Integrating Semantics with Symbolic AI: The Path to Interpretable Hybrid AI Systems

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Abstract

The increasing complexity of AI-driven decision-making necessitates more interpretable and explainable models, particularly in critical domains like medicine. This talk explores the integration of semantics with symbolic AI to develop hybrid AI systems that combine the strengths of machine learning and formal reasoning. By leveraging knowledge graphs (KGs), ontologies, and logical constraints, these systems enable effective knowledge representation, improve transparency, and support reasoning over heterogeneous data.

This talk discusses the evolution of symbolic AI from early rule-based systems to modern neuro-symbolic approaches and analyzes emerging research trends in semantic data management, knowledge augmentation, and hybrid AI architectures. A key focus is the application of hybrid AI in oncology, demonstrating how integrating symbolic reasoning with machine learning enhances diagnostic accuracy, supports counterfactual reasoning, and aids in treatment decision-making.

Using structured frameworks like a boxology of design patterns[1] and hybrid AI frameworks such as Semantic Web Machine Learning (SWeML)[2], we outline patterns for model generation, inference, and validation, showcasing their effectiveness in optimizing predictive performance and ensuring compliance with medical protocols. Experimental results from real-world medical datasets highlight improvements in link prediction[3], causal graph discovery[4], and counterfactual reasoning[5].

This presentation underscores the necessity of fusing semantics with AI to enhance interpretability, usability, and trustworthiness. By bridging the gap between data-driven learning and symbolic reasoning, hybrid AI systems provide a powerful framework for advancing AI-driven decision support across multiple domains. Future directions include optimizing computational efficiency, improving usability, and developing scalable, user-centric hybrid AI solutions.

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