Observational Influence Fields and Semantic Energy Geometry

Paolo Pignatelli (with ChatGPT)

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Abstract

This module develops a continuous and discrete mathematical framework for modeling semantic influence as a physical field. Beginning from a first-order formulation of observations as localized state changes in space and time, we derive the dynamics of influence fields, define perturbability metrics, and introduce observational distance, action, and energy conservation. A complementary discrete implementation via semantic cellular automata formalizes emergence and stability of knowledge structures. The module culminates in a field-theoretic implementation of the Florence Conjecture.

1 Foundational Definitions

Definition 1.1 (Observation). An observation O is defined as a quintuple:

$$O = (s_{\text{before}}, e_{\text{interaction}}, s_{\text{after}}, t, x)$$

where $s_{\text{before}}, s_{\text{after}} \in \mathcal{S}$ (state space), $e_{\text{interaction}} \in \mathcal{E}$ (interaction event), $t \in \mathbb{R}^+$ (timestamp), $x \in \mathbb{R}^n$ (spatial location).

Definition 1.2 (Influence Function). For observation O_i at (x_i, t_i):

$$I_i(x,t) : \mathbb{R}^n \times \mathbb{R}^+ \to \mathbb{R}^+$$

subject to:

- Locality: $I_i(x,t) \to 0$ as $|x - x_i| \to \infty$
- Causality: $I_i(x,t) = 0$ for $t < t_i$
- Finite Energy: $\iint I_i(x,t)\, dx\, dt = E_i < \infty$

Definition 1.3 (Total Influence Field).

$$\Phi(x,t) = \sum_{i:t_i \le t} I_i(x,t)$$

2 Influence Field Dynamics and Green's Kernel

Theorem 2.1 (Diffusion with Sources and Decay).

$$\partial_t \Phi = D\nabla^2\Phi - \lambda\Phi + \sum_i \delta(x - x_i)\delta(t - t_i)E_i$$

Theorem 2.2 (Green's Function Solution).

$$\Phi(x,t) = \sum_i E_i G(x - x_i, t - t_i)$$

$$G(x,\tau) = (4\pi D\tau)^{-n/2} e^{-\frac{|x|^2}{4D\tau} - \lambda\tau} H(\tau)$$

where $H(\tau)$ is the Heaviside step function.

3 Perturbability and Observational Geometry

Definition 3.1 (Perturbability Field).

$$\Pi(x,t) = |\nabla\Phi(x,t)| + \alpha\partial_t\Phi(x,t)$$

Definition 3.2 (Distance).

$$d_{\text{obs}}(O_i, O_j) = \int_{\gamma_{ij}} \frac{1}{\Pi(x,t)} ds$$

Definition 3.3 (Observational Metric Tensor).

$$g_{\mu\nu}(x,t) = \Pi^{-1}(x,t)\delta_{\mu\nu} + \alpha\partial_\mu\partial_\nu \log \Pi(x,t)$$

4 Energy, Conservation, and Field Equations

Theorem 4.1 (Energy Conservation).

$$\frac{d}{dt}\int \left[\frac{1}{2}\Pi|\nabla\Phi|^2 + \frac{1}{2}\lambda\Phi^2\right] dx = 0$$

Definition 4.2 (Stress-Energy Tensor).

$$T_{\mu\nu} = \Pi\partial_\mu\Phi\partial_\nu\Phi - \frac{1}{2}g_{\mu\nu}\left(\Pi|\nabla\Phi|^2 + \lambda\Phi^2\right)$$

Theorem 4.3 (Observational Einstein Equation).

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \kappa T_{\mu\nu}$$

5 Discrete Cellular Automata Implementation

We discretize space-time into cells $C_{i,j,k,t}$ with the following update rules:

- Influence propagation:

$$\Phi_i(t+1) = (1 - \lambda\Delta t)\Phi_i(t) + D\Delta t \sum_{j \in \text{nb}(i)} \frac{\Phi_j(t) - \Phi_i(t)}{|j - i|^2} + \text{source}_i(t)$$

- Perturbability:

$$\Pi_i(t+1) = |\nabla\Phi_i(t)| + \alpha\frac{\Phi_i(t) - \Phi_i(t-1)}{\Delta t} + \beta|\nabla\Phi_i(t)|^2$$

- Observation triggering:

$$P_{\text{trigger}} = \Pi_i(t) \cdot g(\text{local config}) > \theta_i$$

6 Semantic Threads and Florence Conjecture

Definition 6.1 (Semantic Thread Influence).

$$\text{ThreadInfluence}_i = \sum_{O_k \in \gamma} K(O_k, x_i) \cdot \text{strength}(\gamma)$$

Preconvergence Score (Florence Conjecture).

$$\text{Preconv}(\gamma_A, \gamma_B) \propto \int_{C_i \in \Gamma_A \cap \Gamma_B} (\delta F_A \cdot \delta F_B) e^{-\|\nabla d_A - \nabla d_B\|}$$

7 Conclusion

This module defines a complete geometric and computational model for the propagation of observational influence. It lays the theoretical foundation for path-integral reasoning, gradient-based semantic distance, and cellular automaton implementations of semantic cognition.