ConvE for Knowledge Base Completion

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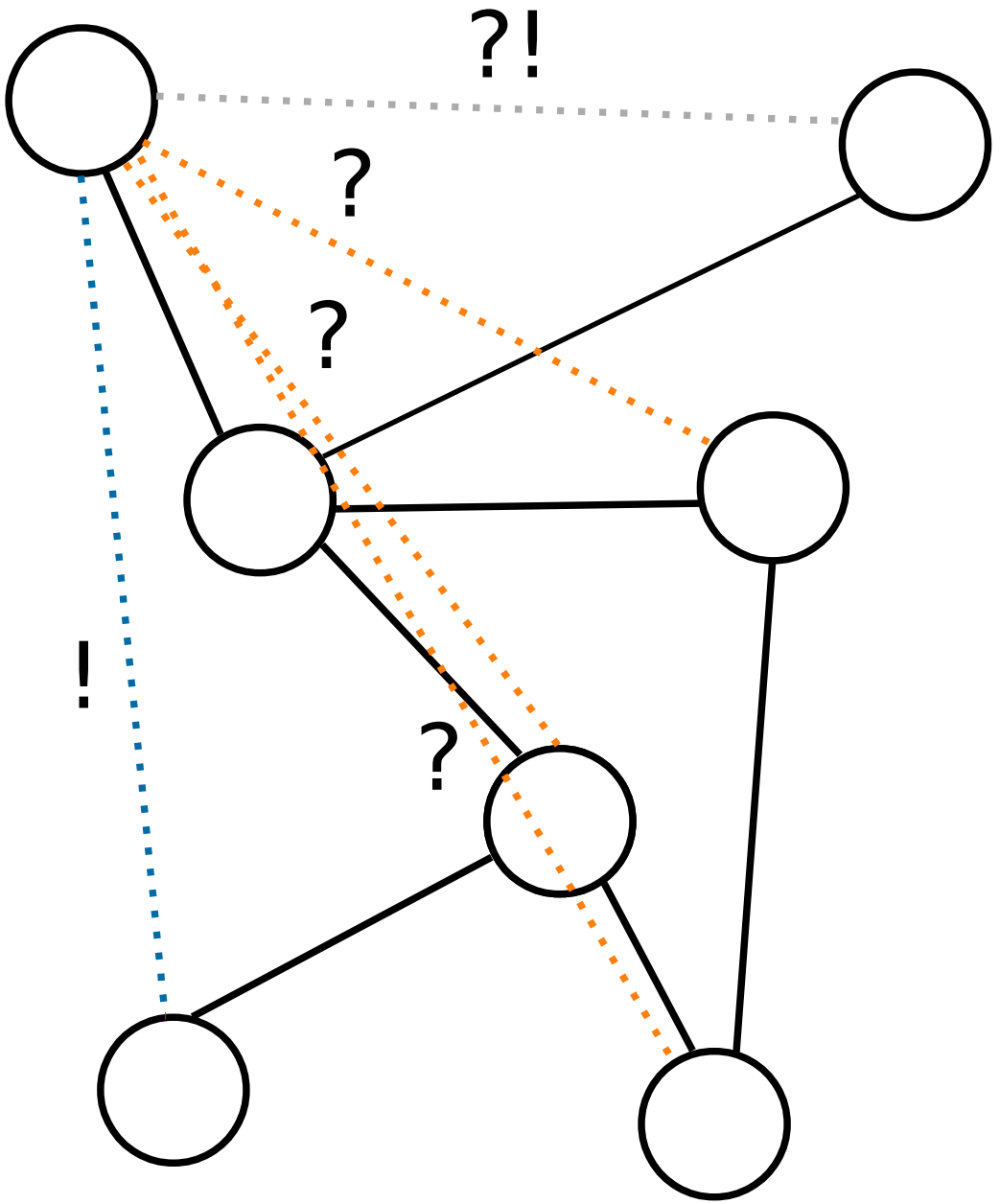
Knowledge Base Completion (KBC)



