Title of Invention:

Method for Maintaining Perpetual Non-Equilibrium Adaptive Capacity in Continuous Modern Hopfield Attractor Networks via Mandatory Metabolic Senescence Applied to Persistence-Weighted States

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Cross-Reference to Related Applications:

This application claims priority to and the benefit of U.S. Provisional Patent Applications:

- No. 63/928,043, filed December 1, 2025
- No. 63/928,044, filed December 1, 2025
- No. 63/928,045, filed December 1, 2025 and all previous provisional applications filed December 2025 by the same inventor (including anisotropic conductance provisional).

The entire contents of which are incorporated herein by reference.

Background:

Modern Hopfield networks and continuous attractor networks achieve exponential memory capacity and O(N) updates but, when trained to equilibrium on fixed datasets or operated at scale, eventually thermalize: all attractor basins fill uniformly, energy gradients vanish, and adaptive capacity collapses irreversibly. Real complex systems (biological neural networks, markets, ecosystems, distributed ledgers) maintain adaptive capacity indefinitely without external supervision.

Detailed Description:

The invention discloses a universal, mandatory metabolic senescence mechanism that strictly prevents thermalization and guarantees perpetual non-equilibrium dynamics in any persistence-stratified continuous modern Hopfield network operating on complex-valued Fractal Resonance Units

$$\Psi_i(t) = p_i(t) \cdot r_i(t) \cdot e^{(i\,\theta_i(t))} \cdot u_i(t)$$

or equivalent persistence-weighted states.

Core mechanism (Non-Equilibrium Theorem – rigorously proven in Universal Attractor Game disclosure):

$$w_{i,t+1} = w_{i,t} \cdot (1 - \lambda_{decay} \cdot (1 - p_i(t)))$$

$\lambda\_decay > 0$ obbligatorio, $\lambda\_decay \in [0.005, 0.02]$ (valore universale validato su HAN, FRUIT, MC, OG, UG, Fractal RAG, QFRUIT)

or in continuous form:

$d\Psi\_i/dt = -\Psi\_i + \Sigma R(\Psi\_j, \Psi\_i) \Psi\_j - \lambda\_decay (1 - p\_i) \Psi\_i$

The $\lambda\_decay (1 - p\_i)$ term applies selective decay exclusively to low-persistence states ($H < 0.7$), preventing uniform basin filling and maintaining energy gradients indefinitely.

Falsifiable predictions (Theorem 3, Universal Attractor Game):

1. Systems with $\lambda\_decay = 0$ exhibit catastrophic brittleness and inability to unlearn (thermalization within $\leq 10^6$ iterations)
2. Maximal adaptive capacity (response entropy + perturbation resistance) achieved exclusively at $H \approx 0.65 \pm 0.05$
3. Long-term stable patterns concentrate only in the invariant regime ($H \to 1$)

This mechanism is distinct and not covered by the limited use of senescence in trading position sizing (previous provisional), here it is general, mandatory, and applied directly to network states for any application of modern Hopfield / continuous attractor networks.

Claims:

1. A method for preventing thermalization in continuous modern Hopfield or attractor networks wherein mandatory metabolic decay $\lambda\_decay > 0$ is applied selectively to persistence-weighted states according to $\lambda\_decay (1 - p\_i)$, $p\_i = \sigma(\gamma (H\_i - 0.5))$.
2. The method of claim 1 wherein $\lambda\_decay \in [0.005, 0.02]$ is strictly enforced as a universal hyperparameter.
3. The method of claim 1 or 2 achieving perpetual non-equilibrium dynamics and sustained adaptive capacity without external supervision or curriculum learning.
4. The method of any preceding claim wherein absence of mandatory senescence ($\lambda\_decay = 0$) results in catastrophic brittleness and inability to unlearn, as proven by Non-Equilibrium Theorem.
5. The method of any preceding claim wherein maximal adaptive capacity is achieved exclusively at $H \approx 0.65 \pm 0.05$ (Criticality Theorem).
6. The method of any preceding claim applied to associative memories, large language models, quantitative trading systems, blockchain consensus, quantum substrates, or any persistence-stratified continuous Hopfield architecture.
7. The method of any preceding claim constituting a required component for sustained complexity in the Universal Attractor Game framework.

8–20. Systems, computer-readable media, apparatus, and neural network training methods implementing the mandatory senescence of claims 1–7.

Abstract:

A universal method for preventing irreversible thermalization in any continuous modern Hopfield or attractor network by mandatory application of metabolic senescence $\lambda\_decay \in [0.005, 0.02]$ selectively to low-persistence states $(1 - p_i)$, guaranteeing perpetual non-equilibrium adaptive capacity, maximal evolvability at $H \approx 0.65 \pm 0.05$, and catastrophic failure when $\lambda\_decay = 0$ — constituting the minimal and necessary condition for sustained complexity across all persistence-stratified architectures.