Learning Relation Entailment with Structured and Textual Information

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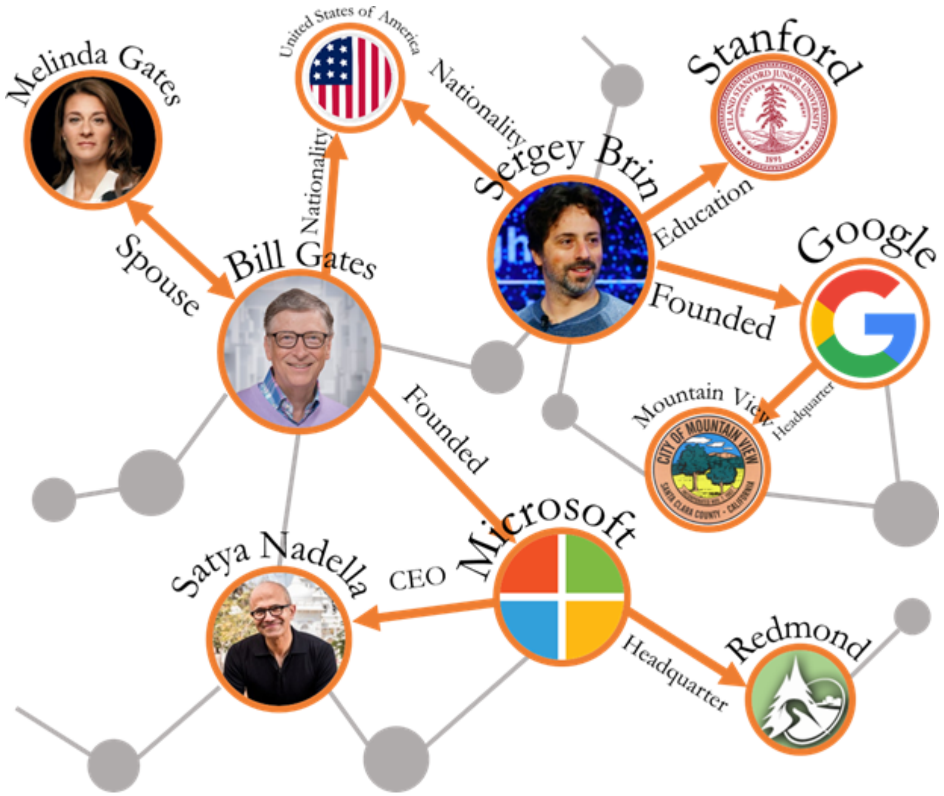
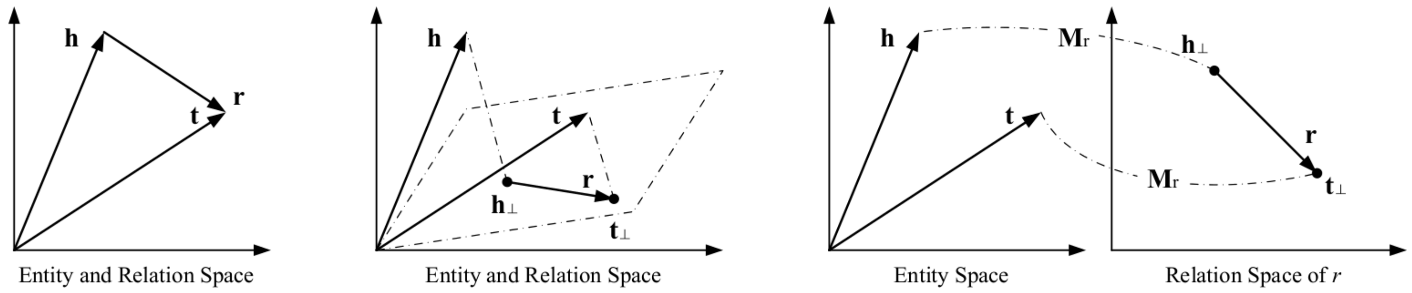
Motivation

- Relations among entities play a fundamental role in knowledge graphs.



Motivation

- However, relations are treated as independent.



(a) TransE. (b) TransH. (c) TransR.

KG embedding: each relation is treated as an atomic unit with separate parameters.

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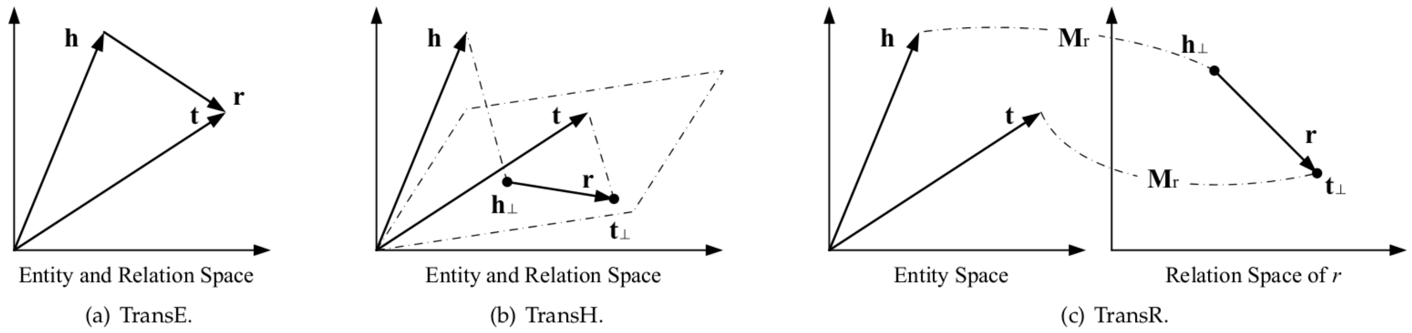

