1 TARTAN: Trajectory-Aware Recursive Tiling with Annotated Noise

1.1 Introduction

The Trajectory-Aware Recursive Tiling with Annotated Noise (TARTAN) framework is a multi-scale simulation and encoding paradigm designed to model the evolution of complex field systems within the Relativistic Scalar Vector Plenum (RSVP) theory. TARTAN integrates scalar (Φ), vector ($\vec{\sqsubseteq}$), and entropy ($\mathcal{S}$) fields to simulate recursive, memoryful dynamics across physical, cognitive, and cosmological domains. By leveraging recursive tiling, trajectory awareness, and annotated noise, TARTAN encodes spatiotemporal memory and semantic coherence, enabling the study of emergent structures and adaptive behaviors. This essay outlines TARTAN's general principles and mathematical framework, emphasizing its role as a computational substrate for RSVP.

1.2 General Principles

TARTAN is built on five core components that facilitate the simulation of complex, adaptive systems:

- **Recursive Tiling**: The simulation space is partitioned into a hierarchical grid of tiles (2D or 3D), with each tile containing sub-tiles. Higher-level tiles aggregate the dynamics of their children, enabling multiscale resolution and coarse-grained emergent behavior.
- **Trajectory Awareness**: Field dynamics depend not only on current states but also on historical configurations, including temporal derivatives, curvature, torsion, and entropic flux. This ensures memoryful evolution and coherent flow structures.
- **Annotated Noise**: Perturbations are introduced as semantically tagged noise, carrying vector alignments or symbolic metadata. This enables meaningful disruptions (e.g., cognitive intentions or physical stresses) that preserve system structure.
- **Field Coupling and Cross-Tile Communication**: Tiles interact via vector field coupling, torsional fluxes, and entropy gradients, promoting coherent propagation of causal chains across scales.
- **Memory Encoding**: Persistent vector alignments, entropy gradient trails, and topology-preserving recursions enable long-term memory without external storage, supporting learning and adaptation.

TARTAN's design draws inspiration from multi-resolution analysis, perceptual control theory, cellular automata, recursive semantic networks, and topological field theory. It serves as a computational framework for RSVP, modeling phenomena such as cognitive semantic drift, thermodynamic relaxation, or cosmological structure formation.

1.3 Mathematical Framework

TARTAN models a system as a hierarchical graph $\mathcal{G} = (V, E)$, where vertices V represent tiles (field configurations) and edges E encode interactions. Each tile at level k is defined by a state vector $\mathbf{s}_k(t) = [\Phi_k, \vec{\sqsubseteq}_k, \mathcal{S}_k]$, capturing local RSVP fields. The system evolves via a recursive update rule:

$$\mathbf{s}_k(t+1) = \mathcal{T}_k\left(\mathbf{s}_k(t), \mathbf{s}_{k-1}(t), \mathbf{u}_k(t), \mathbf{n}_k(t)\right), \tag{1}$$

where $\mathcal{T}_k$ is the transformation operator for level k, $\mathbf{s}_{k-1}(t)$ is the state of child tiles, $\mathbf{u}_k(t)$ is an external input, and $\mathbf{n}_k(t)$ is annotated noise with semantic tags.

The transformation $\mathcal{T}_k$ is governed by a topological action:

$$S_{\text{TARTAN}} = \sum_k \int_{\mathcal{M}_k} \omega_k(\mathbf{s}_k, \nabla \mathbf{s}_k, \mathbf{n}_k)\, d\mu_k, \tag{2}$$

where $\mathcal{M}_k$ is the manifold of tile k, ω_k is a differential form encoding field interactions, and $d\mu_k$ is the measure. The action is minimized subject to:

$$\delta S_{\text{TARTAN}} = 0, \tag{3}$$

yielding equations of motion for tile states. Cross-tile communication is modeled via:

$$\nabla \cdot (\mathcal{S}_k \vec{\sqsubseteq}_k) = \sum_{j \in \text{neighbors}} \alpha_{kj}(\Phi_k - \Phi_j) + \beta \mathbf{n}_k, \tag{4}$$

where α_{kj} governs field coupling, and β weights annotated noise. Memory is encoded through persistent terms:

$$\mathbf{m}_k(t) = \gamma \int_0^t \vec{\sqsubseteq}_k(\tau) \cdot \nabla \mathcal{S}_k(\tau)\, d\tau, \tag{5}$$

where $\mathbf{m}_k(t)$ is the memory vector, and γ is a persistence factor.

1.4 Implications and Applications

TARTAN's recursive, trajectory-aware structure makes it a versatile tool for modeling complex systems. In cognitive modeling, it simulates recursive thought and semantic drift, with annotated noise representing intentions or surprises. In RSVP cosmology, TARTAN models entropic relaxation and spacetime emergence, with tiles representing coarse-grained field configurations. In AI, it enables field-like reasoning systems with symbolic perturbations. In materials science, TARTAN can simulate adaptive systems, where recursive tiling mirrors lattice dynamics, and annotated noise models external stresses. Visual simulations benefit from TARTAN's ability to drive self-organizing field dynamics with meaningful perturbations.

The framework's emphasis on memory and coherence supports applications in consciousness modeling, where persistent field invariants may encode qualia. Future work may involve numerical implementations of TARTAN to simulate specific systems, such as cosmological structure formation or neural learning, leveraging its multiscale and recursive nature.

1.5 Conclusion

TARTAN provides a powerful computational substrate for RSVP theory, enabling the simulation of recursive, memoryful, and semantically coherent dynamics. Its mathematical framework, rooted in hierarchical tiling, trajectory awareness, and annotated noise, captures the interplay of RSVP fields across scales. By modeling adaptive systems as interwoven field trajectories, TARTAN offers a path toward unifying physical, cognitive, and cosmological phenomena under a single computational paradigm.