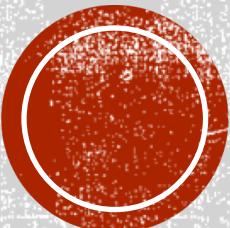


POPULARITY AGNOSTIC EVALUATION OF KNOWLEDGE GRAPH EMBEDDINGS

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Background: Knowledge Graphs, Knowledge Graph Embedding Models



Popularity Bias in Knowledge Graphs



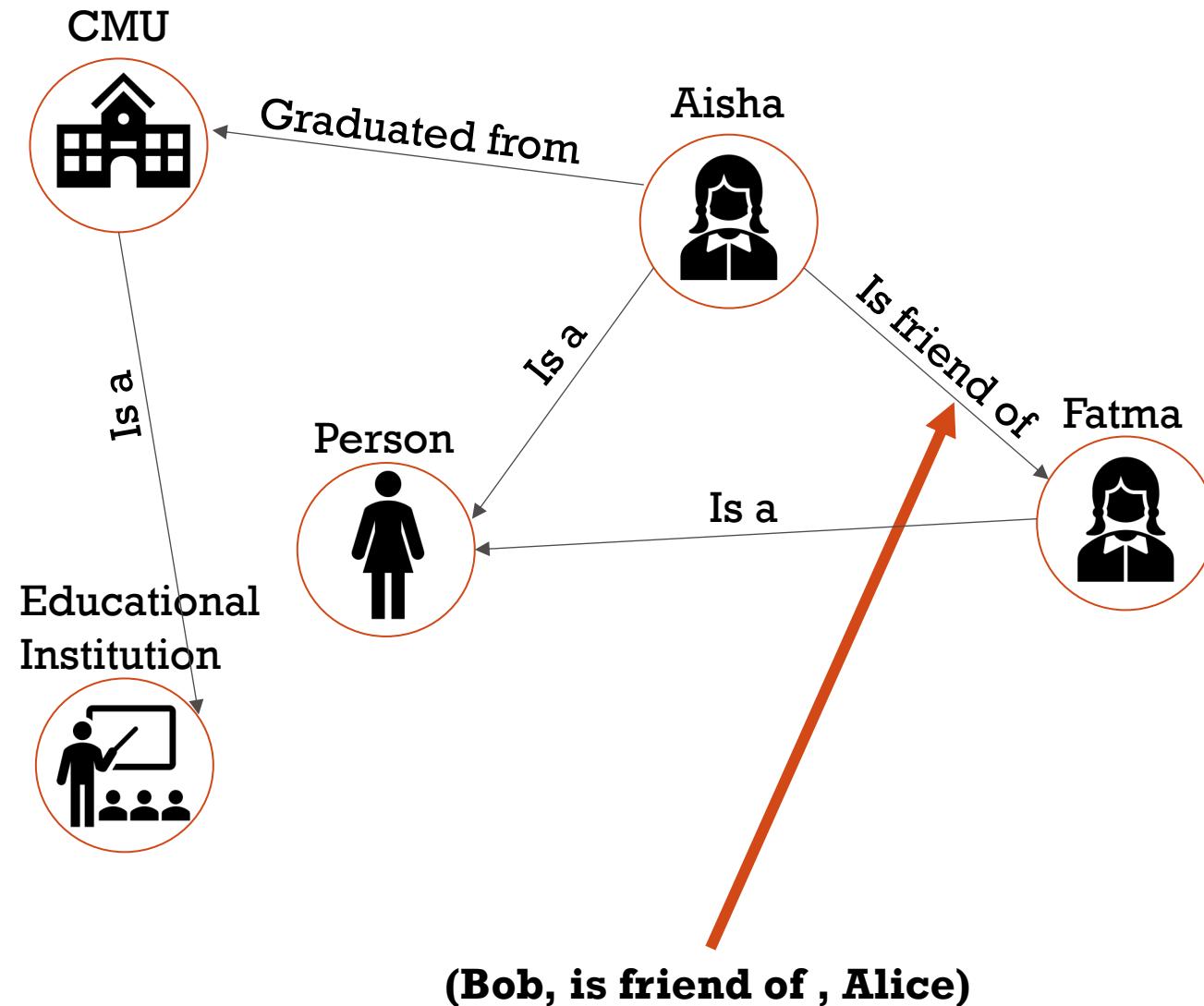
Simple Fix?