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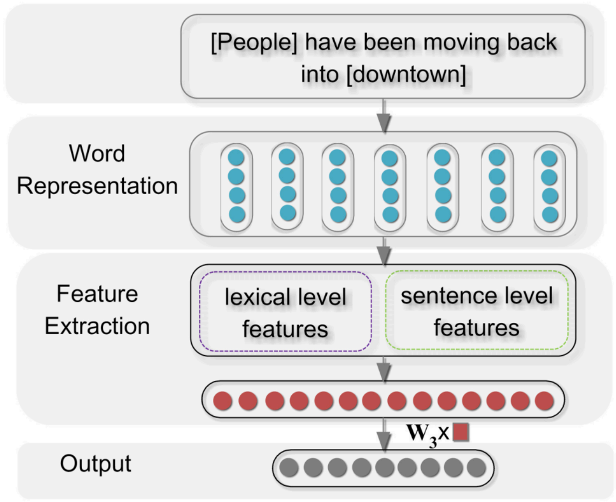
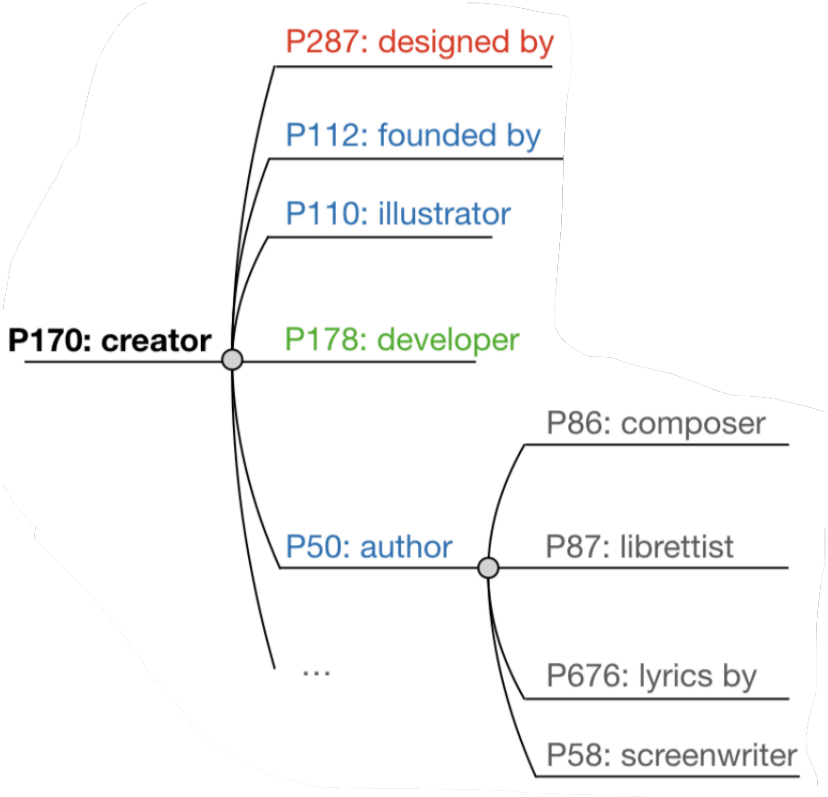


Relation extraction: each relation is an independent class.

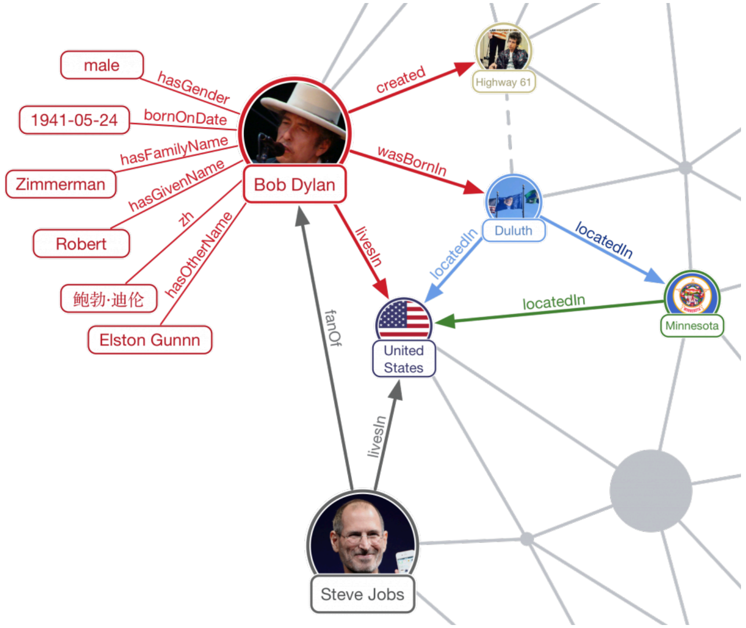
Meta-relation: Relations Between Relations

- Relation entailment: existence of one relation can entail the existence of another relation.



Applications of Relation Entailment

- Knowledge graph representation learning.



