



Digital Reconstruction and Interactive Communication of Bashu Inscription Characters Based on a Civilization Gene Repository: A Case Study of Taoist Inscriptions at Mount Qingcheng

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Abstract. Bashu stone inscriptions are important carriers of Chinese cultural heritage, linking local history, Taoist belief, calligraphic form, and spatial memory. Taking Taoist inscriptions at Mount Qingcheng as a case, this paper introduces the concept of a civilization gene repository into the digital reconstruction of damaged inscription characters. It proposes a four-layer model of morphological, semantic, contextual, and communicative genes, and develops a workflow covering data acquisition, character segmentation, form–meaning corroboration, AI-assisted reconstruction, expert validation, and interactive communication. The study argues that damaged inscription characters should not be treated as isolated visual fragments, but as compound cultural units embedded in textual, religious, spatial, and media contexts. The framework offers a transferable approach for the intelligent preservation and digital communication of local cultural heritage.

Keywords: Civilization gene repository, Bashu stone inscriptions, Mount Qingcheng, Taoist inscriptions, Digital reconstruction, Interactive communication

1 Introduction

Bashu is a key cultural region in Chinese civilization, whose stone inscriptions integrate writing, calligraphy, history, religion, and place. Mount Qingcheng, a major Taoist site, preserves inscriptions on temples, rituals, historical figures, and mountain worship. The Collected Taoist Inscriptions of Bashu provides key evidence [1], while Du Guangting's records support the interpretation of Taoist space and temple construction [2,3].

Weathering and human disturbance have caused missing strokes, erosion, fractures, and rubbing noise. In Mount Qingcheng inscriptions, a damaged character may affect textual interpretation, local religious history, Bashu cultural transmission, and spatial meaning. Traditional epigraphy offers philological evidence but lacks character-level

digital restoration, image-based evidence recording, and public interaction. Thus, inscription reconstruction should preserve historical context and evidential transparency (Figure 1).



Fig. 1. Material Context of Taoist Inscription Characters at Mount Qingcheng

Recent digital heritage studies have moved from static documentation to multi-modal acquisition, intelligent analysis, virtual simulation, and public communication. UNESCO emphasizes long-term preservation and access [4], while the London Charter and Seville Principles stress transparency and evidential responsibility in digital reconstruction [5,6]. A civilization gene repository organizes inscription elements, as a damaged character may contain stroke traces, calligraphic style, meaning, religious ideas, and spatial information. This paper proposes a civilization-gene-based framework for reconstructing and communicating Bashu inscription characters.

2 Related Work

Existing studies on Bashu inscriptions and Taoist documents offer strong historical and philological foundations. Yunji Qiqian, Huayang guo zhi, and Jinshi lu support the interpretation of Taoist vocabulary, regional history, and inscriptional evidence. However, they focus mainly on textual collation, figures, religious thought, and context, with limited attention to character-level databases, digital reconstruction, and interaction.

Digital heritage has shifted from 2D/3D recording to knowledge organization, digital twins, and extended reality. Heritage digital twins now serve conservation, management, and interpretation, while HBIM and extended reality enhance communication and accessibility. For inscriptions, digital twins should link location, material, character structure, semantics, documents, and communication scenarios.

AI tools such as latent diffusion and large-mask inpainting support damaged image completion [7], but inscription reconstruction also requires accurate structure, stroke logic, calligraphy, and semantics. Cultural gene studies emphasize cultural structure,

memory, and communication beyond morphology [8], motivating the form–meaning corroboration method.

3 Civilization Gene Repository Model for Bashu Inscription Characters

A civilization gene bank is a knowledge system for identifying, reconstructing, and disseminating heritage. For Bashu inscriptions, it encodes characters, images, locations, history, religion, aesthetics, and communication into searchable and transmissible units, aligning with transparency, evidence-chain, and traceability principles [9].

In Qingcheng Mountain Taoist inscriptions, single words are basic gene units, integrating glyph structure, calligraphy, semantics, Taoist terms, place names, religious concepts, and design potential. Bashu inscription genes include four levels: morphological, semantic, scene, and communication genes (Table 1), covering visual features, textual meanings, spatial contexts, and dissemination uses such as AR tours, exhibitions, fonts, and international communication.

This paper proposes “mutual proof of form and meaning,” combining glyph and semantic evidence. Candidates are inferred from residual strokes, structure, similar glyphs, and style, then verified through context, documents, Taoist terms, place names, and syntax. The workflow—damaged image → candidate generation → semantic screening → AI reconstruction → expert verification → archiving and dissemination—avoids image-only or literature-only errors, supporting evidence-based heritage reconstruction.

