PROJECT 1: Symbolic-Topological Framework for Physical Systems

Title:

A Unified Symbolic-Topological Framework for Modeling, Predicting, and Controlling Physical Systems

Abstract:

Physical systems—across classical, quantum, thermodynamic, and multi-agent domains—exhibit dynamics that are often nonlinear, heterogeneous, and span symbolic, continuous, and discrete representations. Existing modeling paradigms either lack generality, are black-box and unprovable, or fail to scale across physical regimes. This project proposes the development of a unified symbolic-topological framework that integrates advanced mathematics and modern AI to model and control general physical systems in a way that is interpretable, verifiable, and composable.

The core framework uses tools from sheaf theory, noncommutative geometry, and topos logic to encode local and global system laws, while symbolic PDE solvers, dynamic graph theory, and meta-learned control policies enable adaptive simulation and policy learning. A custom domain-specific language (DSL) forms the foundation for expressing physical systems across domains, with built-in support for symbolic reasoning, thermodynamic constraints, hybrid quantum-classical systems, and game-theoretic multi-agent environments.

Key deliverables include:

* A formal DSL and type system for physical systems;
* A symbolic-numeric solver stack for PDEs and invariants;
* A meta-learning pipeline for provable and efficient control;
* A web-based interactive simulation engine for open access.

This project aims to build a bridge between rigorous symbolic logic and scalable computational models—offering a new way for how we understand, simulate, and control the physical world.