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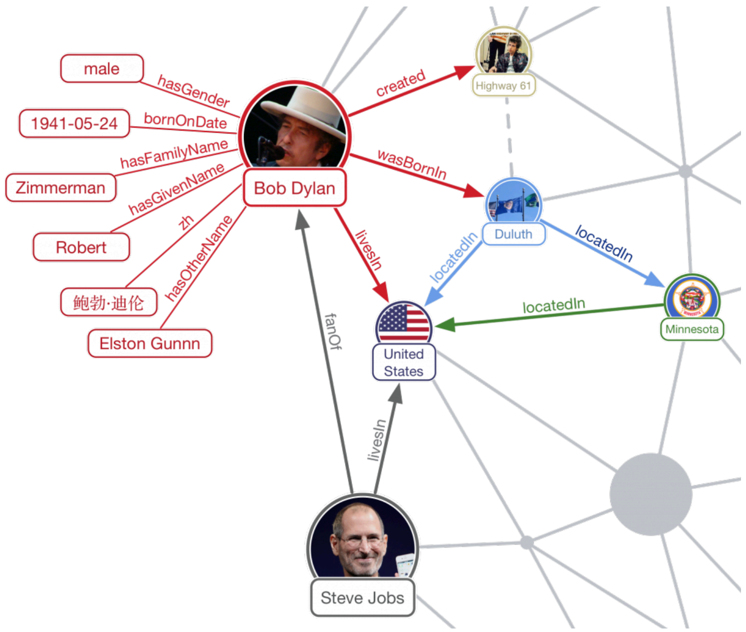
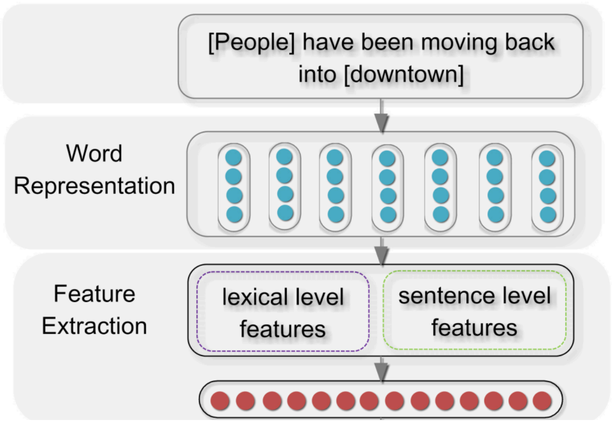
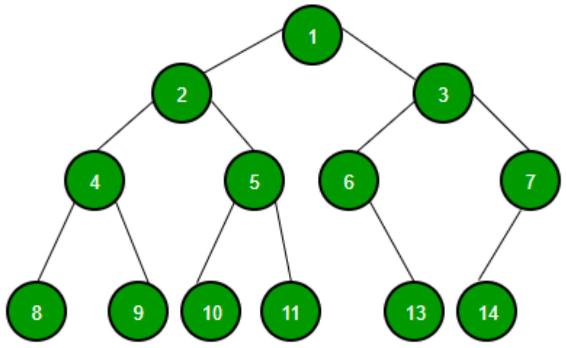
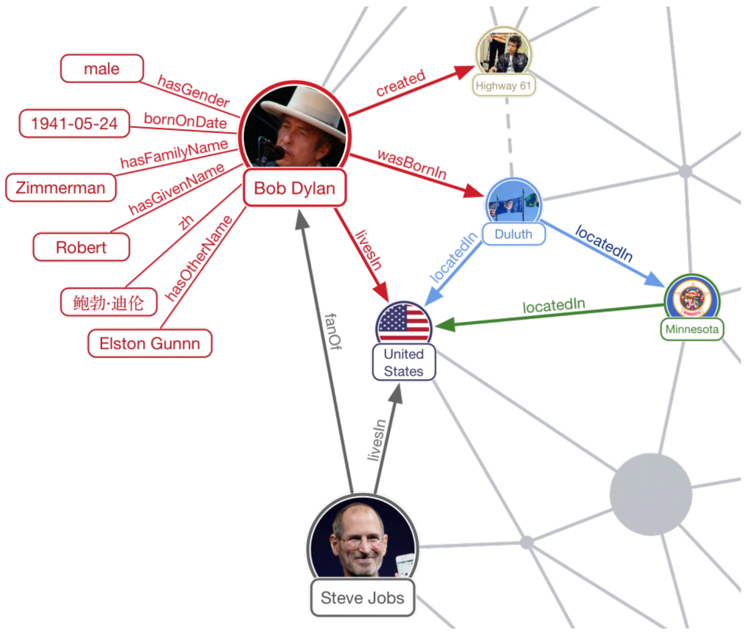


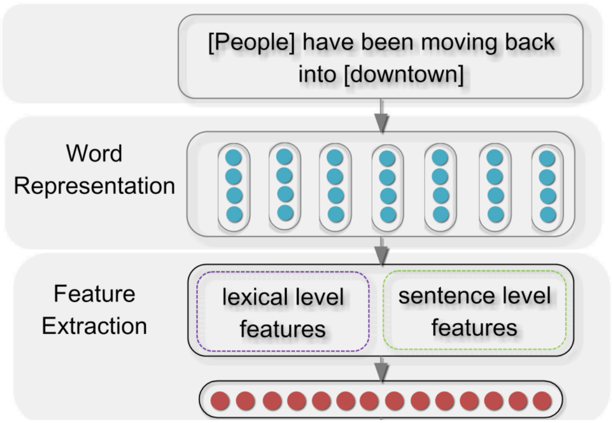


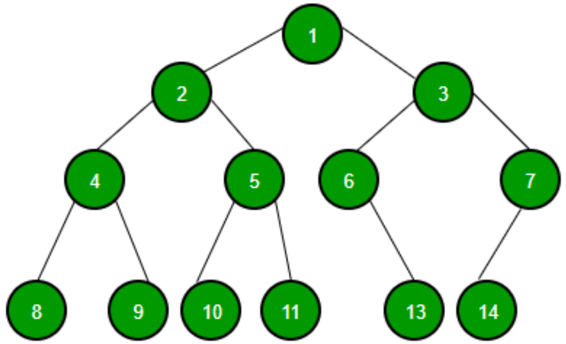


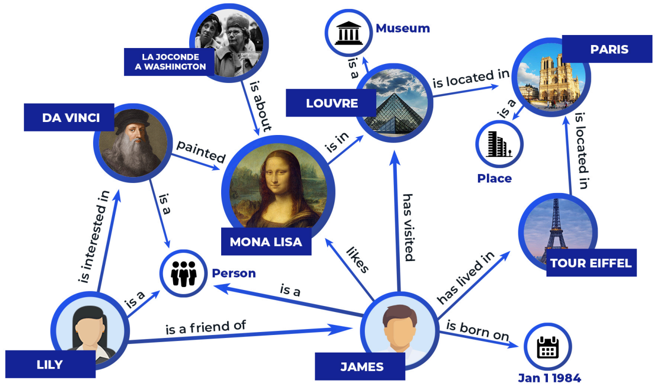
Applications of Relation Entailment

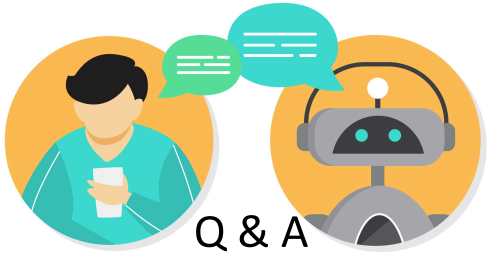
- Knowledge graph representation learning.
- Relation extraction.
- KG-based question answering.