Table 1. Four-layer model of gene bank of word civilization in Bashu inscriptions

levels and ranks	Core meaning	Expression in words inscribed on stone tablets	Digitization and dissemination methods
Morphological gene	Visual Structure and Calligraphy Traces	Stroke residue, way of writing, depth of notch, texture of tablet surface	High-definition acquisition, image enhancement, AI-assisted restoration
Semantic gene	Text Meaning and Literature Evidence	Word meaning, word meaning, Taoist terms, place names of people, context of inscriptions	Textual research, mutual proof of form and meaning, knowledge annotation
Scene gene	Space environment and religious sites	Temple location, landscape path, religious ceremony, local memory	Digital Twinning, AR Navigation, Virtual Simulation
Spreading gene	Contemporary Translation and Public Experience	Font design, interactive exhibition, cultural tour guide, cultural and creative symbols	Interactive design, digital exhibition, immersion communication

4 Research Methods and Technical Process

Focusing on Taoist inscriptions in Qingcheng Mountain, this paper builds the workflow of “data acquisition—word segmentation—mutual proof of form and meaning—AI-assisted reconstruction—expert verification—interactive communication.” Based on photos, rubbings, detailed images, 3D scans, and documents, a single-word database records each word’s source, coordinates, image, damage type, visible strokes, candidates, context, literature, reconstruction, and expert opinion, making inscriptions searchable and analyzable.

Word segmentation combines semi-automatic methods with manual correction, labeling missing strokes, blurred edges, noise, incomplete structure, and semantic uncertainty. For severely damaged words, “mutual proof of form and meaning” infers candidates from residual strokes, radicals, repeated or similar glyphs, and verifies them through context, Taoist terms, documents, and local records. Words such as Guan, Gong, Zhen, Xian, Dao, and Merit help narrow identification.

AI-assisted reconstruction uses image enhancement, defect completion, and style constraints to improve visibility and propose repairs. AI results are only candidate schemes, so the “original image—candidate reconstruction—expert revision” chain must be preserved to avoid over-completion, stroke fiction, and style drift.

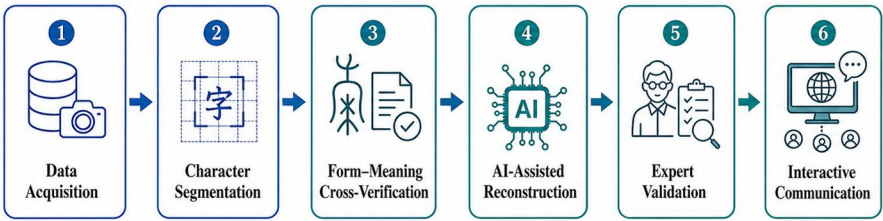


Fig. 2. Digital Reconstruction and Interactive Communication Process of Inscription Words Based on Civilization Gene Bank

Credibility is graded into three levels: A—high confidence with sufficient morphological and semantic evidence; B—moderate confidence with strong semantic support but incomplete image evidence; C—low confidence with severe damage and speculative candidates. This ensures transparency and traceability. The interactive system should display the original image, processed image, reconstruction, evidence, and credibility level together, providing clear reading while showing the academic basis and uncertainty of reconstruction (Figure 2).

5 Inter active Communication Design Path

The goal of digital reconstruction of Bashu inscriptions is to create not only clearer glyphs but also understandable, experiential, and shareable cultural content. Through the civilization gene bank, words become interactive nodes linking original images,

AI reconstructions, glyph analysis, context, Taoist meaning, location, and evidence, turning illegible characters into layered cultural stories while preserving research records.

Qingcheng Mountain inscriptions can be integrated with digital maps, AR recognition, and voice guidance, allowing visitors to scan inscriptions, view reconstructions, and understand their Taoist and spatial meanings. AR content can serve tourists, students, and researchers at different levels.

In exhibitions, Bashu inscriptions can form immersive narratives of “discovery—damage—mutual proof—reconstruction—interpretation,” supported by comparison walls, stroke maps, digital maps, keyword retrieval, and dynamic visuals. Reconstructed words can also become fonts, logos, signage, cultural products, and tourism branding. The civilization gene bank ensures semantic boundaries and cultural evidence, avoiding symbol misuse and supporting cultural re-expression.

6 Discussion and Conclusion

Taking Qingcheng Mountain Taoist inscriptions as an example, this paper proposes a civilization gene bank framework for reconstructing and communicating single words in Bashu inscriptions. Digitalization should move beyond image preservation to structural extraction, evidential reconstruction, and interaction. Single words serve as cultural gene units integrating glyph structure, semantics, religious meaning, spatial context, and communication potential. A four-layer model—morphological, semantic, scene, and spreading genes—combined with data collection, segmentation, mutual proof, AI reconstruction, and expert verification enables the transformation of damaged texts into local cultural symbols.

AI is used only as a “candidate generator” and visual aid, while mutual proof, expert review, and credibility grading ensure transparency, traceability, and rigor. Compared with macro-level Gu Mi culture studies, Qingcheng Mountain inscriptions focus on micro-cultural units, forming a complementary “macro-civilization scene—micro-cultural symbol” relationship. Future work may expand samples, standardize databases and labels, and evaluate interaction through multi-modal models, knowledge graphs, AR navigation, and user studies.

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