Stratified Hits@k

OUTLINE

KNOWLEDGE GRAPHS



Knowledge Graphs consist of
**(subject, relation, object)
triples**

Examples:

DBpedia, YAGO, WordNet,
Freebase, and Google
Knowledge Graph

KNOWLEDGE GRAPH EMBEDDINGS

N = number of entities

K = number of relations

\mathcal{G} = set of (s, r, o) triples

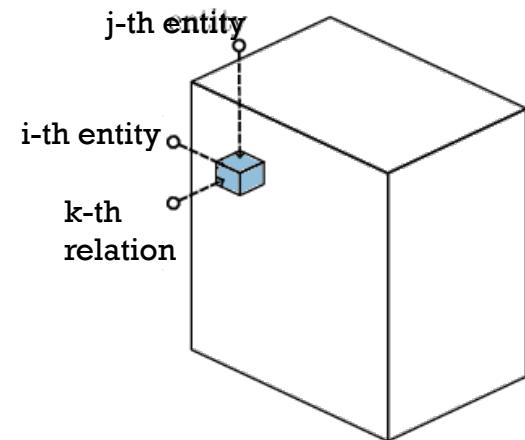
\mathcal{D}^+ = true training triples labeled (1).

\mathcal{D}^- = false generated triples labeled (-1)

$\mathcal{D} = \mathcal{D}^+ \cup \mathcal{D}^-$ is training set of positive and negative triples with their labels.

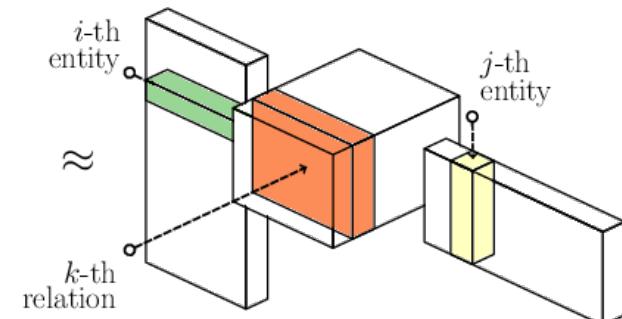
Estimate $P(Y|\Phi)$

3-way tensor \underline{Y}



$$\begin{aligned}\underline{Y} &\in \{0, 1\}^{N \times N \times K} \\ y_{ijk} &= 1 \text{ iff } (s_i, r_k, o_j) \in \mathcal{G} \\ P(y_{ijk}) &= f(e_i, r_k, e_j)\end{aligned}$$