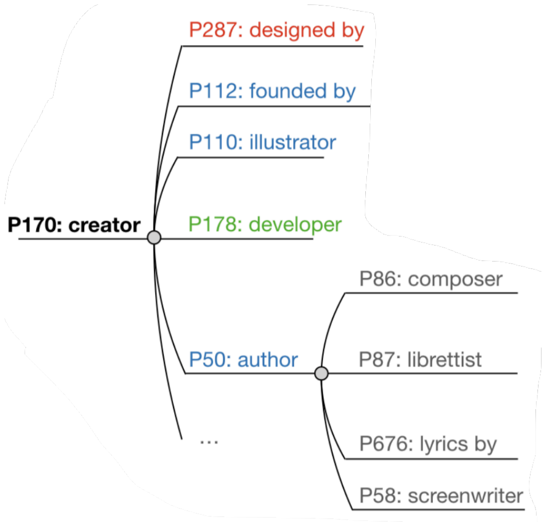




Relation Entailment Task Definition

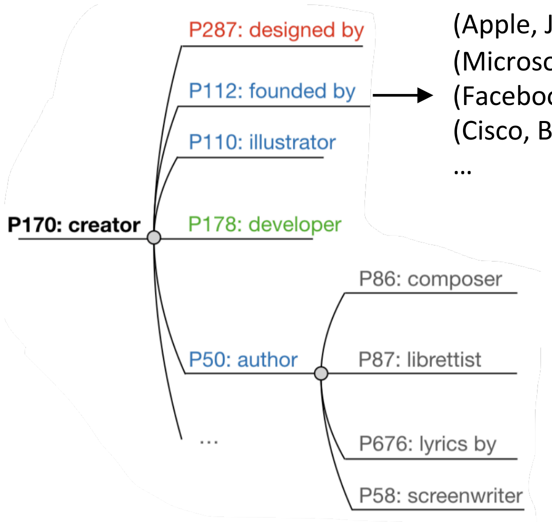
- Notations
  - Head and tail entities $h, t \in \mathcal{E}$.
  - Relations $r \in \mathcal{R}$.
  - Instances of a relation $C_r = \left\{(h, r, t)^{(i)}\right\}_i$.
- Relation entailment
  - $r \vDash r'$ if and only if $C_r \subseteq C_{r'}$.
- Task of predicting relation entailment
  - Given a relation r, choose its (direct) parent $r' \in \mathcal{L}$.
  - A $|\mathcal{L}|$-way multi-class classification problem.

RelEnt Dataset



RelEnt Dataset

1. Instances collection



(Apple, Jobs)
(Microsoft, Gates)
(Facebook, Zuckerberg)
(Cisco, Bosack)
…

RelEnt Dataset

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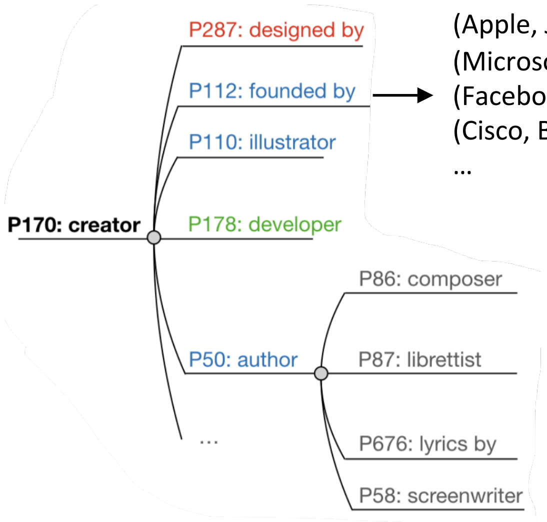


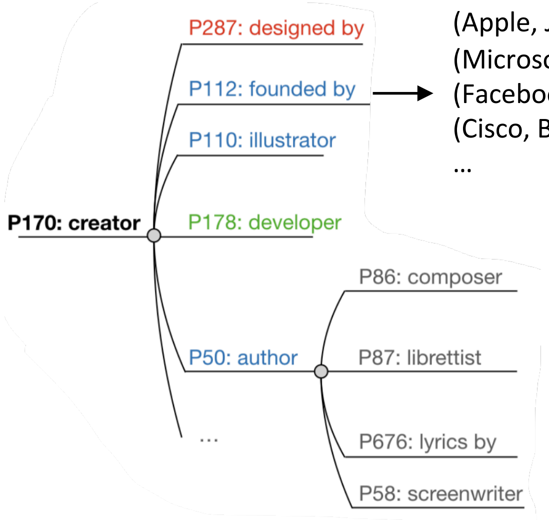
(Apple, Jobs)
(Microsoft, Gates)
(Facebook, Zuckerberg)
(Cisco, Bosack)
…

2. Downsampling

(Apple, Jobs)
(Microsoft, Gates)
(Facebook, Zuckerberg)
…

RelEnt Dataset

1. Instances collection **2. Downsampling** **3. Relation expansion**



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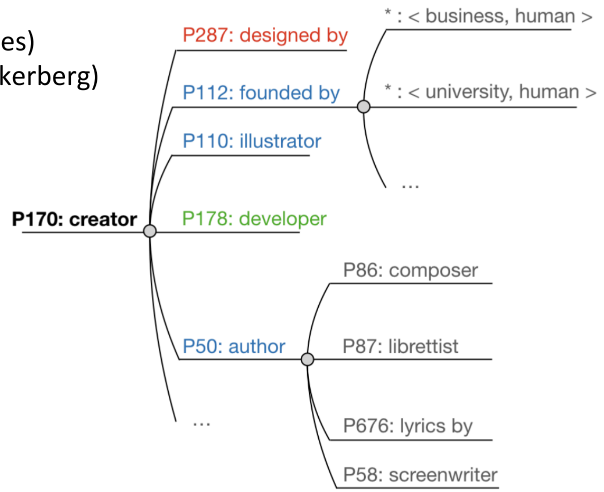

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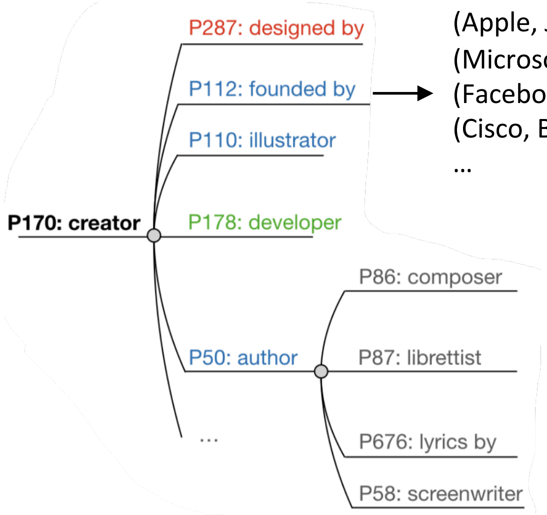

