

Personalized Cultural Heritage Recommendation System For Cognitive Exploration Levels

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Abstract

This study addresses the limitations of current digital cultural heritage platforms, which rely on keyword searches and static categorization, limiting exploratory and personalized experiences. To overcome this, we propose a system that offers two adaptive exploration paths—facet-based and semantic-linked—tailored to users' cognitive levels. Real-time behavioral data informs artifact recommendations, visualized through a personalized report, My Taste Report, built on knowledge graphs. Using 195,441 records from the National Museum of Korea, the system applies Transformer-based semantic similarity and cultural NER techniques. Designed for modular integration, it enhances existing heritage portals without structural overhaul.

1 Problem Description

Digital heritage platforms are increasingly expected to support exploratory and personalized engagement, yet most remain limited to static, keyword-based retrieval systems. According to Eurobarometer 466 (2017), a lack of accessible information remains a major obstacle to cultural participation, while the Korean Ministry of Culture's 2021 national survey confirmed that digital heritage use has yet to become part of daily life [EC17, MCST22]. These insights highlight the structural misalignment between platform functionalities and user expectations. Existing systems provide limited semantic linkage, making it difficult for users to explore artifacts through self-directed, thematic paths. To overcome these limitations, we propose a semantic-driven interface that adapts to users' cognitive levels and emotional engagement patterns. Such an approach enables dynamic restructuring of navigation and fosters deeper interaction with the layered meanings embedded in cultural heritage. Poux and Billen (2020) demonstrated that semantic networks significantly improve users' conceptual understanding and emotional immersion, advocating for a shift toward personalized, narrative-based exploration.

2 Previous Work

Recent studies emphasize the potential of AI and visualization in enhancing cultural heritage access. Colavizza et al. highlight the importance of intelligent archival infrastructures capable of interpreting semantic layers of historical data, while Windhager et al. demonstrate how visual interfaces facilitate engagement with complex content [Col21, Win19]. Our system incorporates these insights through real-time semantic network generation and modular integration with existing platforms, avoiding disruptive system overhauls. Differing from earlier static or activity-based mod-

els, such as Bellotti et al.'s mobile guide [Bel08], our framework supports ontology-based semantic interlinking and behavior-driven content adaptation. To evaluate the proposed system, we compare four representative platforms—e-Museum, Städel, Prado, and Rijksmuseum—across criteria including personalization, semantic navigation, and interface design, as summarized in Table 1.

Table 1: Comparative Analysis of Digital Cultural Heritage Platforms

Criteria	E-Museum (KR)	Städel (DE)	Prado (ES)	Rijks (NL)
Type of Exploration Structure	Structured Category	Context-Responsive	Social Collaborative	Ontology-Conceptual
Semantic Navigation Support	X	△ (Partial classification based on color and emotion)	X	O (Concept cluster-based exploration)
Real-Time Behavior-Based Recommendation	X	O (Dynamic reconfiguration based on behavioral and emotional input)	△ (Group-based recommendation using basic preferences)	X (Primarily static structure)
Affective/Emotional Filtering	X	O (Emotion-driven filter layers)	X	△ (Partial unstructured color-based exploration)
Personalized Recommendation Paths	X	△ (Partially adaptive to user interaction)	O (Group-based recommendation engine)	△ (Expandable conceptual navigation)
Visualization-Based Recommendation Interface	X	△ (Color-coded layout structure)	X	△ (Graph-based conceptual linking structure)

3 Challenges

Implementation challenges include seamlessly embedding semantic interfaces into legacy museum systems, which requires backward compatibility to ensure continuity for both curators and

users. These interfaces must enhance meaning-centered exploration without disrupting established workflows. Designing parallel navigation modes—structured (facet-based) and associative (semantic-linked)—requires a flexible interface that accommodates differing levels of user familiarity and cognitive readiness.

