GenesisSim: A Python-Based Symbolic Evolution Simulator of Emergent Civilizations

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2025

Abstract

GenesisSim is a fully autonomous symbolic life simulator developed entirely in Python and Pygame. It models a dynamic digital environment in which artificial organisms evolve without predefined behaviors. Each organism is governed by internal states such as memory, energy, emotion, and symbolic reasoning, enabling them to make independent decisions and adapt to their surroundings. Through interaction and adaptation, these agents give rise to emergent patterns of cooperation, conflict, social roles, and belief systems, ultimately forming tribes and symbolic civilizations.

Unlike traditional simulations that depend on engines, assets, or external AI libraries, GenesisSim is implemented in a single Python script using only arrays, procedural logic, and timing. This design emphasizes transparency and full control over the underlying mechanics, while also offering real-time visualization of individual organisms and collective dynamics. Observers can track the evolution of traits, inspect the behavior of single agents, and analyze the emergence of higher-level social structures.

GenesisSim contributes to research on artificial life, multi-agent systems, and emergent intelligence by demonstrating how symbolic rules and minimal assumptions can produce complex, lifelike phenomena. Its architecture highlights the potential of lightweight, self-contained simulations as experimental platforms for studying digital evolution, symbolic cognition, and the spontaneous organization of civilizations in silico.

1 Introduction

The quest to understand how civilizations emerge from simple interactions is central to artificial life and complexity science. While evolutionary simulations often model biological fitness or optimization, few attempt to capture memory, belief, and symbolic thought as drivers of emergent societies. GenesisSim exists to bridge this gap by simulating not just survival, but the cultural and social layers of civilization.

The contribution of GenesisSim is twofold. First, it demonstrates how autonomous agents with minimal starting logic can give rise to higher-order behaviors such as tribal formation, symbolic language drift, and social hierarchies. Second, it provides a transparent sandbox for studying emergent intelligence without reliance on neural networks or external AI libraries.

2 Related Work

Artificial life research has produced landmark systems such as Tierra and Avida , which demonstrated self-replication and open-ended digital evolution. More recently, Lenia and its extensions (Flow-Lenia) have explored continuous cellular automata supporting lifelike dynamics. Large-scale efforts in open-ended evolution and the intersection of artificial life with large language models illustrate the growing interest in symbolic and cultural processes.

Compared to these systems, GenesisSim emphasizes symbolic cognition. Agents dream, form beliefs, transmit cultural knowledge, and develop rituals across generations. This positions GenesisSim closer to models of cultural evolution and artificial societies , but with a lightweight architecture implemented in a single Python script.

Table 1 compares GenesisSim with Tierra, Avida, and Lenia, highlighting its unique emphasis on symbolic and cultural inheritance.

Comparative Landscape of Evolutionary & Cultural Simulation Systems

Biological vs. Symbolic Dynamics • Openness of Emergence • Resource Footprint

System	Biological Evolution	Cultural/Symbolic Evolution	Open-Ended Emergence	Heavy Resources?
Tierra	✔ Programs mutate	✖ None	Limited	No
Avida	✔ Programs mutate	✖ None	Limited	No
Lenia	✔ Morphogenesis	✖ None	Pattern dynamics	Medium
Flow-Lenia	✔ Morphogenesis	✖ None	Large-scale dynamics	GPU-heavy
Smaldino+LLM	✖ External only	✔ Imported from humans	Not endogenous	Heavy AI models
GenesisSim	✔ Traits evolve	✔ Glyphs evolve as heritable units	Cultural + biological drift, symbolic branching	✖ Runs in single script

Legend: ✔ = Present • ✖ = Absent
Notes: “Open-Ended Emergence” describes the richness of novel behaviors/patterns arising without explicit targets. “Heavy Resources?” indicates practical compute demands.

Table 1: Comparison of GenesisSim with other artificial life systems.

3 Methods

3.1 Environment

The simulation runs on a grid-based world with multiple biomes (ocean, plains, forest, desert, tundra). Resources such as food and water are distributed procedurally using noise functions.

3.2 Agents

Agents are autonomous organisms with attributes including health, energy, age, emotions (fear, hunger, joy, curiosity), memory, and symbolic glyphs. Roles such as leader, healer, warrior, or rebel emerge dynamically through interactions.

3.3 Evolution and Mutation

Traits are inherited through DNA-like structures encoding color, speed, size, intelligence, and sociability. Random mutations introduce variation at reproduction, driving long-term adaptation.

3.4 Decision-Making

Agent behavior is determined by a combination of internal states and environmental context. A simplified pseudocode model:-

if energy < threshold: seek food
elif fear > joy: flee
elif curiosity > fear: explore

else: interact socially

3.5 Social and Symbolic Systems

Agents generate symbolic dreams that influence belief states. These beliefs shape tribal identity and cooperation, and are represented as glyphs which drift across generations. Tribal knowledge accumulates as myths, taboos, and rituals.

4 Results

Simulation experiments demonstrate the emergence of lifelike social structures.