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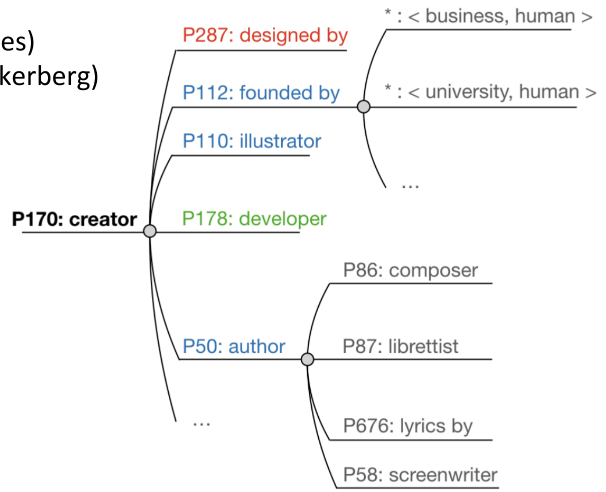
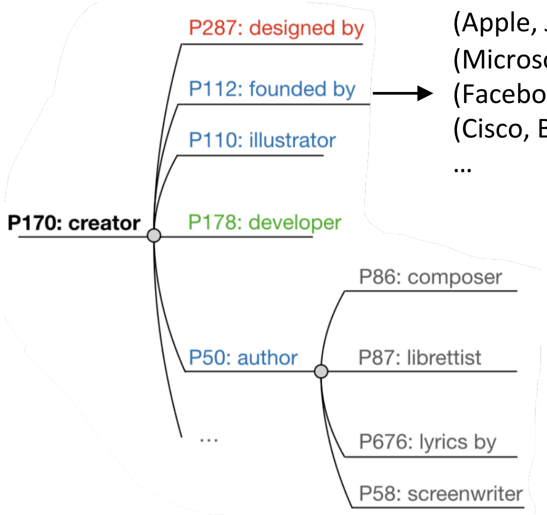


parent	Sub-relations
parent organization	<laboratory, university>, <airline, airline>, <record label, record label>, …
architectural style	<railway station, architectural style>, <church, architectural style>, ...
award received	<film, Academy Awards>, <human, campaign medal>, <human, scholarship>, ...

RelEnt Dataset

1. Instances collection **2. Downsampling** **3. Relation expansion** **4. Entity linking**



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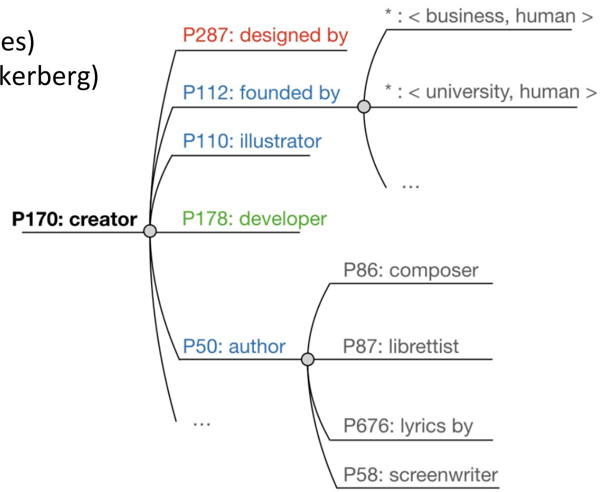

WIKIPEDIA
The Free Encyclopedia

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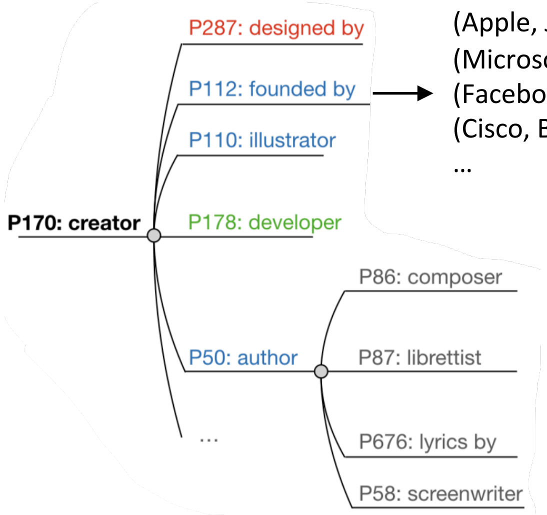

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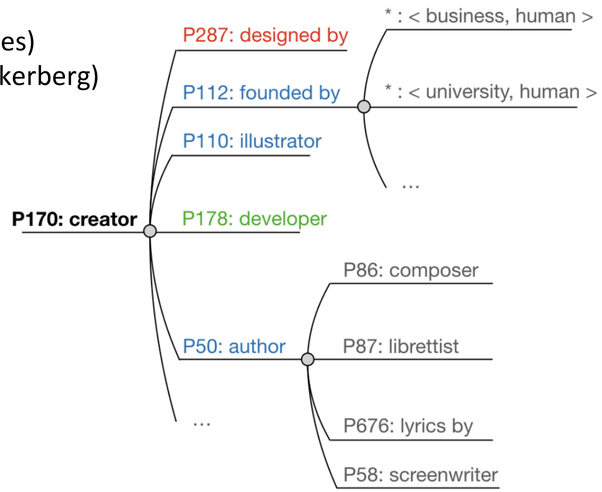

4. Entity linking

WIKIPEDIA
The Free Encyclopedia

5. Train/dev/test split

Train
founded by ⊨ creator
illustrator ⊨ creator
author ⊨ creator
Dev
developer ⊨ creator
Test
designed by ⊨ creator

