Improving Historical Algorithm Recreation Through Systems Thinking: A Study Using Large Language Models and Early Computer Art

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Abstract

This paper reports on preliminary research that examines whether systems thinking principles can improve the accuracy of large language models (LLMs) in recreating historical computer art algorithms. Using nine projects listed in my references, detailed in the Computer Arts Society's PAGE magazine (1969-1974), I compared giving the AI the exact text, against an approach that translated the text into a loosely defined systems thinking approach that decomposed algorithms into constants, variables, interactions, feedback loops, and emergence. Results demonstrate that the systems thinking approach achieved higher fidelity in conceptual and interactive elements, while direct implementation excelled in mathematical precision. This suggests that a systems approach could enhance LLM-based preservation of computer art by better capturing the purpose of underlying processes involved in the algorithm and balancing those with experiential qualities, though with some admitted tradeoffs in technical precision. The research contributes towards a novel framework for digital art preservation that balances algorithmic accuracy with experiential authenticity.

Keywords

Systems Thinking, Digital Art Preservation, Large Language Models, Computer Art History, Algorithm Recreation, Digital Archives, Historical Computing, Artistic Implementation, PAGE Magazine, Computer Arts Society

Introduction

The preservation of early computer arts faces a significant challenge: recreating historical algorithms while maintaining both technical accuracy and artistic integrity. Current digital preservation techniques often fail to capture the technical implementation details and experiential qualities of these pioneering works. This paper reports on research that investigates whether systems thinking [1] principles can provide a structured framework to enhance large language models' (LLMs) capacity for accurate algorithmic recreation.

The research centers on the Computer Arts Society's PAGE magazine (1969–1974), a publication that serves as a crucial historical record of early computer art practices. PAGE magazine provides an ideal dataset for this investigation due to its comprehensive documentation of artistic practice, technical specifications, and theoretical discussions from the foundational period of computer art.

While Ippolito's Variable Media Approach [2] emphasises the importance of strategies such as emulation and migration for preserving digital works, it acknowledges the challenges inherent in maintaining authentic implementations of artworks reliant on obsolete technologies.

Many early pioneers of computer art were deeply influenced by cybernetic theory and systems thinking. Reichardt's foundational exhibition Cybernetic Serendipity [3] and subsequent writing in Cybernetics, Art and Ideas [4] explicitly positioned computer art within the context of systems theory and cybernetic thinking. Similarly, Ascott's "Behaviourist Art and the Cybernetic Vision" [5] established clear theoretical connections between systems thinking and early computational creative practices. This historical alignment suggests that systems thinking, with its emphasis on interconnected components and emergent behaviors, offers an especially appropriate framework for preserving these works.

Recent research by Mirzadeh et al. [6] demonstrates that LLMs perform best when processing information that matches patterns present in their training data. Given the prevalence of various systems thinking approaches in technical and scientific literature, structuring algorithmic descriptions using systems thinking principles may enable LLMs to better leverage their pattern-matching capabilities in the recreation of historical computer art.

I have deliberately adopted a flexible interpretation of systems thinking, as my goal is not to establish a definitive framework for computer art but to explore how an LLM can better perform algorithmic recreation using the frameworks already embedded in its knowledge base. Arnold and Wade's (2015) [1] definition provided a broad yet structured overview of systems thinking, allowing me to select key elements that best guide the LLM toward a way of structuring its response.

Methodology

The study examines ten algorithms selected from PAGE magazine based on specific criteria designed to ensure meaningful comparison and analysis. The selection process prioritised algorithms with comprehensive documentation, requiring a minimum of 1000 words of original description to provide sufficient context for recreation. The chosen algorithms represent diverse artistic approaches, allowing examination of the methodology across varying creative contexts. Selection also considered the availability of original implementation details ensuring that comparisons would be practically meaningful.

Each algorithm underwent recreation through two distinct approaches. The control method involved inputting the original descriptions into Claude 3.5 Sonnet with a direct request to recreate the project as a web application that was as authentic as possible to the original implementation. This approach aimed to test the LLM's ability to interpret and implement historical algorithms without additional structural frameworks.

The system's thinking method followed a two-stage process. First, the original algorithm descriptions were input into Claude 3.5 Sonnet with instructions to analyse and restructure the content according to systems thinking framework, identifying constants, variables, interaction points, feedback loops, and emergence patterns. This systems analysis was then used as the sole input for a second prompt to the LLM, requesting construction of the web application. This approach ensured that the implementation was based purely on the structured systems analysis rather than the original description.

Evaluation Framework

The evaluation process consisted of three distinct analytical stages. In the first stage, systems diagrams were created from both the original text descriptions, control method code, and the systems thinking code. These diagrams were compared to identify similarities and differences in how each method interpreted the core mechanisms of the original works. This comparison provided insight into how the different approaches structured their understanding of the algorithms.

