Link Prediction in Knowledge Graphs Using Graph Embedding

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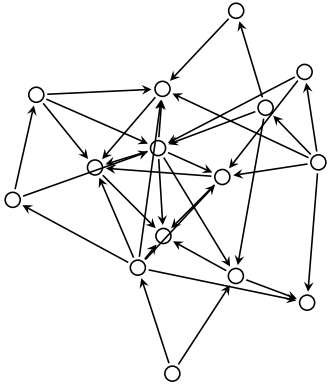
Quick Note

Agenda

Link Prediction
The Problem Setting

- True knowledge

$$\mathcal{G} = (V, E).$$



Link Prediction
The Problem Setting

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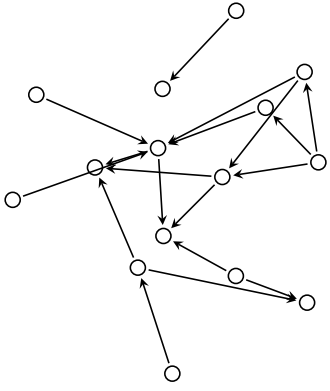
- Observed knowledge

$$\mathcal{G}' = (V, E') \text{ where } E' \subset E.$$



Link Prediction
The Problem Setting

- True knowledge

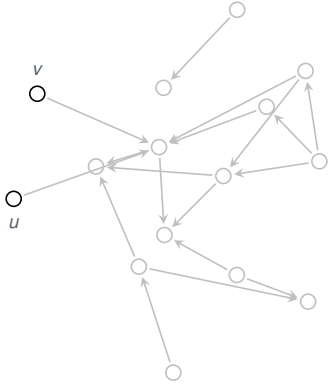
$$\mathcal{G} = (V, E).$$

- Observed knowledge

$$\mathcal{G}' = (V, E') \text{ where } E' \subset E.$$

- Given $(u, v) \in V \times V$, is it true that

$$(u, v) \in E.$$

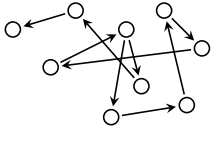


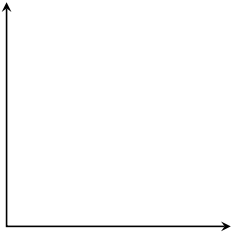
Link Prediction as an Embedding Problem

- An *embedding* is a representation of one mathematical structure in the terms of another, e.g. *graphs* represented as *vectors*.

Link Prediction as an Embedding Problem

Learning Embeddings





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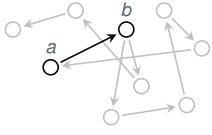

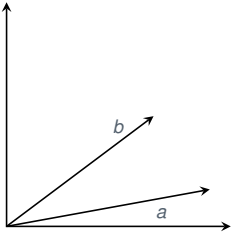

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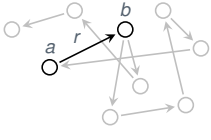

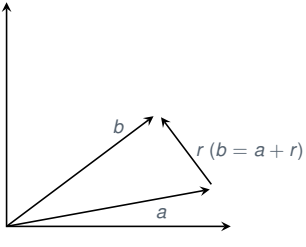

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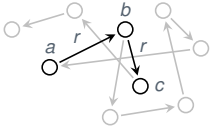

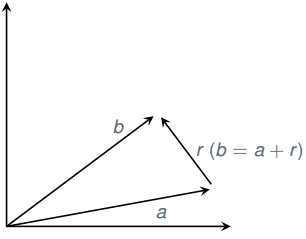

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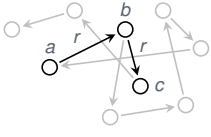

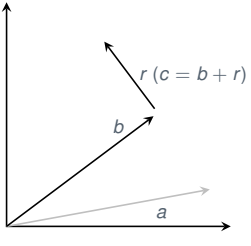

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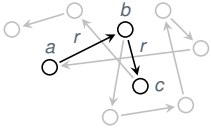
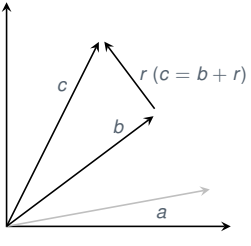
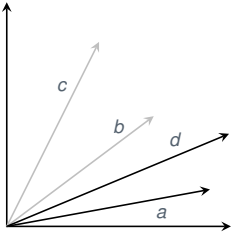




Link Prediction as an Embedding Problem

Inferring with Embeddings

- Are *d* and *a* related with *r*?