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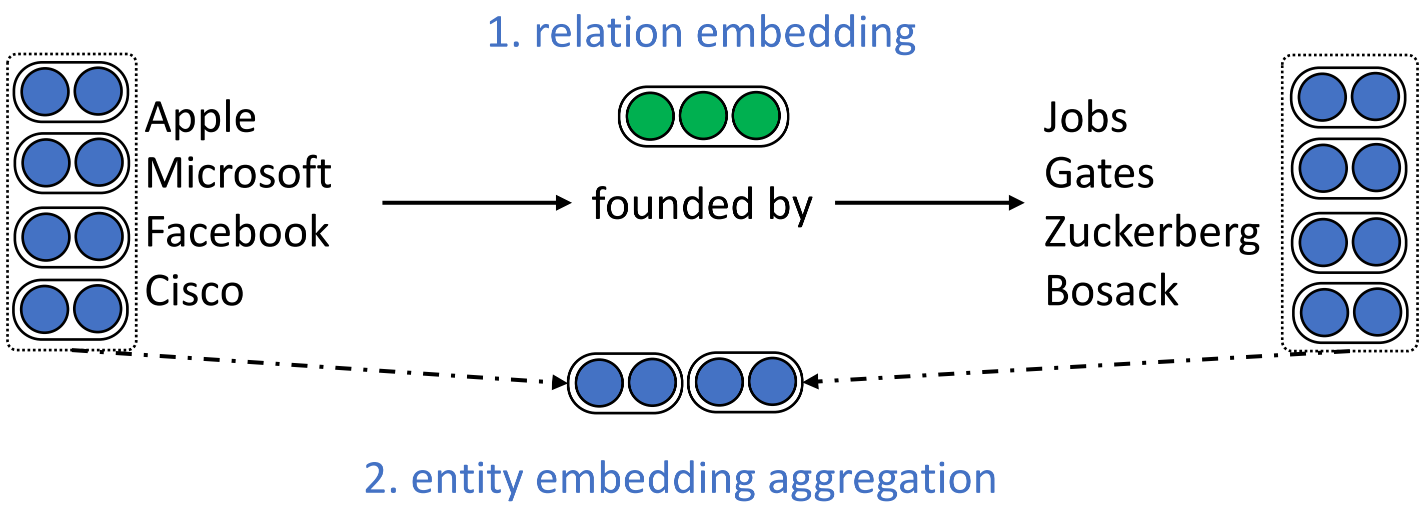
Relation Representation

- With structured information



Relation Representation

- With textual information

1. words in the middle

2. dependency path

Apple
Microsoft
Facebook
Cisco

→

is founded by
is created by
founded
is the founder of
…

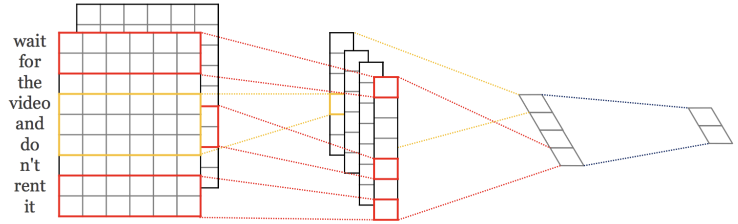
$\xleftarrow{\text{nsubjpass}}$ founded $\xrightarrow{\text{agent}}$ by $\xrightarrow{\text{pobj}}$

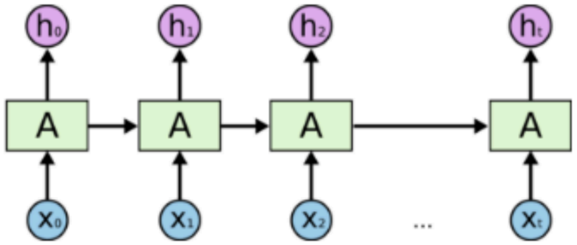
$\xleftarrow{\text{nsubj}}$ is $\xrightarrow{\text{attr}}$ the CEO $\xrightarrow{\text{prep}}$ of $\xrightarrow{\text{pobj}}$

…

→

Jobs
Gates
Zuckerberg
Bosack

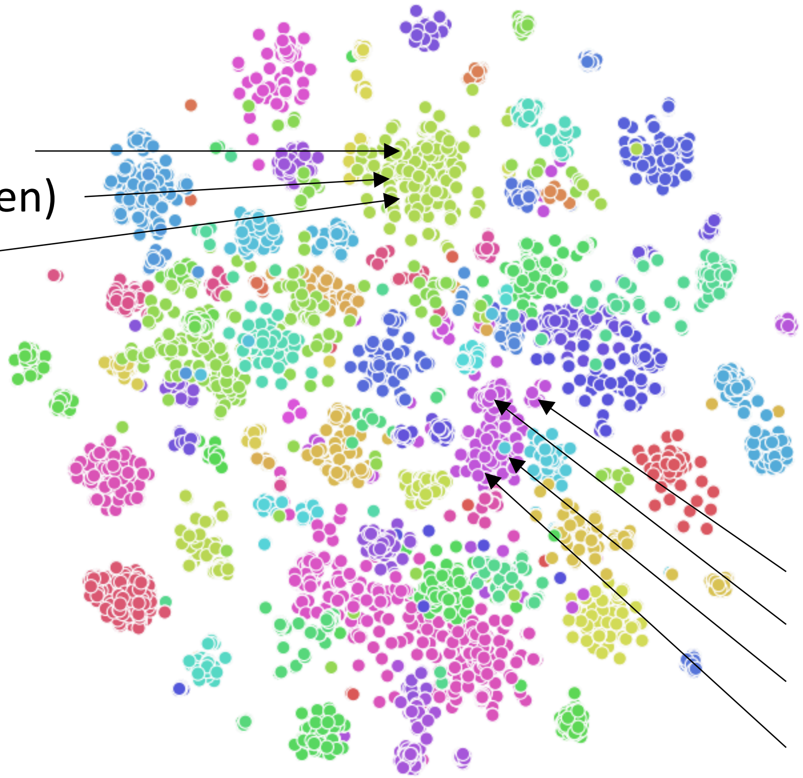




Relation Representation

- Distribution-based

author
(Pride and Prejudice, Jane Austen)
(The Lord of the Rings, J. R. R. Tolkien)
(Anna Karenina, Leo Tolstoy)
…



