Persistence — the Fractal Persistence Law

Contents

How is this related?

The Thermodynamics of Existence: A Formal Proof of the Fractal Persistence Law

Authors: [Project: Fractal Graph Theory]
Field: Information Physics / Cybernetic Ontology
Keywords: Information Persisting Systems, Entropy, Free Energy Principle, Fractal Graphs, Landauer's Limit

Abstract

This paper provides a formal proof that the persistence of any discrete entity—from subatomic particles to social structures—is strictly governed by the **Fractal Persistence Equation (FPE)**. We demonstrate that persistence is not a static property but a non-equilibrium steady state (NESS) requiring a positive "informational profit margin." By synthesizing Landauer's Principle, the Second Law of Thermodynamics, and Friston's Free Energy Principle, we prove that any system for which the persistence ratio $\mathcal{R}$ falls below unity must undergo immediate and non-linear dissolution.

I. Introduction: The Universal Persistence Equation (UPE)

The fundamental question of ontology is why certain patterns in the universe persist over time while others dissolve into entropy. We define a **Node** at level L as a discrete informational pattern whose survival is governed by the equation:

$$\mathcal{R}^{(L)} = \Psi(\mathcal{R}^{(L+1)}) \cdot \left[\frac{P_{in}^{(L)} \cdot \eta(I)}{\omega^{(L)} \mathcal{E}_{\Sigma}^{(L)} \left(1 + \mathcal{D}_{KL}^{(L)} + \Gamma^{(L)}\right)} \right] \cdot \Phi(\mathcal{R}^{(L-1)})$$

Where: * $\mathcal{R}$: The Sustainability Ratio (Persistence requires $\mathcal{R} \geq 1$). * $P_{in} \cdot \eta$: Computational Power (Energy flow $\times$ algorithmic efficiency). * $\omega \cdot \mathcal{E}_{\Sigma}$: Entropic Tax (Structural complexity $\times$ fundamental noise floor). * $\mathcal{D}_{KL}$: Model Divergence (Information-theoretic delusion). * Γ: Structural Fatigue (Senescence/Wear). * Ψ, Φ: Contextual Shelter and Fractal Integrity.

II. Fundamental Axioms

To prove the necessity of this law, we establish three axioms derived from the Standard Model and Information Theory:

1. **Axiom of Universal Noise:** The fundamental noise floor $\mathcal{E}_{\Sigma}$ (comprising Strong, Weak, EM, and Gravitational fluctuations) is non-zero in all regions of spacetime.
2. **Axiom of Landauer Efficiency:** The erasure of any erroneous bit (correction of $\mathcal{D}_{KL}$) requires a minimum energetic dissipation of $k_B T \ln 2$.
3. **Axiom of Finite Information Density:** No node possesses infinite internal information (I) or infinite power (P_{in}).

III. The Proof of Necessary Convergence

Lemma 1: The Dissipation Constraint (The Numerator/Denominator Balance) A node is a configuration of matter/energy in a low-entropy state relative to its environment. According to the Second Law of Thermodynamics, this state is statistically unstable. * To maintain structure (ω), the system must perform work to counteract the noise floor $\mathcal{E}_\Sigma$. * If the energy harvested and processed ($P_{in} \cdot \eta$) is less than the energy required to maintain the structure ($\omega \cdot \mathcal{E}_\Sigma$), the system must compensate by consuming its own internal structural information. * **Conclusion:** Since internal structural information is finite, a system where the internal metabolic bracket < 1 will reach total entropy in finite time. Persistence is impossible.

Lemma 2: The Delusion Penalty (The $\mathcal{D}_{KL}$ Proof) The Free Energy Principle (FEP) states that any system that minimizes its variational free energy minimizes its surprise. * Surprise is mathematically equivalent to $\mathcal{D}_{KL}$ (the divergence between the system's model and reality). * As $\mathcal{D}_{KL}$ increases, the system performs actions based on erroneous predictions. These actions do not harvest P_{in} and instead increase Γ (Fatigue). * By Landauer's Principle, the cost of "correcting" these errors grows exponentially as the environment changes. * **Conclusion:** A system that fails to minimize $\mathcal{D}_{KL}$ will experience a "Denominator Explosion," driving $\mathcal{R}$ to zero.

Lemma 3: The Fractal Dependency (The Ψ and Φ Proof) A node at Level L is a graph of nodes at Level $L - 1$. * If the persistence of sub-nodes $\mathcal{R}^{(L-1)}$ falls below the lethal threshold, the aggregate integrity Φ collapses. The Level L node no longer has "hardware" to run its "software." * Conversely, if the Level $L + 1$ environment reaches total entropy ($\mathcal{R}^{(L+1)} \to 0$), the noise E_{noise} becomes infinite. * **Conclusion:** No node can be self-caused. Persistence is a property of the **Graph**, not the **Individual**.

IV. Proof by Reductio ad Absurdum

Assume a system exists that violates the Fractal Persistence Law (i.e., it persists indefinitely while $\mathcal{R} < 1$).

1. If $\mathcal{R} < 1$, the system produces more entropy than it exports.
2. If it produces more entropy than it exports, its internal temperature must rise or its structural bonds must break.
3. If its bonds break, its structural complexity ω dissolves.
4. If ω dissolves, the node loses its Markov Blanket (boundary).
5. A node without a boundary is, by definition, background noise, not a persisting system.
6. **Contradiction:** The system cannot persist if it has dissolved into background noise.

Therefore, $\mathcal{R} \geq 1$ is a mandatory condition for existence.

V. Empirical Verification

The proof is visible in the "Phases of Collapse" observed in all complex systems: 1. **Biological Death:** As Γ (age) and $\mathcal{E}_{\Sigma}$ (wear) increase, Φ (cellular health) eventually drops until $\mathcal{R} < 1$. 2. **Corporate Bankruptcy:** When $\mathcal{D}_{KL}$ (market delusion) and ω (bureaucracy) exceed $P \cdot \eta$ (revenue/innovation), the firm liquidates. 3. **Radioactive Decay:** In heavy isotopes, $\mathcal{E}_{Weak}$ (internal noise) exceeds the $\mathcal{E}_{Strong}$ (binding energy), leading to a persistence ratio $\mathcal{R}$ that is transiently < 1 until a stable configuration is reached.

VI. Conclusion

We have proven that persistence in the universe is a **rigorous accounting identity.** The universe is a fractal graph of nodes performing a continuous calculation. Those that generate an informational profit persist; those that generate an informational loss are deleted by the fundamental noise of the vacuum.

The Final Law: Existence is the state of a pattern whose predictive truth (η) is sufficient to overcome the fundamental chaos of its constituent forces ($\mathcal{E}_\Sigma$) and the errors of its own perspective ($\mathcal{D}_{KL}$).