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Using Compositional Embeddings for Fact Checking

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DICE

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Introduction I

Why is fact-checking needed?

- Need for reliable data.

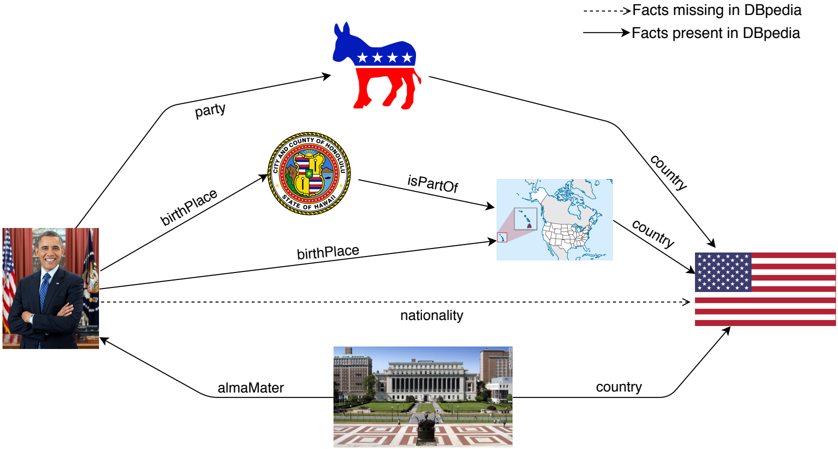


Image source: https://dice-research.org/COPAAL.

Introduction II

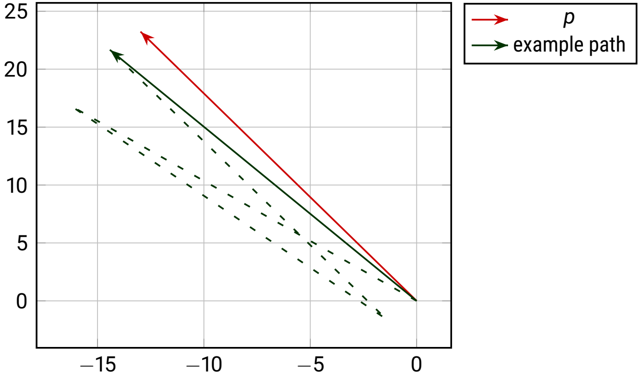
We propose **ESTHER**, a fact checker that acts on a continuous space:

- Path search leveraged by knowledge graph embedding models;
- Enables the augmentation of existing approaches.

Intuition

The embedding of the path is computed by combining the embeddings of the properties in $\vec{q}$:

$$\bigoplus_{i=1}^{|\vec{q}|} e(q_i) \approx e(p) \tag{1}$$



Search requirements

- Cost function:

$$\min(\varepsilon) = \min\left(||e(\vec{q}) - e(p)|| + \eta|\vec{q}|\right) \tag{2}$$

- Search space defined by a binary matrix $\mathcal{M}_{i,j}$:

$$\mathcal{M}_{i,j} = \begin{cases} 1, & \text{if properties } p_i \text{ and } p_j \text{ can be adjacent} \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

Search modes

- 5 different property-adjacency modes:

Strict equality (S) : $$\mathcal{M}_{i,j} = 1 \Leftrightarrow R'(p_i) = D'(p_j) \quad (4)$$

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$$\text{Irrelevant (I)}: \quad \forall p_i, p_j \in \mathbb{P}^*_{\mathcal{G}}, \mathcal{M}_{i,j} = 1 \tag{8}$$

Path search

1. Initialize priority queue;
   - $D(p) = D(p_i)$
2. Iterate queue in a sorted manner.
   - Stop properties:

$$R(p) = R(p_{i-1}) \tag{9}$$

   - Intermediate properties:

$$D(p_i) = R(p_{i-1}) \tag{10}$$

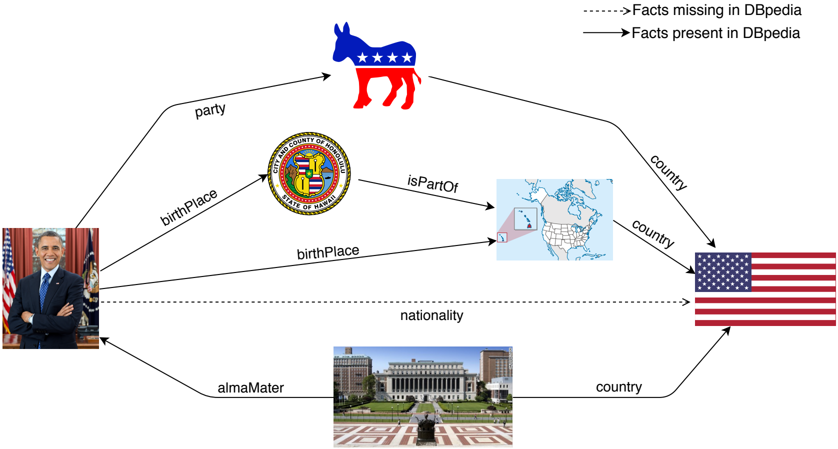
Subject to

- maximum path length k;
- maximum number of paths N;
- cycle-free paths indicator.

Statement validation at runtime

1. Corroborative path check between subject and object;
2. Summarize the found paths' scores.

$$\tau = \sqrt[3]{\frac{1}{|Z|} \sum_{\zeta_{p,\vec{q}} \in Z} \zeta_{p,\vec{q}}^{3}} \tag{11}$$



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ESTHER

Path found	A^* cost	PNPMI
$\xrightarrow{\texttt{place\_of\_birth}} \xleftarrow{\texttt{marriage.location\_of\_ceremony}} \xrightarrow{\texttt{nationality}}$	7.87	0.47
$\xrightarrow{\texttt{people.place\_lived.location}} \xleftarrow{\texttt{place\_of\_birth}} \xrightarrow{\texttt{sibling}} \xrightarrow{\texttt{nationality}}$	9.30	0.27
$\xrightarrow{\texttt{languages}} \xrightarrow{\texttt{countries\_spoken\_in}}$	10.88	0.07

- Example paths for the predicate `nationality` found by ESTHER in the FB15k-237 dataset;
- The veracity score is higher for lower search scores.

Experiment setup

Datasets:

- FB15K-237 [1];
- WN18RR [2].

KGE models:

- TransE [3];
- RotatE [4];
- DensE [5].

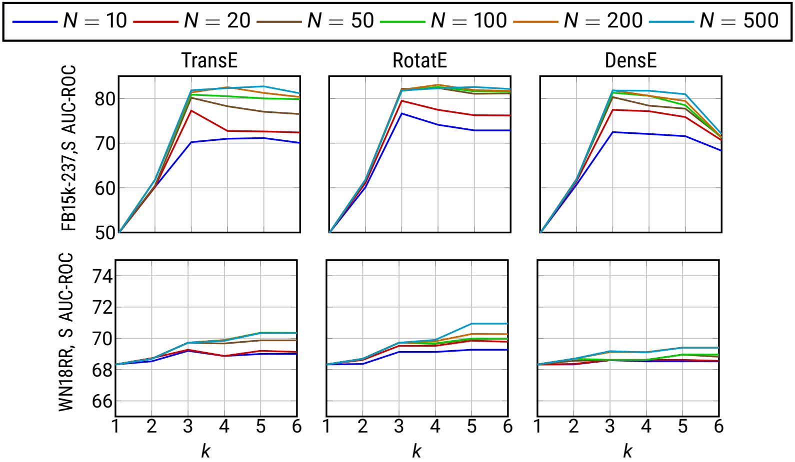
Evaluation

Different configurations experiment I

	KGE	Mode	Loops	k	N	AUC-ROC
FB15k-237	TransE	S	Y	4	200	82.53
	RotatE	S	Y	4	200	**83.07**
	DensE	S	Y	3	200	81.82
WN18RR	TransE	I	Y	3	500	**77.55**
	RotatE	I	Y	5	500	73.15
	DensE	I	Y	2	500	71.19

Evaluation

Different configurations experiment II



Evaluation

Comparison with other approaches

	AUC-ROC	
Approach	FB15k-237	WN18RR
ESTHER	83.07	77.55
COPAAL [6]	77.42	68.11
KS [7]	**87.59**	**86.44**
Katz [8]	82.80	69.96
Pathent [9]	73.46	79.98
Simrank [10]	40.07	44.15
AdamicAdar [11]	72.12	59.86
Jaccard [12]	38.56	42.34
Degree product [13]	77.11	65.57
PredPath [14]	69.87	80.20
PRA [15]	08.53	71.80

Evaluation

Combinations with ESTHER

	AUC-ROC	
Approach	FB15k-237	WN18RR
COPAAL	87.12(+09.70)	79.38(+11.27)
KS	89.97(+02.38)	**94.92**(+08.48)
Katz	86.30(+03.50)	86.22(+16.26)
Pathent	84.75(+11.29)	86.94(+06.96)
Simrank	81.60(+41.53)	82.47(+38.32)
AdamicAdar	85.36(+13.24)	84.22(+24.36)
Jaccard	82.91(+44.35)	87.18(+44.84)
Degree product	83.28(+06.17)	87.43(+21.86)
PredPath	83.76(+13.89)	82.20(+02.00)
PRA	**97.44**(+88.91)	75.35(+03.55)

Evaluation

Runtime experiment

Approach		FB15k-237	WN18RR
ESTHER	Pre-processing	1 684	99
	Fact checking	375	1166
	Sum	2 059	1265
COPAAL		408	67
KS		9 702	3 259
Katz		11 227	722
Pathent		2 324	690
Simrank		4 003	3 219
AdamicAdar		2	1
Jaccard		2	1
Degree product		2	1
PredPath		2 400	660
PRA		10 654	13 046

Summary

- First path-based approach on continuous representations;
- ESTHER as a standalone system can be competitive;
- The performance improved when combined with other approaches.

https://github.com/dice-group/esther/

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