SOUTENANCE DE THÈSE DE M. BIKRAM PRATIM BHUYAN

M. Bikram Pratim BHUYAN soutiendra sa thèse intitulée "Hypergraphes de connaissances neuro-symboliques : représentation des connaissances et apprentissage en intelligence artificielle neuro-symbolique", réalisée sous la direction du Pr. Amar RAMDANE-CHERIF , le lundi 7 avril 2025 à la salle CASIMIR au 1er Etage du Bâtiment Boucher Pôle scientifique et technologique de Vélizy 10-12 avenue de l'Europe 78140 Vélizy.

Titre : Hypergraphes de connaissances neuro-symboliques : représentation des connaissances et apprentissage en intelligence artificielle neuro-symbolique

Résumé :

The integration of symbolic reaso-ning and neural learning in Artificial Intelligence (AI)

has become increasingly important as thedemand for models capable of handling complex, dynamic, and interconnected data grows. While traditional approaches have made progress in these domains separately, a unified framework that combines these paradigms is crucial for advancing AI's ability to interpret, learn,and predict in real-world environments. Despite the advancements in symbolic and neural models, existing literature reveals a gap in frameworks that effectively merge the two, particularly in the context of spatio-temporal knowledge representation and learning. Traditional knowledge graphs (KGs), though useful, struggle with capturing high-order relation-ships and dynamic, temporal changes. This limitation necessitates a novel approach that can incorporate higher-order logic and flexible structure to model real-world complexities.
The objective of this study is to developand validate a Neuro-Symbolic Knowledge Hypergraph framework that extends traditional knowledge graphs into Higher-Ordered Knowledge Graphs (HOKGs) capable of representingn-ary and temporal relationships. The frame-work integrates Monadic Second-Order Temporal Logic (MSOTL) for temporal reasoning and Hypergraph Neural Networks (HGNNs) for learning and predictive modeling, bridging the symbolic and neural paradigms.
The methodology involves formulating a robust hypergraph structure that encodes spatio-temporal and semantic relationships using MSOTL. It is then coupled with hypergraph neural networks, incorporating convolution and attention mechanisms for effective learning and inference. The framework is tested on real-world scenarios, specifically in urban agriculture, to demonstrate its predictive capabilities and robustness.
Key findings show that the proposed framework significantly enhances the expressiveness and inference capacity compared to traditional KGs. The MSOTL component ensures precise modeling of temporal and spatial relationships, while HGNNs validate predictive accuracy. The case study on urban agriculture high-lights the framework's utility, showcasing how it can provide meaningful insights and precise predictions on dynamic agricultural practices.This research has broad implications for AI applications requiring complex, dynamic knowledge representation, such as smart cities, environmental monitoring, and beyond.
The proposed hypergraph-based approach opens pathways for integrating higher-order logic, ontology-based knowledge, and deep learning, offering a comprehensive solution to the limitations observed in current knowledge graphs and AI models.