Knowledge Graph Embedding with Diversity of Structures

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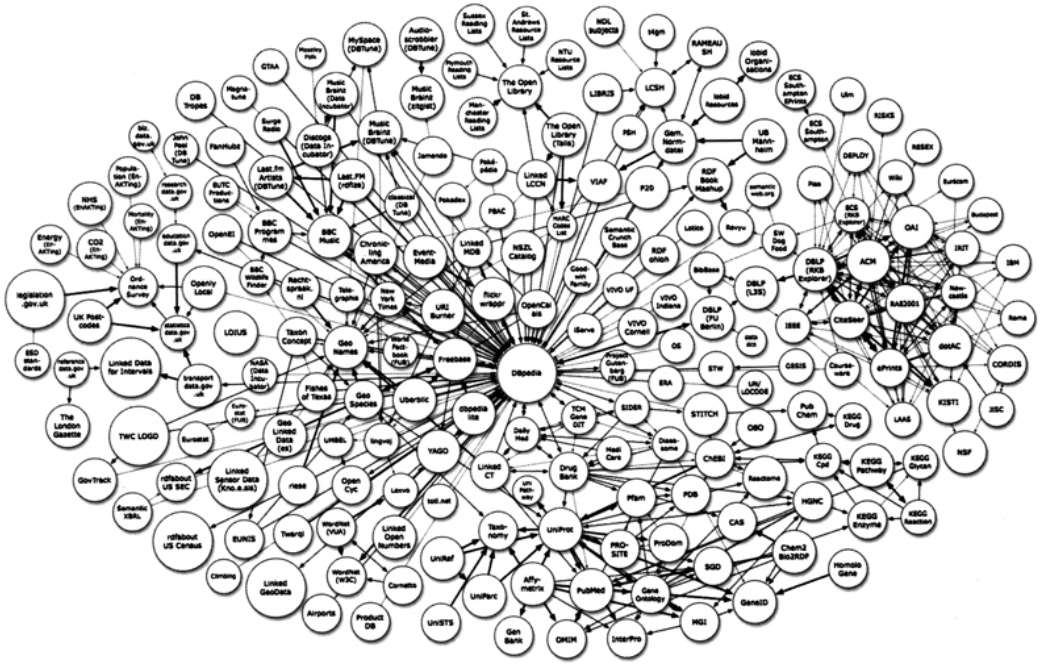
What is knowledge graph?

What is Knowledge graph embedding?

What is diversity of structures?

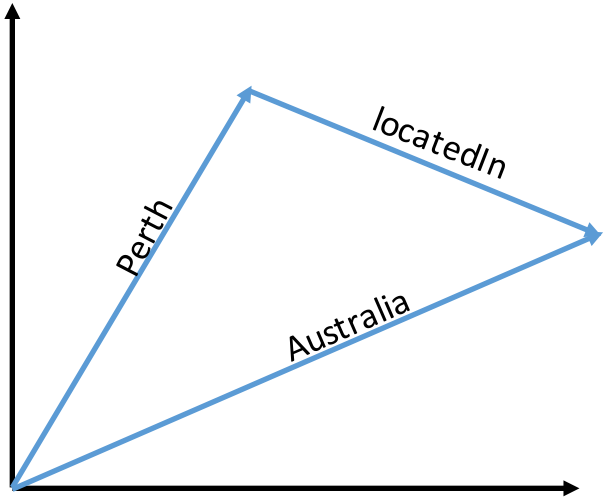
What is knowledge graph?



Triple example:
<Perth, locatedIn, Australia>

Famous large KGs:
WordNet,
Freebase,
YAGO,
Nell,
…

What is knowledge graph embedding?

