Type-aware Embeddings for Multi-Hop Reasoning over Knowledge Graphs

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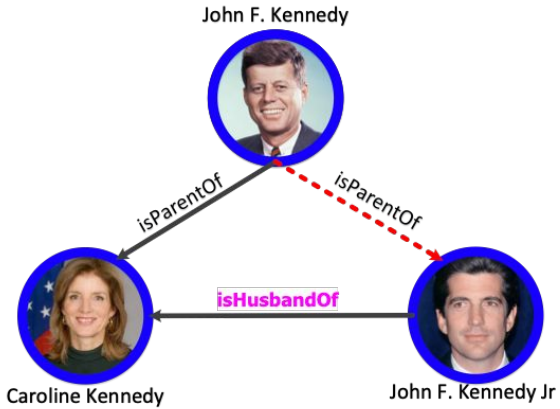
Knowledge Graphs

- **Knowledge Graph(KG)**
  - graph-structured Knowledge Base
  - knowledge is organized as an **inter-linked multi-relational** network between entities.
  - KGs are inherently **incomplete** and **inevitably noisy**.



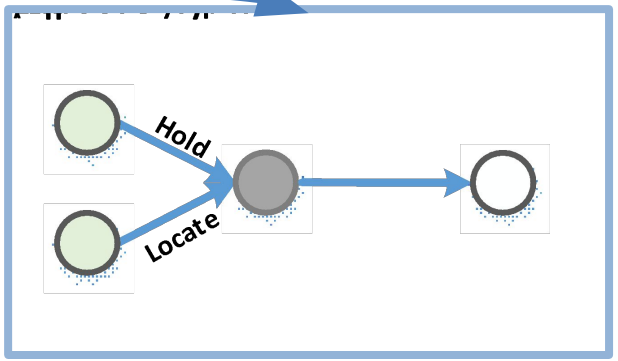
Multi-hop Reasoning over KGs

- **i.e. answering logical queries, is challenging:**
  - **Missing information** and **noise** lead to **empty** or **incorrect** answers
  - **Interlinked** nature implies **high computational complexity,** traversing reasoning paths could lead to an **exponential blow-up**

List the presidents of Asian countries that have held the Summer Olympics?

?P. ∃C. Locate(A, C) ∧ Hold(O, C) ∧ Lead(?P, C)

Logical Form



Multi-hop Reasoning over KGs

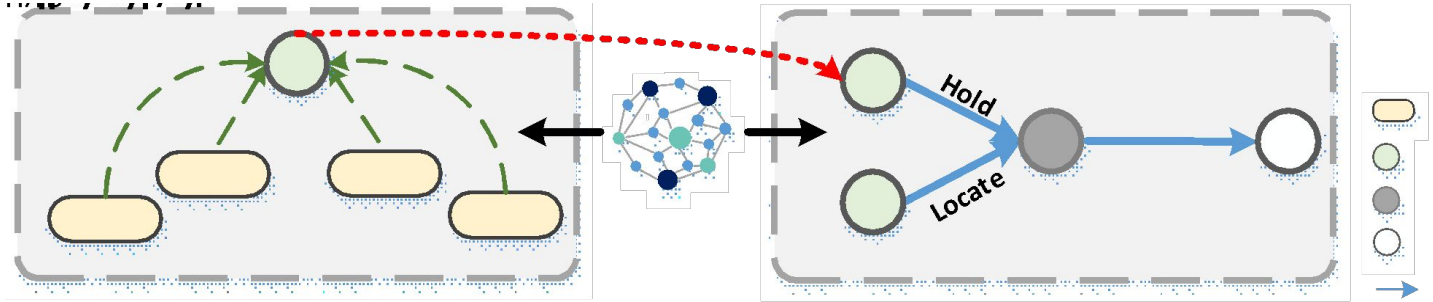
- **Query Embedding (QE) models**
  - Alternative to traditional approach
  - Embed entities and queries into a joint **low-dimensional vector space**
  - Entities that answer the query are **close to the embedding of the query**

- **Inherently available semantic knowledge -- type information, in KGs are ignored!**