Data

- Train data
- ! Test data
- ? False candidates
- ?! True candidates

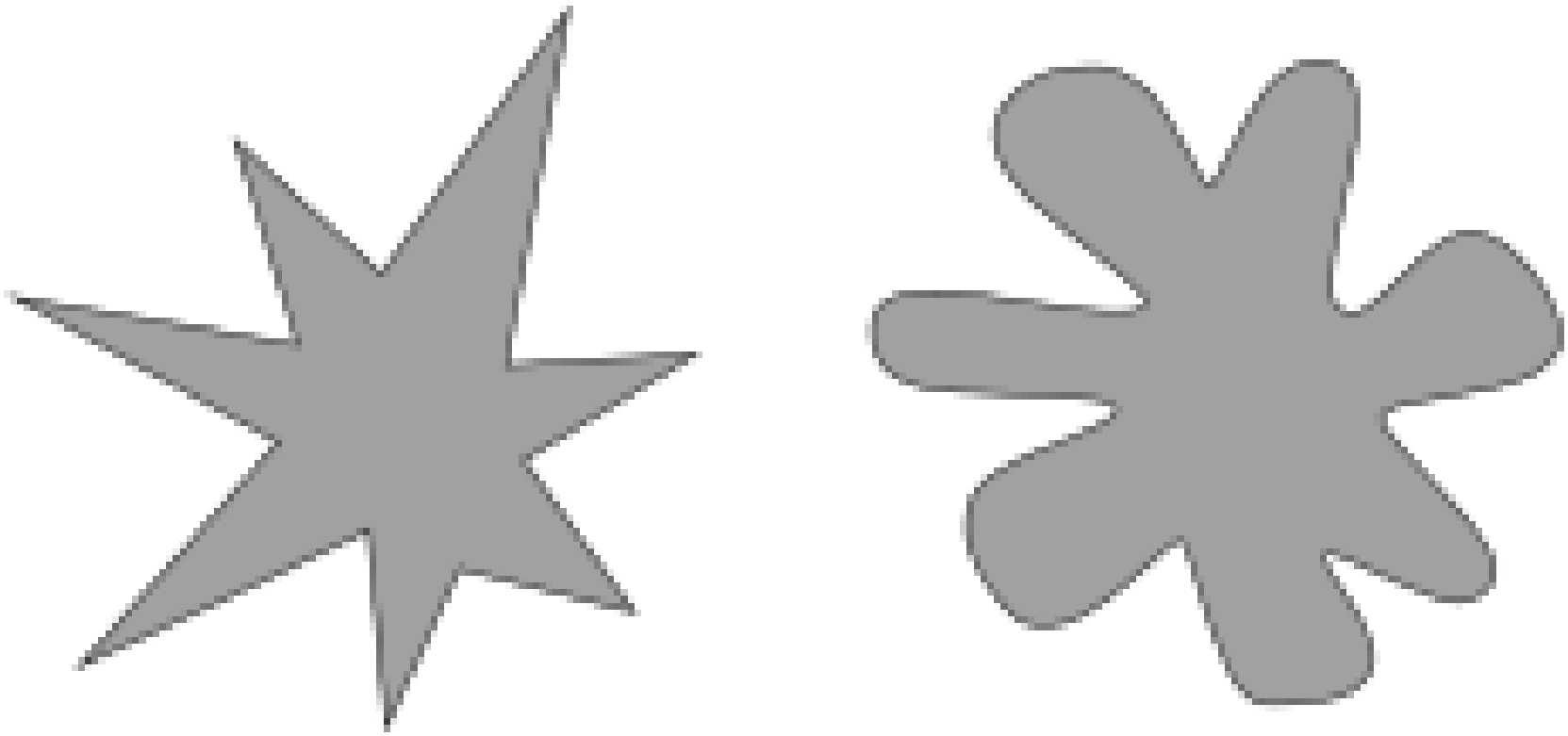
Goal: Rank links

1. ——
2. ·····
3. ·····
4. ·····
5. ·····
6. ·····

Evaluation

Fraction of ····· in Top 10 Ranks

Problems with Language



Robustness of KBC models

DistMult on FB15k:

- 2015 0.58 Hits@10
- 2015 0.79 Hits@10
- 2016 0.84 Hits@10 (not replicable)
- 2017 0.81 Hits@10
- 2017 0.82 Hits@10

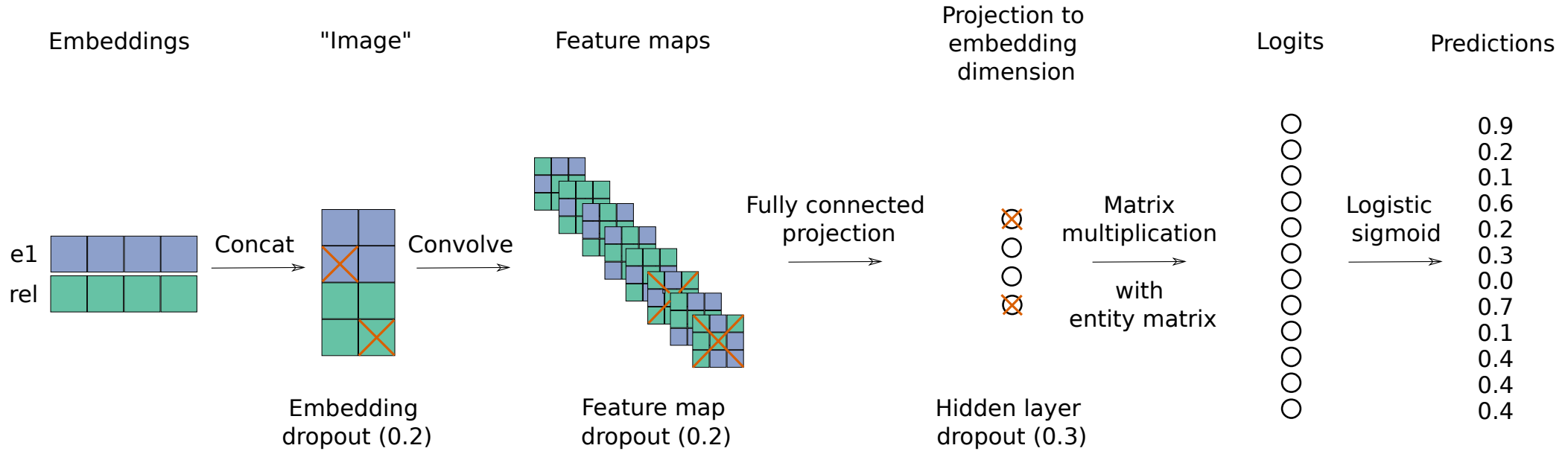
Evaluation Time of KBC Models

- Training one epoch on 150k samples: 1 min
- Evaluating one epoch on 5k samples: 15 mins

Making KBC Fast and Robust

- Fast: 1-N training
- Robust: Computer vision methodology

ConvE


Embeddings
"Image"
Feature maps
Projection to embedding dimension
Logits
Predictions
e1
rel
Concat
Convolve
Fully connected projection
Matrix multiplication
with entity matrix
Logistic sigmoid
0.9
0.2
0.1
0.6
0.2
0.3
0.0
0.7
0.1
0.4
0.4
0.4
Embedding dropout (0.2)
Feature map dropout (0.2)
Hidden layer dropout (0.3)