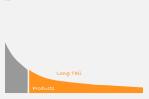
Representation in latent space



Φ
the models' parameters



Background: Knowledge Graphs, Knowledge Graph Embedding Models



Popularity Bias in Knowledge Graphs

OUTLINE



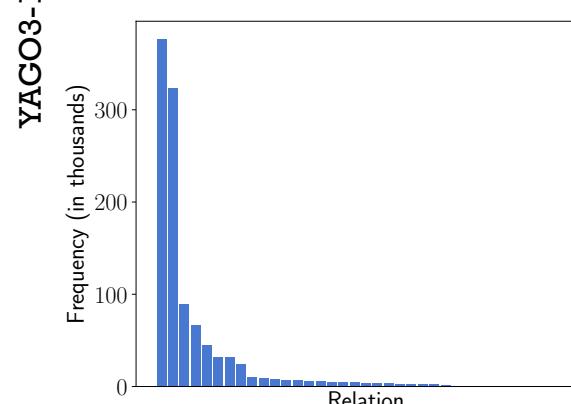
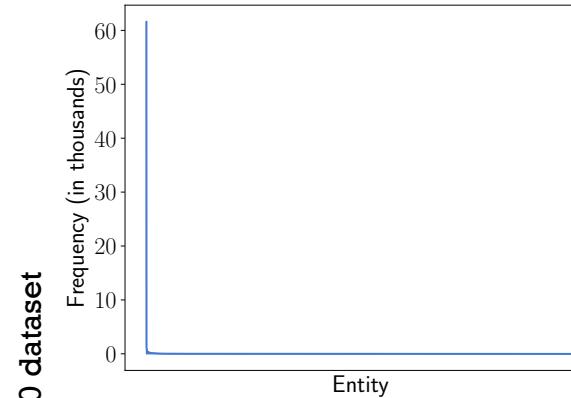
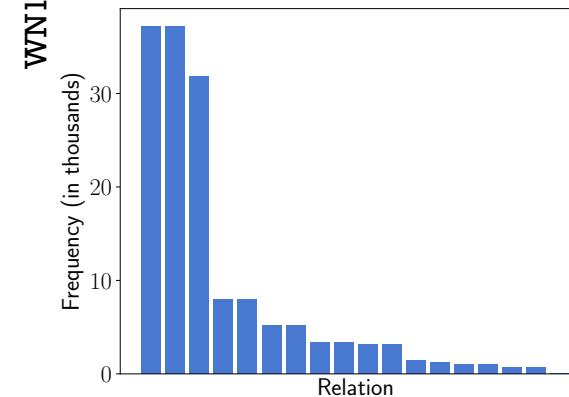
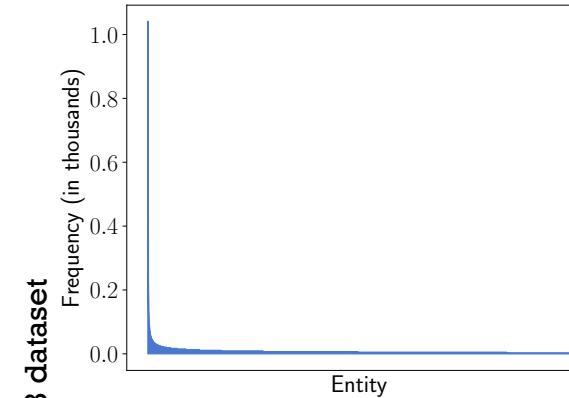
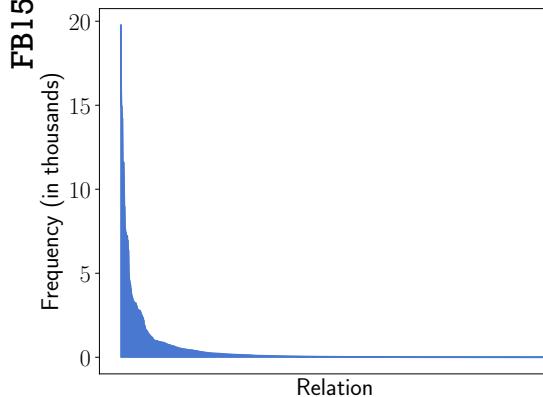
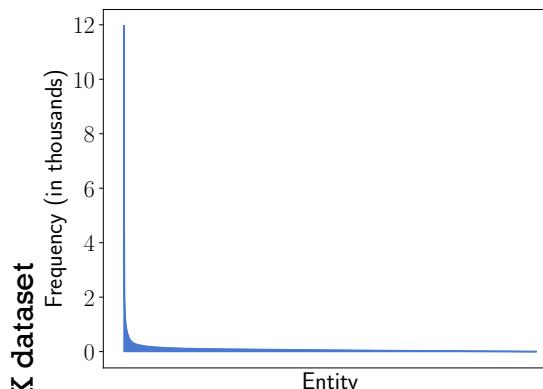
Simple Fix?