Type Information in KGs

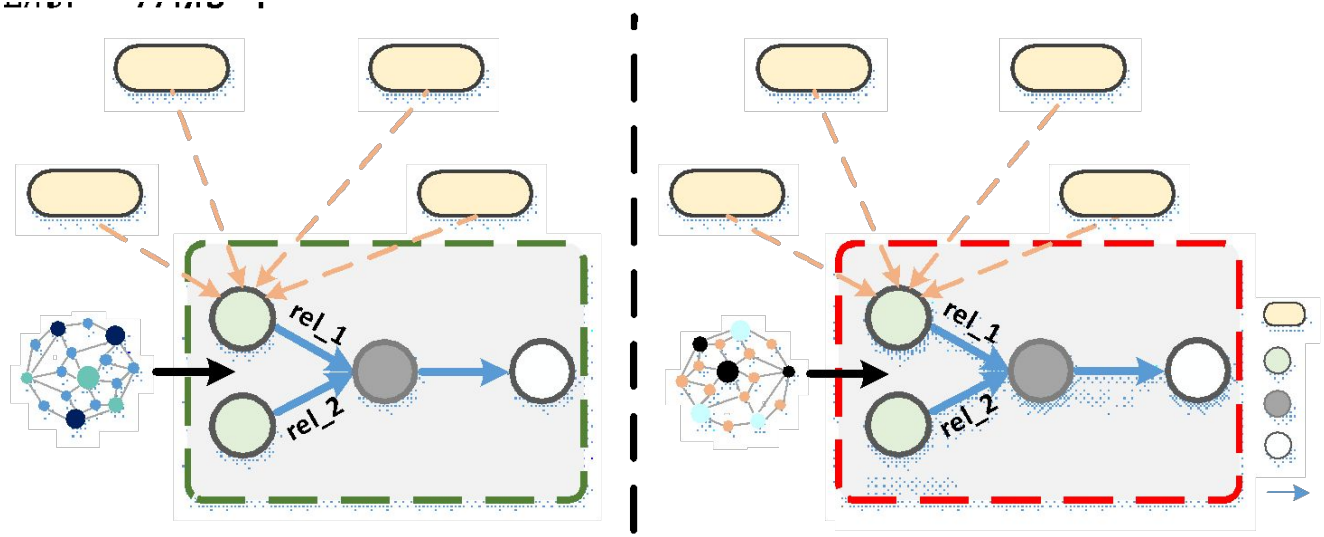
Type information

- **semantically enriching** the representations of entities or relations;
- helping tackling the **inductive query answering** problem, **entities used in test queries cannot be observed at training time.**



Inductive Reasoning

- **Inductive** — entities used in test queries cannot be observed at training time.

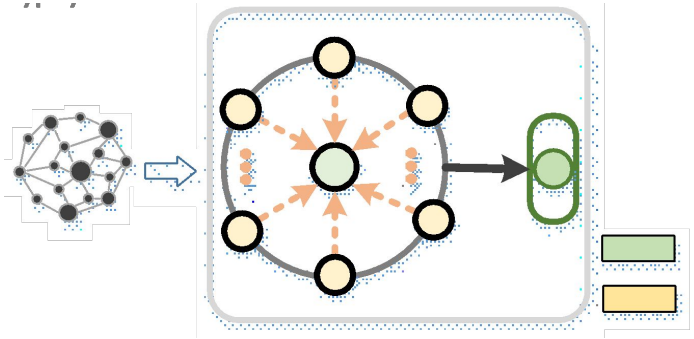


List the presidents of Asian countries that have held the Summer Olympics?

List the presidents of European countries that have held the Winter Olympics?

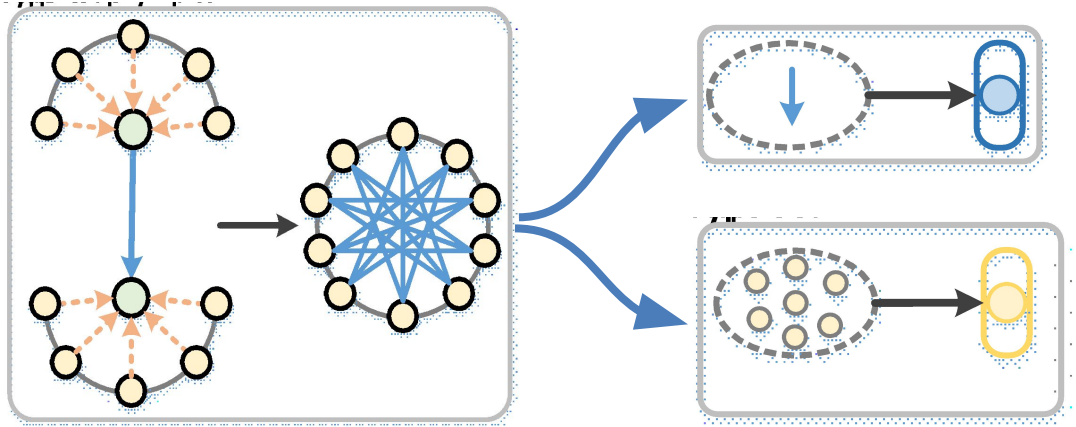
Type-aware Message Passing

- **TER: Type-aware Entity Representations**
  - iteratively aggregate the type information
  - highway-based mechanism to fuse the initial entity and its type aggregation representation



Type-aware Message Passing

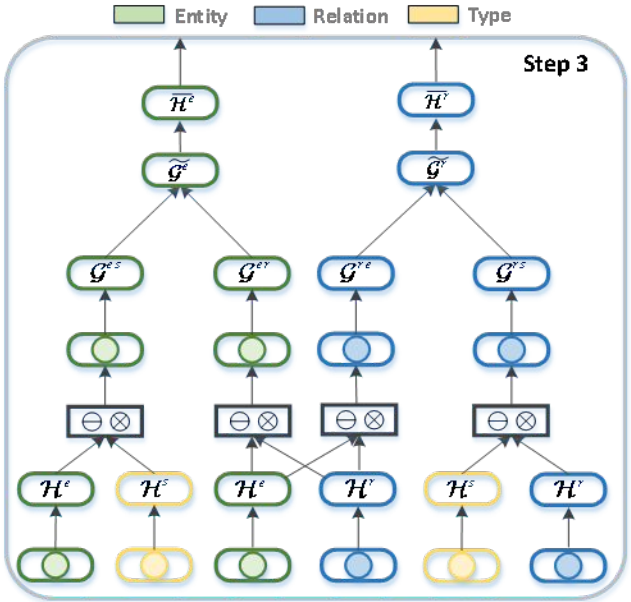
- **TRR: Type-aware Relation Representations**



- Step 1: Type Graph Construction
- Step 2: Relation Type Aggregation

Type-aware Message Passing

- **TRR: Type-aware Relation Representations**
  - Step 3: Pairwise Representation Integration



Summary

Contributions

- propose a novel type-aware **plug-and-play** model to answer complex logical queries over KGs
- improve the **generalization**, **deductive** and **inductive reasoning** abilities on 4 existing SOTAs on 3 benchmarks
- Paper and source code: