Modular Design Patterns for Hybrid Learning and Reasoning Systems

a taxonomy, patterns and use cases

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The **unification of statistical (data-driven) and symbolic (knowledge-driven) methods** is widely recognized as one of the key challenges of modern AI.

We analyze a large body of recent literature and we propose a **set of modular design patterns for such hybrid, neuro-symbolic systems**. We are able to describe the architecture of a very large number of hybrid systems by composing only a small set of elementary patterns as building blocks.

The main contributions of this paper are:
1) a **taxonomically organised vocabulary** to describe both processes and data structures used in hybrid systems;
2) a **set of 15+ design patterns for hybrid AI systems** organized in a set of elementary patterns and a set of compositional patterns;
3) an application of these design patterns in two **realistic use-cases** for hybrid AI systems.

Our patterns reveal similarities between systems that were not recognized until now. Finally, our design patterns extend and refine Kautz's earlier attempt at categorizing neuro-symbolic architectures.
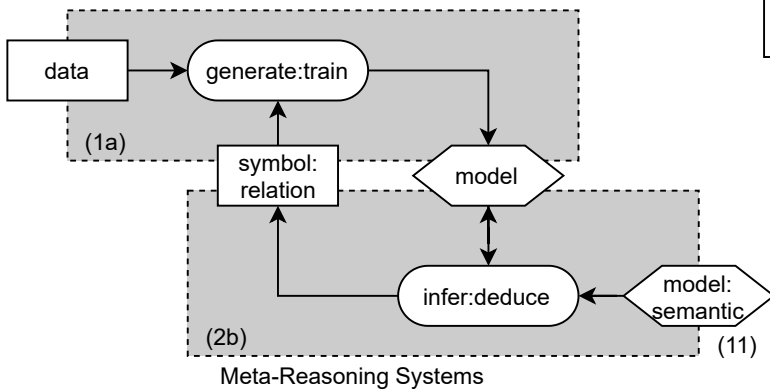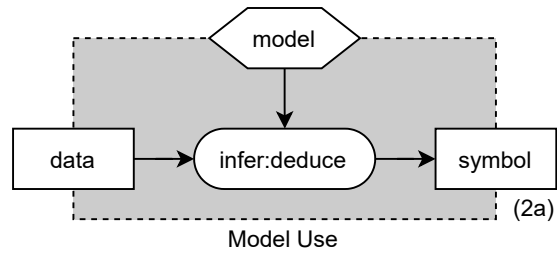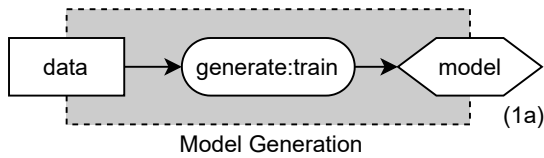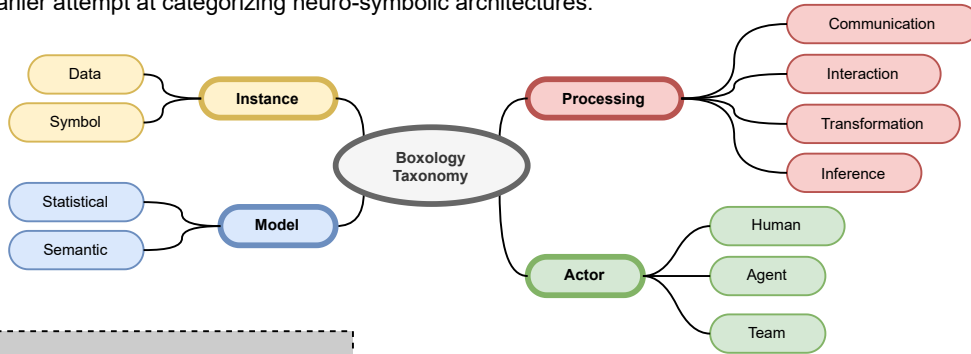
Future

- Actors and Interactions
- Dependencies: Types, Pre-/Postconditions
- Design Tool, Code Generation
- Epistemic Orchestration:
  Logics for Analysis and Verification
- Auditing Framework
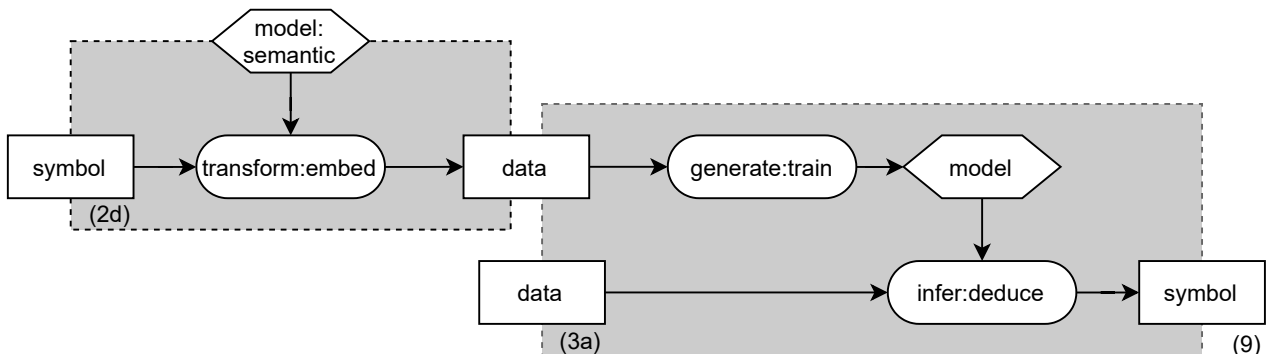
Integrating knowledge representations into a machine learning system, e.g., GNN