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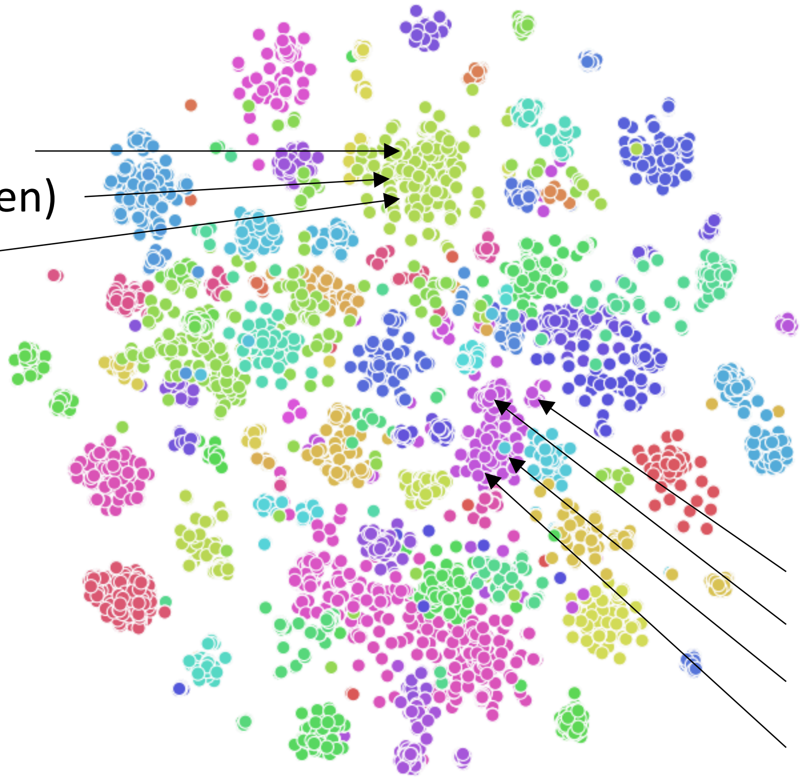

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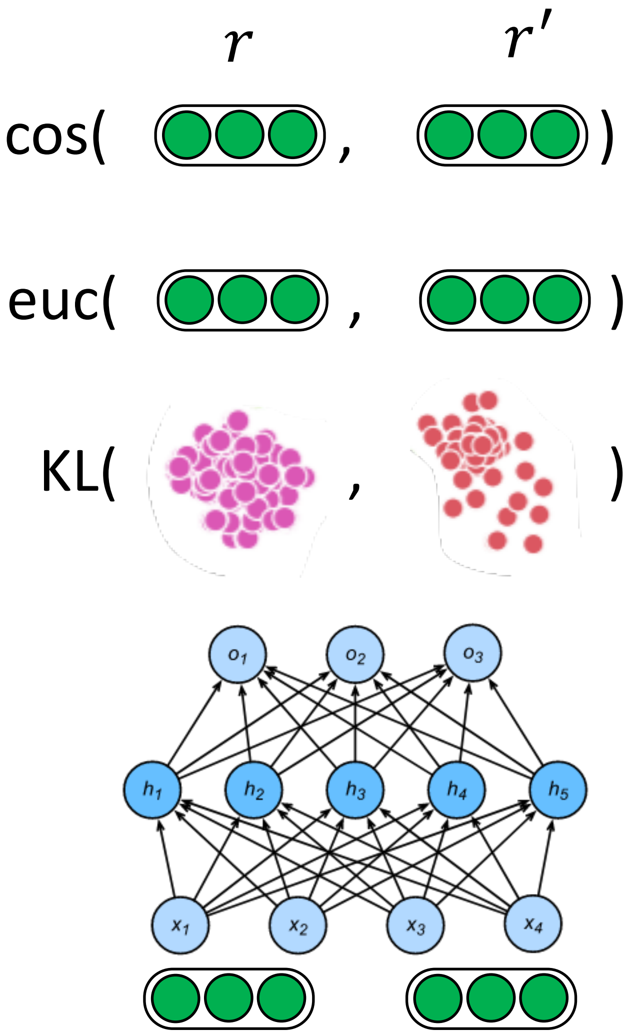
Kernel density estimation with a Gaussian kernel

Relation Entailment Prediction

Unsupervised methods

Supervised methods



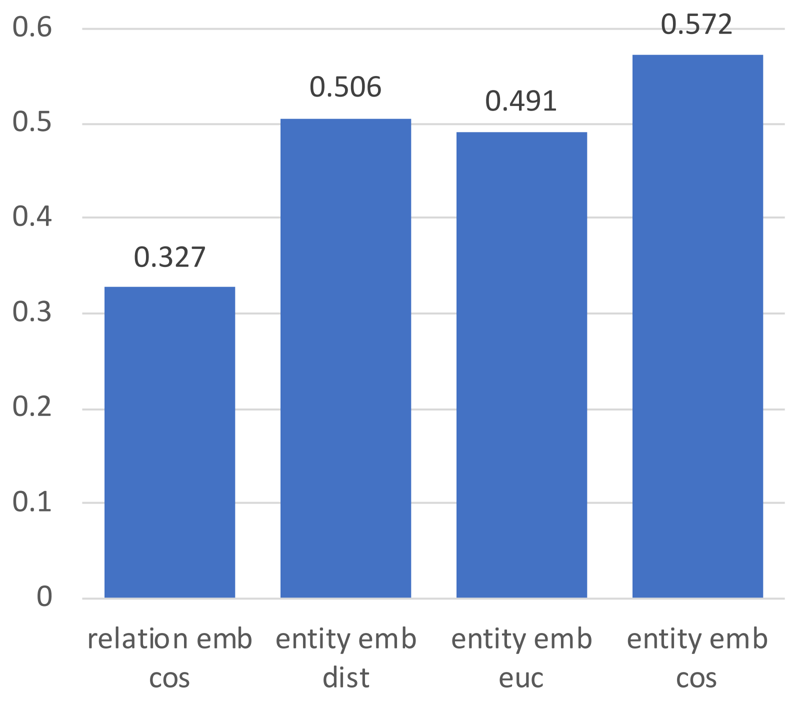
Experimental Settings

- RelEnt Dataset
  - #Train, #Dev., #Test relations: 2055, 804, 692
  - #Classes: 498

- Evaluation Metrics
  - Accuracy@1, Accuracy@3, and mean reciprocal rank (MRR)

- Implementation Details
  - KG embedding methods: TransE, DistMult, ComplEx.
  - 50-dimensional GloVe embeddings.
  - BiLSTM with 64 hidden units, CNN with window size of 3 and 64 filters.

Unsupervised Methods' Results



Acc@1 of different unsupervised methods with TransE.

