Image Dynamics Theory v4: Mathematical Formulation with Structured Display Equations

Abstract

Image Dynamics Theory (IDT) formalizes cognition and consciousness as the evolution of a high-dimensional representational image governed by energy minimization. This document presents a fully mathematical formulation of IDT with all core equations separated as structured display mathematics for clarity and rigor.

1. Representational Image

The internal mental state is represented as a structured high-dimensional image. Each component corresponds to a distinct functional role in cognition.

$$Z \in \blacksquare\blacksquare$$

$$Z = \{ p, s, r, a, c\blacksquare, c\blacksquare, \phi \}$$

2. Slices and Projections

Cognitive slices correspond to low-dimensional projections of the full representational image. These projections define momentary cognitive orientation and intensity.

$$\Pi(Z) = [s , r , a]$$

$$\text{orientation} = \Pi(Z) / ||\Pi(Z)||\blacksquare$$

$$\text{radius} = ||\Pi(Z)||\blacksquare$$

3. Energy Functional

Cognitive dynamics are governed by an energy functional that penalizes incoherence between perception, prediction, intention, and internal structure.

$$E(Z) = w\blacksquare\blacksquare p - x\blacksquare\blacksquare^2$$

$$+ w\blacksquare\blacksquare s - x\blacksquare\blacksquare\blacksquare\blacksquare^2$$

$$+ w\blacksquare\blacksquare a - y\blacksquare^2$$

```
+ w_sf■c■ − c■■²
+ w■■r − W■ s■²
+ w_ϕ■ϕ − mean(ϕ)■²
+ w_reg■Z■²
```

4. Microslice Dynamics

State evolution occurs through discrete relaxation steps called microslices. Each microslice corresponds to a gradient descent step on the energy landscape.

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Z■■■ = Z■ − η ∇■ E(Z■)
```

5. Liminality

Liminality is a control parameter that modulates the system’s flexibility, noise, and reconfiguration potential.

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η ← λ η
ε ~ ■(0, λ² I)
```

6. World Prediction

The system learns a predictive world model that enforces consistency between internal dynamics and observed outcomes.

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■■■■ = f_θ(Z■, y■)
L_world = ■■■■■ − s■■■■²
```

7. Goal Revision

Goals are treated as embedded vectors that can be revised based on experienced outcomes.

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y′ = y + g_ψ([s, c■])
L_goal = ■y′ − y_ref■²
```

8. Reflection Generation

Reflection is modeled as a conditional language generation process grounded in latent state and episodic context.

$$r■ = h_{\phi}(s, e)$$

$$L_{dec} = -\sum \log P(w■ \mid s, e)$$

9. Training Objective

All learning objectives are combined into a single weighted loss function optimized in multiple phases.

$$L = L_{world} + \alpha L_{dec} + \beta L_{goal}$$

Conclusion

This formulation presents Image Dynamics Theory as a cleanly structured mathematical system. Separating prose from equations clarifies the relationship between conceptual constructs and their operational realization in an energy-based geometric mind.