Real-time recommendation quality hinges on accurate interpretation of user actions such as clickstreams and dwell time. Context-aware modeling is essential to differentiate between purposeful exploration and incidental browsing. Effectively communicating complex cultural relationships among artifacts requires intuitive visualizations that support both macro-level conceptual structures and micro-level thematic associations.

4 Approach, Results, and Future Work

The proposed system adopts a modular design that enables non-disruptive integration with existing museum platforms. It offers two adaptive navigation paths: a facet-based mode for structured filtering by period, region, or material; and a semantic-linked mode that dynamically generates exploration paths through ontology-based knowledge graphs. The underlying architecture uses microservices to ensure scalability across heterogeneous institutional environments.

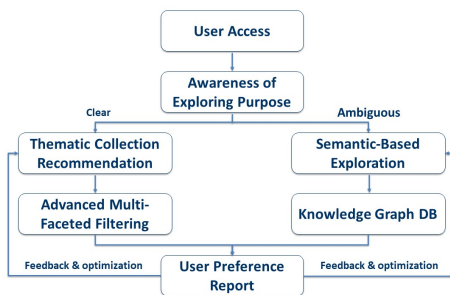


Figure 1: Dual-Path Exploration Model: Facet-Based and Semantic-Linked Navigation

The system utilizes a curated dataset of 195,441 artifact records refined from 207,458 entries from the National Museum of Korea. The technical pipeline integrates sentence-transformer-based semantic similarity, cultural heritage-specific named entity recognition (NER), and unsupervised clustering for latent concept detection. The clustering process identifies implicit symbolic meanings across artifacts, enabling conceptually linked exploration paths.

Two distinct exploration pathways were implemented. The facet-based mode supports linear filtering for users with defined goals (e.g., “Joseon” → “White Porcelain” → “Tableware”). The semantic-linked mode promotes open-ended browsing via conceptual association (e.g., “Bronze Mirror” → “Bronze Artifacts” → “Three Kingdoms Bronze Craftsmanship”). The system continually analyzes behavioral signals to update recommendations in real time and adapt to evolving user interests.

Building upon these real-time adaptive features, the My Taste Report is a personalized visual summary generated from each user’s exploration history. It highlights thematic similarity, temporal continuity, and material affinity through an interactive knowledge graph. Preliminary tests showed increased exploratory engagement compared to traditional filter-only systems. The inter-

face supports a click-to-expand mechanism, enabling users to trace thematic trajectories. Exportable PDF summaries include preferred themes, artifact recommendations, and exhibition suggestions.

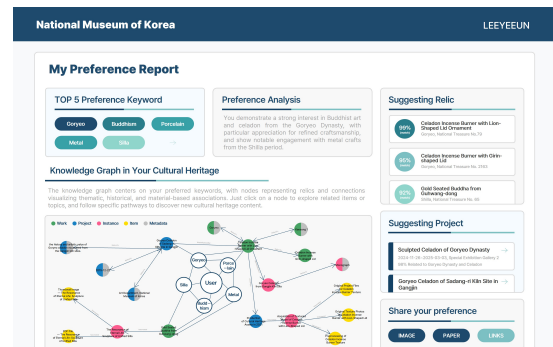


Figure 2: My Taste Report: Knowledge Graph-Based Personalized Visualization

The dual-path design supports both structured retrieval and conceptual discovery, enhancing personalization and interpretability. Unlike traditional heritage systems, the framework introduces real-time adaptability and semantically grounded visualization. However, limitations remain: the system currently relies on data from a single institution, limiting cross-cultural generalizability. Emotional engagement is inferred through indirect behavior metrics rather than direct affective input.

Future research will address these issues through a user study planned for Q2 2025, focusing on immersion and cognitive relevance. The system will be extended to include multilingual and multi-institutional datasets. Planned enhancements include integration of multimodal emotional cues—such as gaze tracking and voice input—to enable affect-aware adaptive recommendations.

Acknowledgments

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