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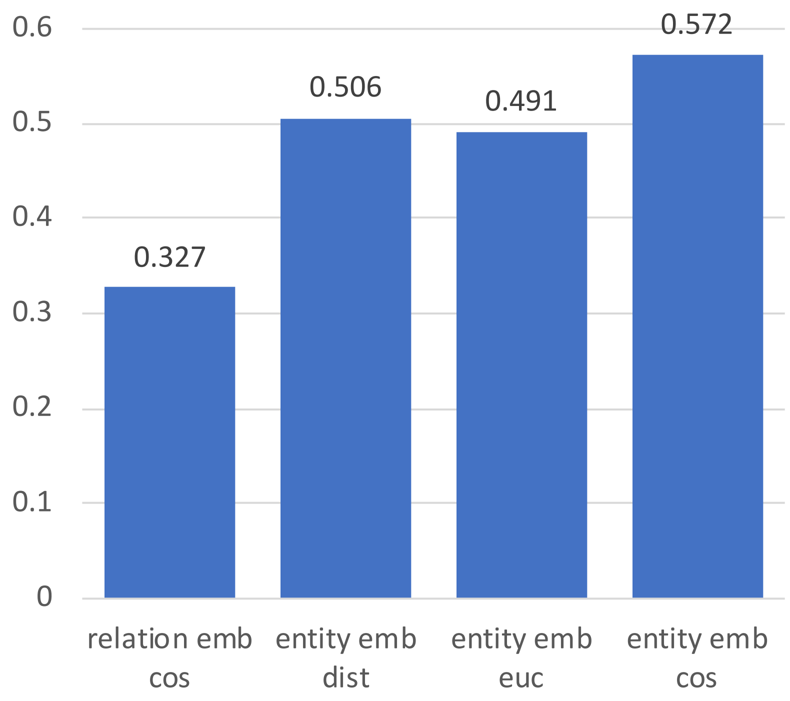

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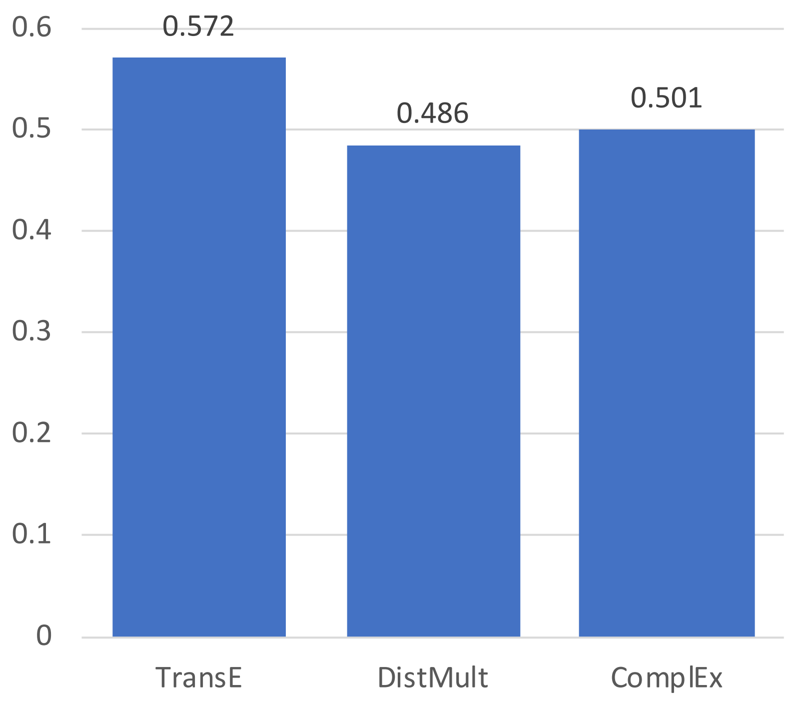
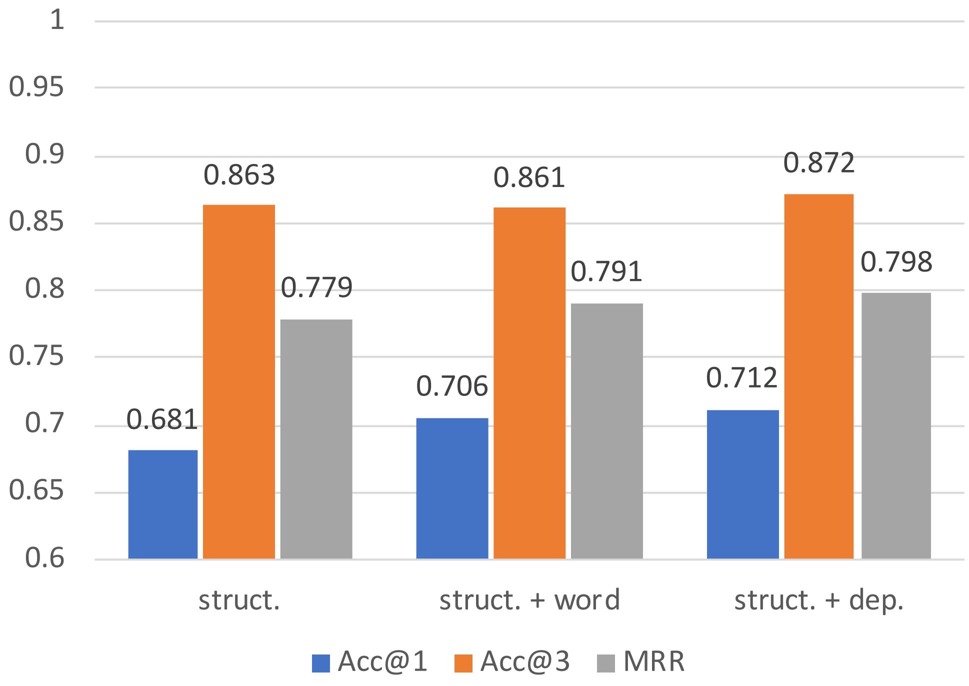


Acc@1 of entity embedding with cosine using different KG representations.

Supervised Methods' Results

- Supervised > unsupervised.
- Textual information is complementary to structured information.



Error cases

Parent	Child (train)	Child (test)
follows	has cause	replaces
instance of	taxon rank	legal form
participant	performer	participating team

(2010 Wimbledon Championships, Roger Federer)
(First Continental Congress, George Washington)
(Hambach Festival, Ludwig Börne)

(Runaway, Linkin Park)
(The Freewheelin' Bob Dylan, Bob Dylan)

(1977 UEFA Cup Final, Juventus FC)
(2016–17 Premier League, Watford F.C.)
(1956 Wrestling World Cup, Iran)

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BOSCH Invented for life

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NEULAB

Take away

1. Both structured and textual information contribute to relation entailment prediction.

2. Relation entailment prediction requires high-level abstraction.

Paper: https://openreview.net/pdf?id=ToTf_MX7Vn
Code: https://github.com/jzbjyb/RelEnt