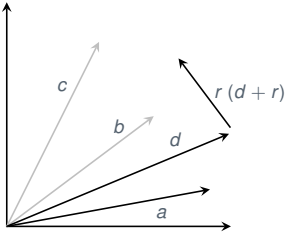
Link Prediction as an Embedding Problem

Inferring with Embeddings

- Are d and a related with r?
- We use the distance

$$(d + r) - a$$

as plausibility measure.



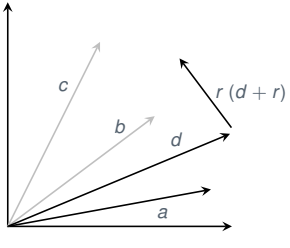
Link Prediction as an Embedding Problem

Inferring with Embeddings

- Are d and a related with r? Probably not!
- We use the distance

$$(d + r) - a$$

as plausibility measure.



Link Prediction as an Embedding Problem

Embedding Semantic Hierarchies

- Hierarchy-Aware Knowledge Graph Embedding (HAKE)

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Embedding Semantic Hierarchies

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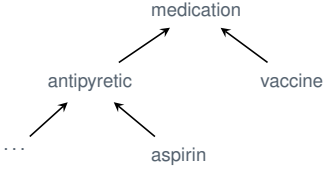
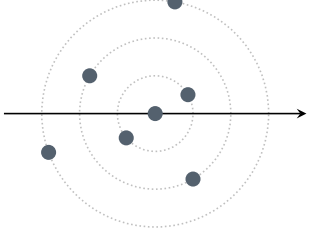
- Knowledge naturally exhibits hierarchies.
- Polar coordinates help encode entities on different hierarchical levels.





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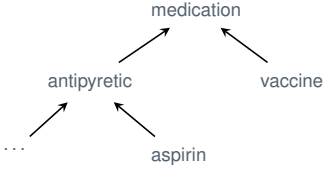

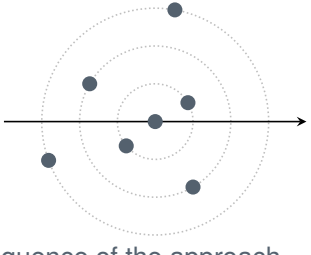

- Hierarchies are not explicitly embedded but a consequence of the approach.

Experiment Results

- Replication: 0.172% to -11.7% deviation.

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- Replication: 0.172% to -11.7% deviation.
- Domain-specific data: close to 50% of replication performance (at best).

Experiment Results
Visualising Embeddings

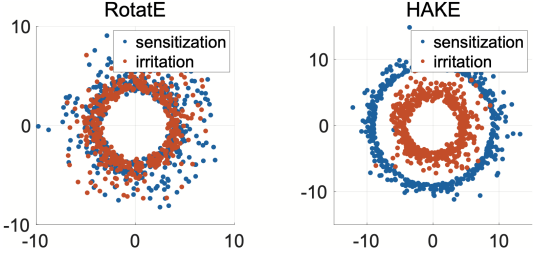

Figure: HAKE Paper

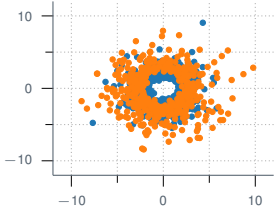

Figure: Domain-Specific

Improving Link Prediction
Why (Not) Embeddings?

- Graph embeddings are fast and efficient for inferring.

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- Flawed evaluation methods due to reverse and Cartesian product relations.

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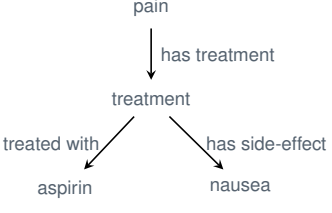
Why (Not) Embeddings?

- Graph embeddings are fast and efficient for inferring.
- Flawed evaluation methods due to reverse and Cartesian product relations.
- Transparency, explainabilty, and interesting graph properties are lost.

Improving Link Prediction
Then What?

- Knowledge base representations may be inappropriate (Cartesian product relations).



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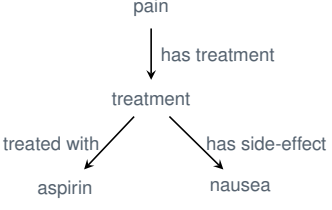

- Similarity measures may give better results, transparency, and explainabilty.

Thank you!

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