Reconstruction of Cultural Identity through Artificial Intelligence (AI)-Assisted Design: A Semiotic Approach to Cultural Heritage Preservation and Innovation in the Fifteenth-Century Cirebon Sultanate Royal Throne

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Abstract

Generative artificial intelligence (AI) offers new opportunities for cultural heritage design regeneration, yet visual resemblance alone does not ensure the continuity of cultural meaning. This study develops and applies the Semantic-Driven Regenerative Design Framework (SDRDF), operationalized through the Meaning-Driven AI-Assisted Design Framework (MDAIF), using the Cirebon Sultanate throne as a case study. A sequential mixed-methods approach integrates historical inquiry, semiotic interpretation, perceptual assessments involving 88 design students, and multidisciplinary evaluation involving 11 professional and cultural participants. The analysis identified eight Core Cultural Meaning Attributes (CCMAs), organized within a Semantic Cultural Knowledge Base (SCKB) and translated into design parameters through Semantic Quality Function Deployment (SQFD). Semantic prompting generated 100 design alternatives, subsequently narrowed to 17 candidates and three finalists. Design 9 achieved the highest aggregate evaluation score (4.80/5) and informed the development of three additional contemporary furniture alternatives. The findings demonstrate a traceable methodological relationship between cultural interpretation, semantic parameterization, generative exploration, and human evaluation. Rather than establishing historical authenticity or the superiority of meaning-driven generation, the study demonstrates the framework's applicability to culturally informed design transformation. SDRDF–MDAIF contributes a structured approach to regenerative design that positions cultural meaning as a foundation for AI-assisted exploration while retaining human judgement in cultural interpretation and validation.

Keywords: *generative artificial intelligence; regenerative design; cultural heritage; semantic knowledge modelling; semantic fidelity; cultural validation.*

Introduction

Generative AI offers new opportunities for cultural heritage regeneration, yet visual similarity alone cannot ensure the preservation of historical and cultural meanings. Using the Cirebon Sultanate throne as a case study, this research develops the Semantic-Driven Regenerative Design Framework (SDRDF), operationalized through the Meaning-Driven AI-Assisted Design Framework (MDAIF). The framework integrates historical evidence, semiotic interpretation, eight Core Cultural Meaning Attributes (CCMAs), and the Semantic Cultural Knowledge Base (SCKB) into AI-assisted design parameters. Through a mixed-methods approach, the study evaluates 100 generated design alternatives using Semantic Fidelity Assessment (SFA) and cultural validation, establishing a traceable approach to meaning-driven cultural regeneration.



Picture 1. Architectural Transformations of Key Buildings within the Palace Complex: *(1A) Celebration of the Birthday of Queen Wilhelmina of the Netherlands (Wilhelmina Pauline Marie van Orange-Nassau) in the Bangsal Agung Panembahan courtyard, 1905; (1B) Kutagara Wadasan Gate at Bangsal Agung Panembahan, 2026; (2) Kapuntren Gate, 1905; (3) Kapuntren Gate, 2026; (4) Prabayaksa Hall, 2026; and (5) Prabayaksa Hall during the colonial period, 1905. These architectural elements illustrate the dynamics of cultural hybridisation in the historical evolution of the palace complex.*

Research Method

This study employs a sequential mixed-methods approach integrating historical, semiotic, and semantic analysis, visual perception studies, and generative AI-assisted design through the Semantic-Driven Regenerative Design Framework (SDRDF) and its operational framework, Meaning-Driven AI-Assisted Design Framework (MDAIF).



Picture 2. Semantic-Driven Regenerative Design Framework (SDRDF-MDAIF)

The framework comprises (1) historical–cultural evidence acquisition; (2) semiotic and semantic interpretation; (3) development of the Semantic Cultural Knowledge Base (SCKB) and Core Cultural Meaning Attributes (CCMAs); (4) translation of cultural meanings into design specifications through the Semantic Relationship Matrix and Voice of Culture (VoC)-based QFD; (5) AI-assisted design generation; and (6) evaluation and cultural validation. The resulting semantic design parameters guide AI-generated alternatives. The AI used in this research is Chat GPT 5.6 SOL with high intelligent and Gemini AI Pro.

Discussion & Result

The initial screening by five design practitioners selected 17 out of 100 AI-generated designs based on five criteria: semantic fidelity, cultural continuity, historical traceability, design coherence, and regenerative innovation potential.





Three finalists were selected through staged evaluation. Design no.9 achieved the highest score (4.80/5), demonstrating the potential of meaning-driven AI-assisted design to transform cultural heritage into contemporary furniture. Three additional design alternatives were subsequently developed as further explorations.





Picture 3. Three Contemporary Furniture Designs.

Conclusion

Through the SDRDF–MDAIF workflow, eight Core Cultural Meaning Attributes were organised in the Semantic Cultural Knowledge Base and translated into design parameters using Semantic QFD. These parameters guided AI generation of 100 alternatives, narrowed to 17 candidates and three finalists. Design 9 scored 4.80/5 and informed 3 contemporary furniture designs.