Stratified Hits@k

PROBLEM? KGS ARE BIASED

- Popularity Bias: popular items occur in more triples while less popular ones are under-represented.



SIMPLE FIX?

WEIGHT EACH INSTANCE BY THE
INVERSE OF THE FREQUENCY

DOESN'T WORK!

Problems:

- No correlation between entity and relation popularity in the same triple.
- We would like to be able to control how much focus is put towards the unpopular entities and relations.

	Number of triples (train/valid/test)	All Popular	All Unpopular	Mix of Popular and Unpopular
FB15K	483K/50K/59K	69,687	45,295	477,231
WN18	141K/5K/5K	7,612	26,691	177,139
YAGO3-10	1M/5K/5K	6,848	119,765	962,387

CURRENT EVALUATION METRICS

For each test triple (s, r, o) :

For all entities (e) in the graph except s :

Find the score of of the triple (e, r, o)

Rank all entities (e) in the graph based on their score.

$is_top_k = s$ is in the top k entities

$$hits@k = \frac{\sum_{r \in \mathcal{R}} hits@k_r \times |\mathcal{E}(r)|}{\sum_{r \in \mathcal{R}} |\mathcal{E}(r)|}$$

$$hits@k_r = \frac{1}{|\mathcal{E}(r)|} \sum_{(e_i, e_j) \in \mathcal{E}(r)} \frac{1[(e_i, r, e_j) \in top_k(e_i, r, *)] + 1[(e_i, r, e_j) \in top_k(*, r, e_j)]}{2}$$

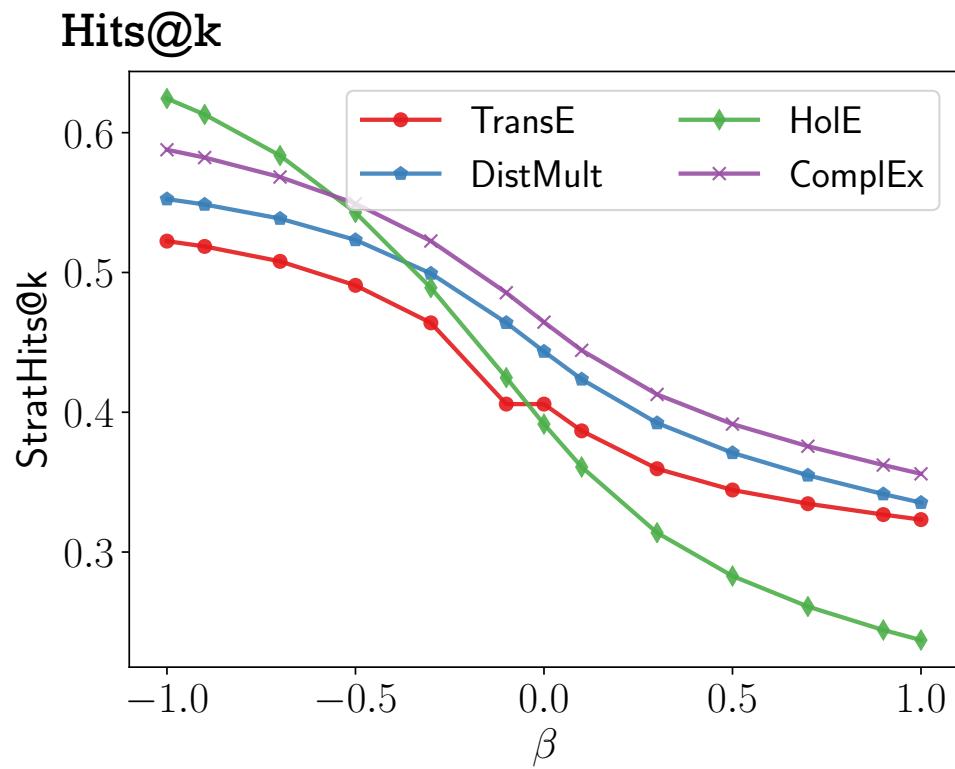
OUR PROPOSED POPULARITY AGNOSTIC EVALUATION: STRAT_HITS@K

$$hits@k = \frac{\sum_{r \in \mathcal{R}} w_r hits@k_r}{\sum_{r \in \mathcal{R}} w_r}$$

