Foundations of Knowledge Graphs

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1 Introduction

Since the beginning of the 2000s, Knowledge Graphs have been widely used for modeling various domains ranging from linguistics [1] to biomedicine [5]. Recently, Knowledge Graphs have become even more crucial for improving diverse real-world applications at the intersection of Natural Language Processing (NLP) and Knowledge Management, such as question answering, named entity disambiguation, information extraction, etc. [6]. Raising awareness about Knowledge Graphs in other research communities will allow them to benefit from the versatile Knowledge Graph formalisms, methods, and tools. To this end, this tutorial focuses on the foundations of Knowledge Graphs [4]. Starting from basic notions and techniques of Knowledge Graphs, the tutorial will then move on to more advanced topics such as how logical reasoning over these Knowledge Graphs [3], where formally specified background knowledge is taken into account to enrich the explicitly stated information by facts that can be logically inferred. Furthermore, we will discuss how to express real-world aspects such as context, time, and uncertainty in the Knowledge Graph framework. As they are typically used in an open-world setting, Knowledge Graphs can almost never be assumed to be complete, i.e., some information will typically be missing. In order to address this problem, different Knowledge Graph embedding models have been proposed for automated Knowledge Graph completion. These models are mostly based on the tasks such as link prediction, triple classification, and entity classification/typing. This tutorial will also target the topic of Knowledge Graph embedding techniques. Finally, various applications of Knowledge Graphs and Knowledge Graph embeddings will be discussed.

2 Program of the Tutorial

The program of this tutorial will be in three parts, (i) basics of Knowledge Graphs, (ii) logical reasoning over Knowledge Graphs, and (iii) various Knowledge Graph embedding Techniques for Knowledge Graph Completion.

– Knowledge Graph formalisms (RDF, RDFS, OWL)

– Different ways to encode, store, and access Knowledge Graphs (graph DBs, triple stores, SPARQL)
– Logical reasoning over Knowledge Graphs (ontology-based data access...)
– Different types of Knowledge Graphs, such as multi-modal, temporal, or uncertain Knowledge Graphs
– Algorithms for generating distributed representation over Knowledge Graphs, TransE, TranH, etc. [7]
– Algorithms for generating distributed representations over multi-modal Knowledge Graphs
– Applications: Knowledge Aware Recommender Systems, Question Answering Systems, etc.

3 Conclusion

Lately, there have been very fast advancements in the field of Knowledge Graphs not only in academia but also in industry. Various domains are modeling domain ontologies as well as the experimental data such as in the field of Materials Science. Logical reasoning continues to be an important technology of Knowledge Graphs and comes particularly handy in settings where little data is available, where the underlying domain knowledge is complex, and where accuracy is essential. On the other hand, the distributed representations generated using subsymbolic methods, i.e., Knowledge Graph embedding techniques have also been widely developed and being used in many applications. Currently, many studies are being conducted in the area of Neurosymbolic Reasoning [2] which integrates knowledge representation and reasoning with deep learning techniques.

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