Inital Results

	WN18					FB15k				
	MR	MRR	Hits @10	Hits @3	Hits @1	MR	MRR	Hits @10	Hits @3	Hits @1
DistMult [31]	902	0.822	0.936	0.914	0.728	97	0.654	0.824	0.733	0.546
ComplEx [30]	–	0.941	0.947	0.936	0.936	–	0.692	0.840	0.759	0.599
Gaifman [22]	**352**	–	0.939	–	0.761	75	–	0.842	–	0.692
ANALOGY [17]	–	**0.942**	0.947	0.944	**0.939**	–	0.725	0.854	0.785	0.646
R-GCN [23]	–	0.814	0.964	0.929	0.697	–	0.696	0.842	0.760	0.601
ConvE	504	**0.942**	0.955	0.947	0.935	**64**	**0.745**	**0.873**	**0.801**	0.670
Inverse Model	567	0.861	**0.969**	**0.968**	0.764	1897	0.706	0.737	0.718	**0.689**

The Inverse Relationship Problem

e1 r1 e2

(Special Bird, specialization of, Bird Class I)

(Bird Class I, specialization of, Bird Class II)

inverse relationship

(Bird Class I, generalization of, Special Bird)

(Bird Class II, generalization of, Bird Class I)

e2 r2 e1

Results on Better Datasets

	WN18RR					FB15k-237				
			Hits					Hits		
	MR	MRR	@10	@3	@1	MR	MRR	@10	@3	@1
DistMult [31]	**5110**	0.425	0.491	0.439	0.389	254	0.241	0.419	0.263	0.155
ComplEx [30]	5261	0.444	**0.507**	**0.458**	**0.411**	**248**	0.240	0.419	0.263	0.152
R-GCN [23]	–	–	–	–	–	–	0.248	0.417	0.258	0.153
ConvE	5277	**0.464**	0.479	0.429	0.385	246	**0.316**	**0.491**	**0.350**	**0.239**
Inverse Model	13219	0.359	0.359	0.359	0.359	7148	0.009	0.012	0.010	0.006

	YAGO3-10					Countries		
			Hits			AUC-PR		
	MR	MRR	@10	@3	@1	S1	S2	S3
DistMult [34]	5926	0.337	0.540	0.379	0.237	**1.000±0.000**	0.721±0.122	0.516±0.070
ComplEx [33]	6351	0.355	0.547	0.399	0.258	0.965±0.021	0.571±0.104	0.430±0.072
ConvE	**2792**	**0.523**	**0.658**	**0.564**	**0.448**	**1.000±0.000**	**0.985±0.013**	**0.856 ±0.051**
ReverseModel	60251	0.015	0.022	0.017	0.010	–	–	–

Ablation Study

Table 6: Ablation study on FB15k-237.

Ablation	Hits@10
Full ConvE	0.491
Hidden dropout	-0.055
1-N scoring	-0.019
Input dropout	-0.017
Feature map dropout	-0.005
Label smoothing	-0.001

Why Are Results on WN18RR Bad?

ConvE good for nodes with high PageRank!

Table 5: Mean PageRank $\times 10^{-3}$ of nodes in the test set vs reduction in error in terms of AUC-PR or Hits@10 of ConvE wrt. DistMult.

Dataset	PageRank	Error Reduction
WN18RR	0.104	0.91
WN18	0.125	1.28
FB15k	0.599	1.23
FB15RR	0.733	1.17
YAGO3-10	0.988	1.91
Countries S3	1.415	3.36
Countries S1	1.711	0
Countries S2	1.796	18.6

Robustness of KBC models

ConvE FB15k-237:

- Random sample for input [0.1, 0.5], feature map [0.0, 0.5], and hidden dropout [0.1, 0.5]:

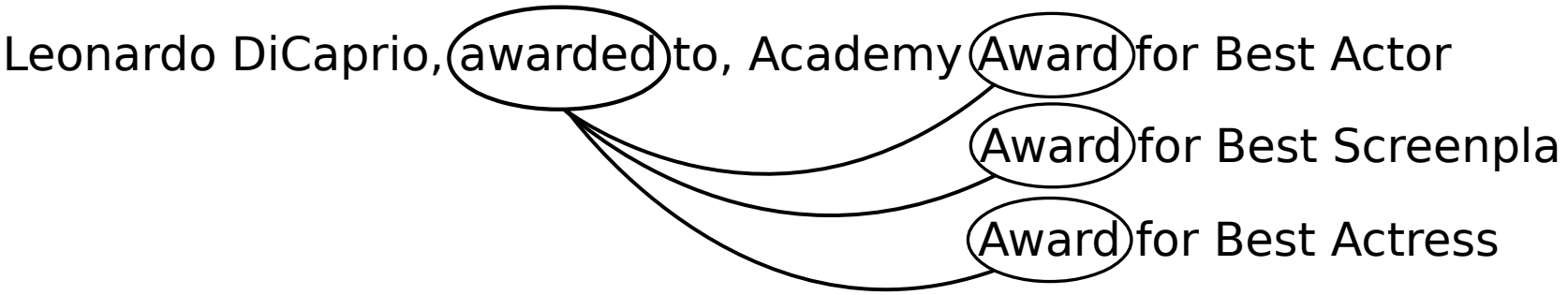
  0.45 – 0.49 Hits@10

  Previous State-of-the-art: 0.42

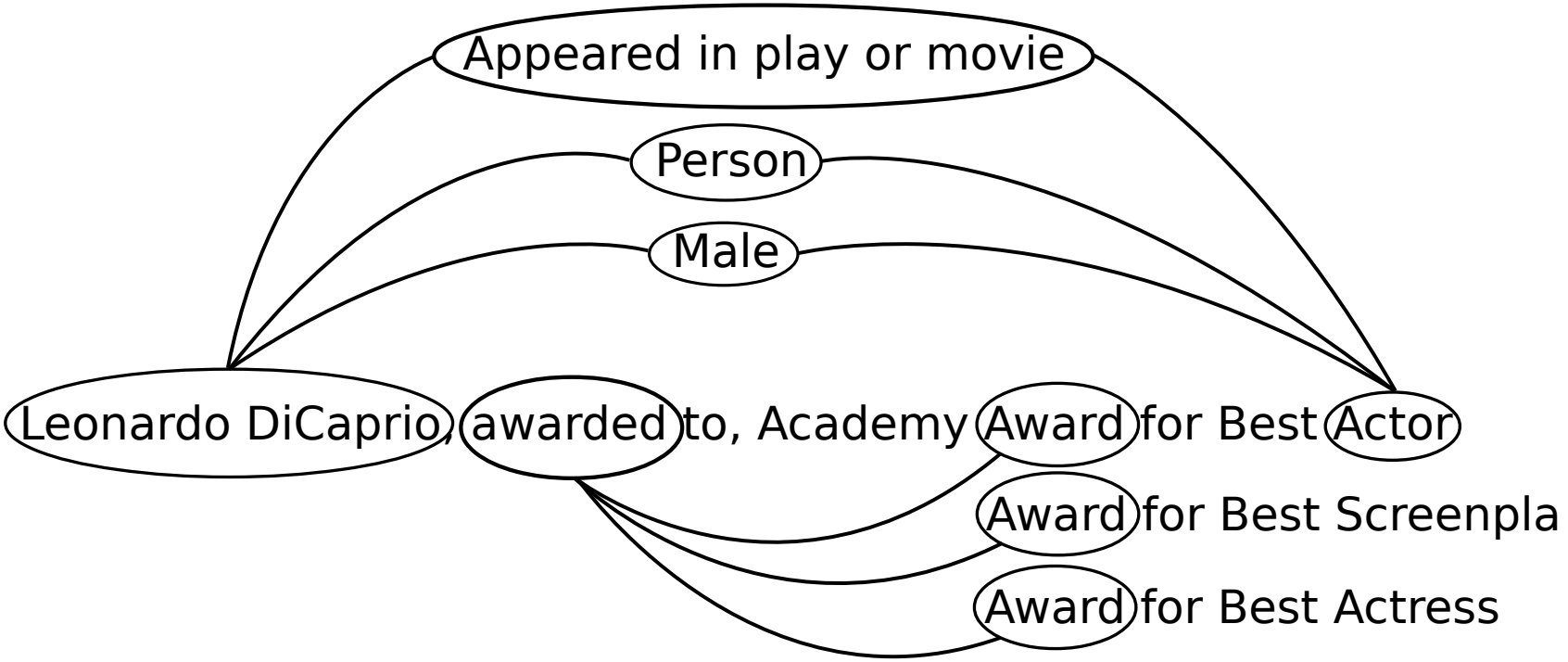
Future Work: Word Level KBC

(Leonardo DiCaprio, awarded to, Academy Award for Best Actor)