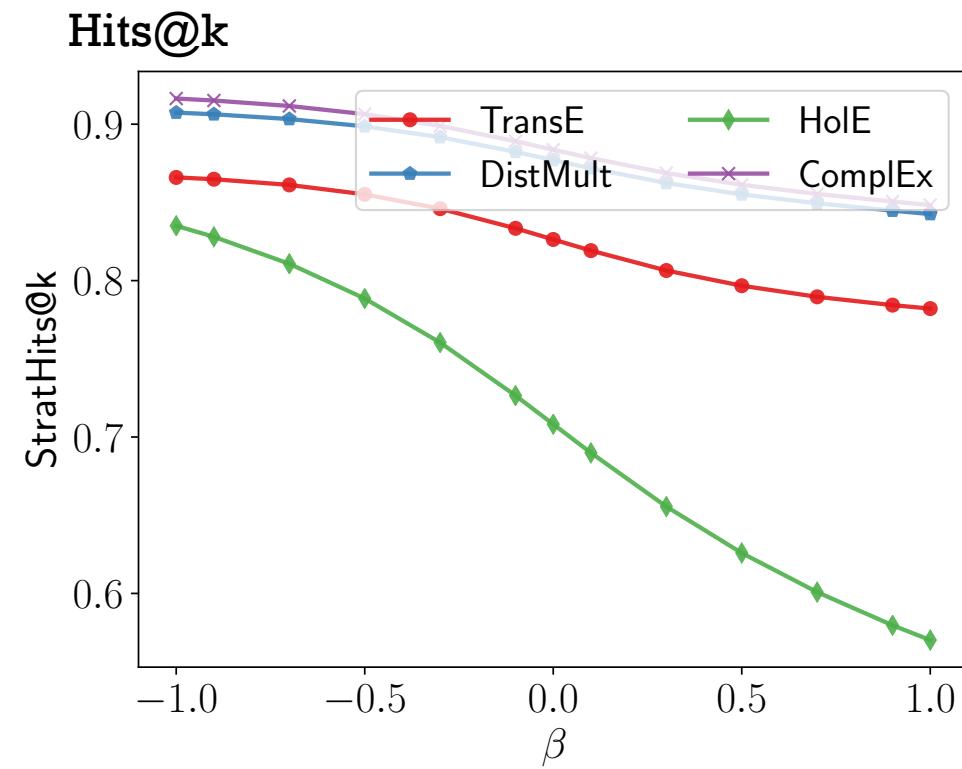
$$strat_hits@k_r = \frac{1}{|\mathcal{E}(r)|} \sum_{(e_i, e_j) \in \mathcal{E}(r)} \frac{w_{e_i} \mathbf{1}[(e_i, r, e_j) \in top_k(e_i, r, *)] + w_j \mathbf{1}[(e_i, r, e_j) \in top_k(*, r, e_j)]}{w_{e_i} + w_{e_j}}$$

$$w_x = \frac{1}{popularity(x)^\beta}$$

RESULTS



YAGO3-10 StratHits@10, $\beta_r = 0, \beta = \beta_e$



FB15K StratHits@10, $\beta_r = 0, \beta = \beta_e$

CONCLUSION

- There is popularity bias in knowledge graphs
- Hits@k is biased towards popular entities and relations and encourages development of biased models
- Strat-Hits@k evaluates the performance on popular and unpopular entities and relations.



THANK YOU!

Q&A