Applying this framework, I define systems thinking in algorithmic recreation as decomposing historical descriptions into constants, variables, interactions, and feedback loops. This enables large language models (LLMs) to reconstruct not just the technical precision of historical algorithms but also their experiential and artistic intent. By structuring LLM inputs in this way, this research contributes a new model for digital art preservation that aims to balance accuracy with authenticity.

The second stage leveraged the LLM's analytical capabilities to assess technical fidelity. The generated code from both control and systems thinking implementations was compared back to the original text descriptions. The LLM was prompted to analyse which implementation more closely aligned with the original specifications and to provide detailed explanations for its assessment.

The final stage involved the researcher examining each implemented web application to evaluate their educational value. This assessment focused on how effectively each implementation explained the underlying algorithmic processes and enabled meaningful user interaction. The key criterion was whether a user could coherently understand and engage with the original artistic and technical concepts through the implementation.

Discussion

The comparison between systems thinking and control implementations revealed distinct patterns across technical, structural, and educational dimensions. Analysis focused on how each approach captured the original works' structural representation, technical fidelity, and potential for user understanding.

Structural Representation

The systems thinking approach demonstrated superior capability in representing the structural complexity of the original works, with nine out of ten implementations showing clearer articulation of process flows and interdependencies. This advantage was particularly evident in Field Work 3 [7], where the systems diagram captured the intricate relationships between lighting, perspective, and user interaction that were less apparent in the control implementation. Similarly, The Transformations Program [8] benefited from the system approach’s ability to represent the complex relationships between vector morphing operations.

Technical Fidelity

Analysis of technical fidelity revealed a more nuanced picture. The control method excelled in works where mathematical precision was paramount, particularly in Barbadillo's Modules/Structures/Relationships [9] and Mallary's TRPL [10], where exact plotting and grid positioning were essential. However, the systems thinking approach proved superior in preserving relationships between technical components in seven cases, notably in works like Meyer's Diary: October 1972 [11], where user engagement and spatial relationships were central to the artistic concept.

Educational Potential

The systems thinking implementations showed clear advantages in educational accessibility, with eight out of ten cases providing more coherent explanations of underlying processes. For interactive works like Dune Tune [12] and the works of Nash [13], Struckyen [14] and Meertens[15], the systems thinking implementations produced more structured descriptions of interaction pathways, making complex concepts more accessible to users. While control implementations successfully executed the algorithms, they often lacked clear pathways

for understanding and engaging with fundamental concepts.

Qualitative Analysis

Deeper examination of the implementations revealed important distinctions in how each approach handled algorithmic recreation. The systems thinking approach consistently produced more structured descriptions of interaction pathways, particularly evident in works requiring user interaction. This structured approach allowed for clearer documentation of feedback loops between user input and algorithmic response.

Implementation Patterns

The evaluation's first stage revealed a fundamental difference in how each method approached the work. Control implementations tended to focus on sequential execution steps, while systems thinking diagrams captured more relational aspects. This distinction became crucial during code generation, where the systems thinking approach more consistently maintained these relationships in the final web applications.

Trade-offs and Limitations

The systems thinking approach revealed an important trade-off. In cases focused primarily on mathematical transformation or pattern generation, the additional systems layer sometimes introduced unnecessary complexity. For these mathematically-focused works, the control method's direct translation proved equally effective, suggesting that the optimal approach may depend on the nature of the original work.

The results suggest that training LLMs to analyze computer artworks through the lens of systems thinking [1] may enhance their ability to preserve both the technical implementation and experiential aspects of these historical works. This approach appears particularly valuable when dealing with works that emphasize conceptual frameworks and user interaction. By analyzing artworks through their interactions, feedback loops, and emergent behaviors, this systems-based approach appears to offer a more authentic method for documenting artistic intent. The focus on these systemic relationships, rather than just technical specifications, suggests a preservation strategy that better aligns with how these early computer artists conceptualised their work.

While this initial study suggests promising directions, several areas warrant further investigation. The systems thinking analysis relied on the LLM's interpretation capabilities rather than strictly predetermined criteria, an approach that should be more formally structured in future work. Similarly, the assessment of educational value would benefit from formal user studies to validate the researcher's preliminary observations. The sample size of nine algorithms provided sufficient insight for this exploratory study but could be expanded to strengthen statistical confidence.

Conclusion

The analysis indicates that a systems thinking approach to algorithmic recreation through LLMs offers computer art archives a potentially efficient method for presenting their collections in more authentic and educationally valuable ways. The structured focus on interactions, feedback, and emergence adopted in this research appears to maintain the conceptual frameworks of historical computer artworks while making them more accessible for exploration and learning.

While further research is needed to validate these initial findings across a larger sample size, the approach appears to offer a promising pathway for archives seeking to balance preservation authenticity with educational access. Future work will focus on refining these methods, developing more robust evaluation metrics, and exploring applications across different types of computer art collections. Most importantly, research could examine how effectively these implementations support user understanding and engagement with historical computer art practices.

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