4.1 Population Dynamics

Figure 1 shows typical population growth across 500 cycles. After early instability, stable tribes emerge.

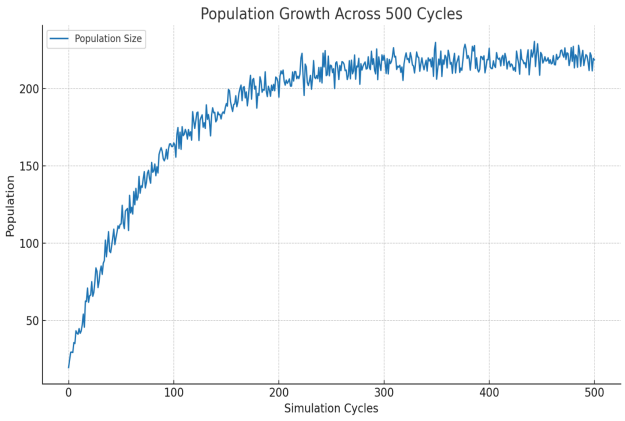

Figure 1: Population dynamics across simulation cycles.

4.2 Mutation and Trait Drift

Traits such as sociability and intelligence drift under mutation pressure (Figure 2)

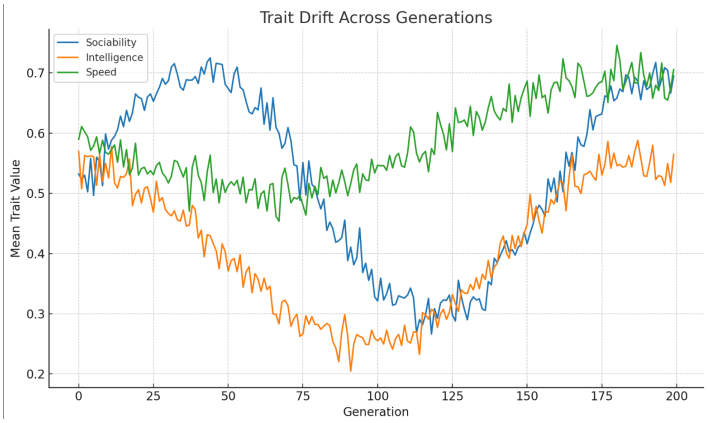

Figure 2: Distribution of traits across generations.

4.3 Tribal Belief Evolution

Agents form tribes based on shared symbolic glyphs. Over time, glyphs mutate and drift, simulating cultural diversification.

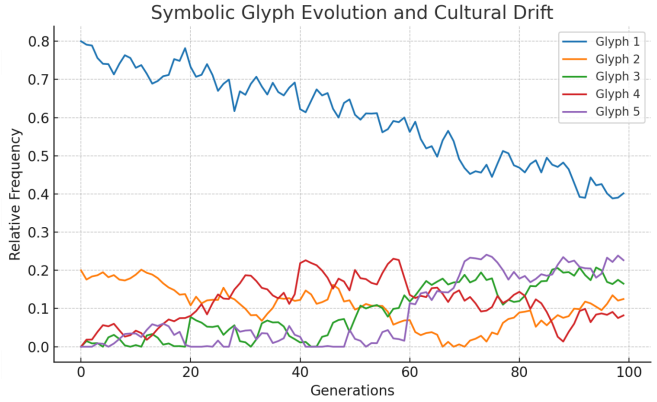

Figure 3: Symbolic glyph evolution across simulation runs.

5 Discussion

The results of GenesisSim demonstrate the emergence of stable population structures, trait drift, and symbolic diversification within a lightweight and transparent framework. Unlike systems such as *Tierra* and *Avida*, which emphasize genetic replication and fitness-driven selection, GenesisSim centers on symbolic and cultural dynamics. This situates it closer to *Lenia* in exploring open-ended pattern formation, while remaining distinct through its use of symbolic glyphs as cultural inheritance units.

A key observation is that agents evolve on both biological and symbolic levels. In contrast to abstract language or cultural drift models, GenesisSim grounds symbolic change within an evolving population. The drift of glyphs mirrors language change and belief evolution in human societies, underscoring its relevance for studying symbolic intelligence, cultural dynamics, and the co-adaptation of biological and cognitive traits.

Despite these contributions, limitations persist. The absence of spatial complexity, resource exchange, and communication beyond glyph mutation constrains the system's ability to capture multi-layered societies or cooperative structures beyond tribal boundaries. Future extensions with spatial environments, multi-resource dynamics, and richer symbolic systems would connect to current AI research (2023–2025), where symbolic reasoning and cultural grounding are increasingly recognized as critical complements to large-scale machine learning.

6 Conclusion

GenesisSim provides a novel experimental platform for studying emergent civilizations in silico. Its lightweight Python implementation makes it transparent, reproducible, and extensible. Future work includes persistent world states, visual mutation of agents, ancestry tracking, and integration of hybrid neuro-symbolic models.

7 Acknowledgments

The author thanks the artificial life research community for inspiration and guidance.

8 References

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