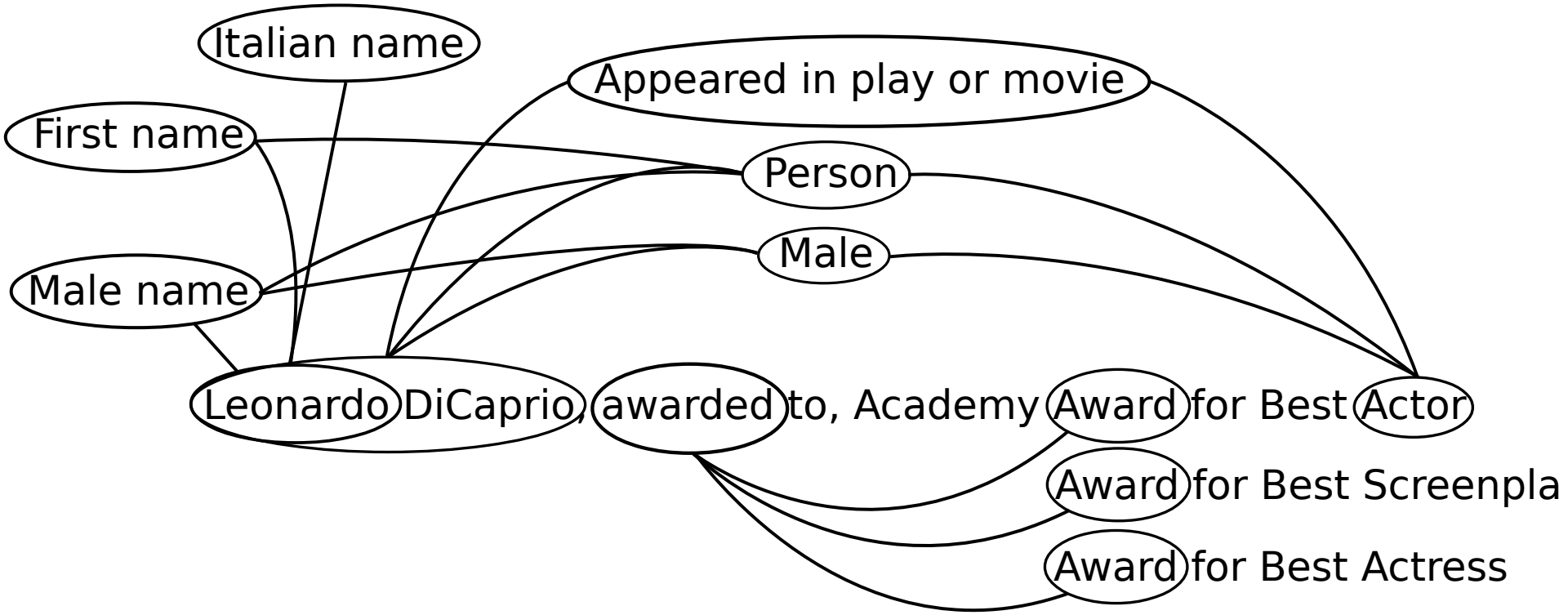
Future Work: Word Level KBC



Future Work: Word Level KBC



Future Work: Word Level KBC



Word Level KBC: Results

FB15k-237 (only words)

- Normal ConvE: 0.08 Hits@10
- Word-level ConvE: 0.32 Hits@10

Conclusion

ConvE:

- Fast and robust training
- Good predictive performance
- Good for high PageRank nodes
- Word-level models might improve performance

Questions & Answers

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