CylE: Cylinder Embeddings for Multi-hop Reasoning over Knowledge Graphs

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Recent geometric-based approaches have been shown to efficiently model complex logical queries (including the intersection operation) over Knowledge Graphs based on the natural representation of Venn diagram. Existing geometric-based models (using points, boxes embeddings), however, cannot handle the logical negation operation. Further, those using cones embeddings are limited to representing queries by two-dimensional shapes, which reduced their effectiveness in capturing entities query relations for correct answers. To overcome this challenge, we propose unbounded cylinder embeddings (namely CylE), which is a novel geometric-based model based on three-dimensional shapes. Our approach can handle a complete set of basic first-order logic operations (conjunctions, disjunctions and negations). CylE considers queries as Cartesian products of unbounded sector-cylinders and consider a set of nearest boxes corresponds to the set of answer entities. Precisely, the conjunctions can be represented via the intersections of unbounded sector-cylinders. Transforming queries to Disjunctive Normal Form can handle queries with disjunctions. The negations can be represented by considering the closure of complement for an arbitrary unbounded sector-cylinder. Empirical results show that the performance of multi-hop reasoning task using CylE significantly increases over state-of-the-art geometric-based query embedding models for queries without negation. For queries with negation operations, though the performance is on a par with the best performing geometric-based model, CylE significantly outperforms a recent distribution-based model.

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