1104–1138. https://doi.org/10.3390/rs3061104.

Selvi Ünlü, T. (2019). Urban memory and planning: Investigating the use of oral history. European Planning Studies, 27(4), pp. 802–817. https://doi.org/10.1080/09654313.2019.1567696.

Stefani, C., Busayarat, C., Renaudin, N., De Luca, L., Véron, P. and Florenzano, M. (2011). An image-based approach for the architectural modeling of past states. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-5/W16, pp. 397–404. https://doi.org/10.5194/isprsarchives-XXXVIII-5-W16-397-2011.

Stein, J. A. (2014). The co-construction of spatial memory: Enriching architectural histories of "ordinary" buildings. Fabrications, 24(2), pp. 178–197. https://doi.org/10.1080/10331867.2014.961222.

The London Charter for the Computer-Based Visualisation of Cultural Heritage (2009). Version 2.1. Available at: https://londoncharter.org/fileadmin/templates/main/docs/london_charter_2_1_en.pdf (Accessed: 24 October 2026).

Yang, Y., Meng, F., Nah, F. F.-H. and LC, R. (2026). "From remembering to shaping": Narrating shared experiences by co-designing cultural heritage artifacts in collaborative VR. In: Proceedings of the 2026 Designing Interactive Systems Conference. New York, NY: Association for Computing Machinery, pp. 371–394. https://doi.org/10.1145/3800645.3812950.

Zuk, T., Carpendale, S. and Glanzman, W. D. (2005). Visualizing temporal uncertainty in 3D virtual reconstructions. In: Mudge, M., Ryan, N. and Scopigno, R. (eds.) The 6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage. The Eurographics Association, pp. 99–106. https://doi.org/10.2312/VAST/VAST05/099-106.