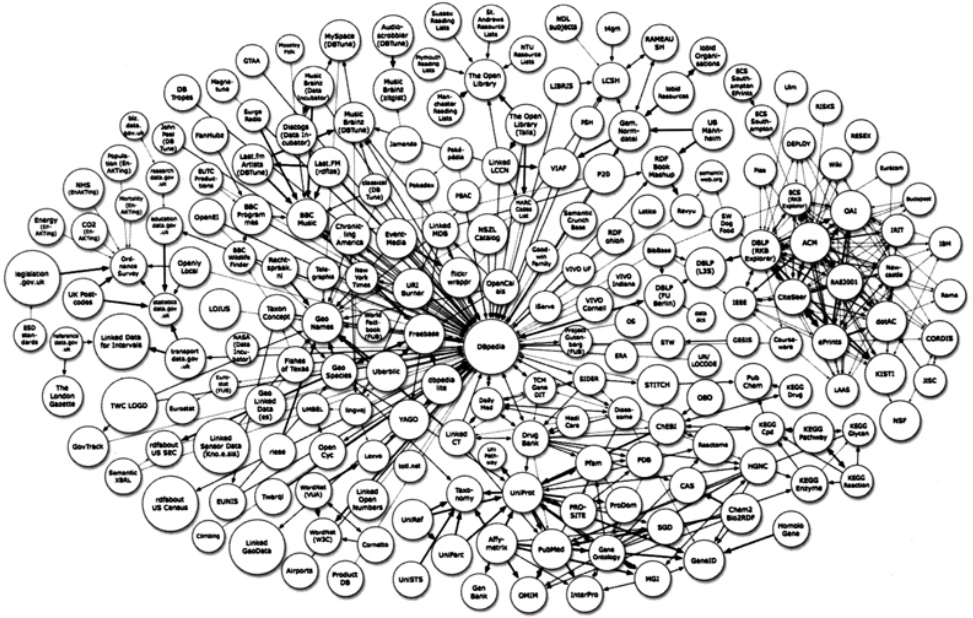


Translate-based methods

for true triple <e_1 , r , e_2>: $\boldsymbol{e}_1 + \boldsymbol{r} = \boldsymbol{e}_2$

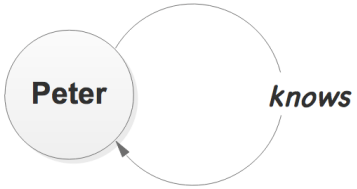
TransE, TransH, TransR, TransD

What is diversity of structures?



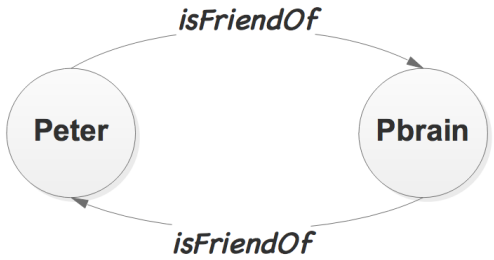
“One-relation-circle”

What is diversity of structures ? ---- ORC structures



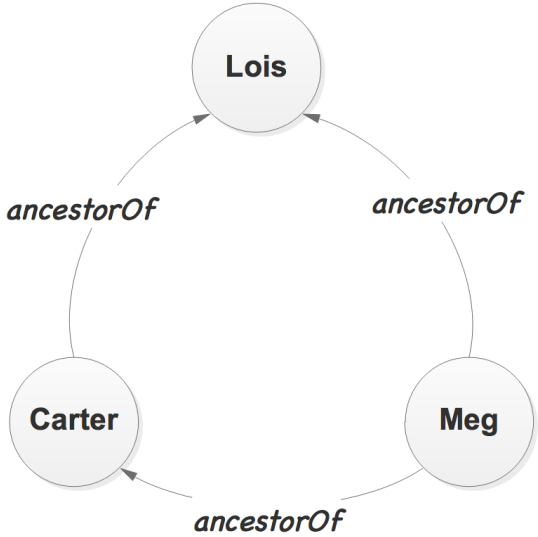
(a) example for C1

reflexive object properties



(b) example for C2

symmetric object properties



(c) example for C3

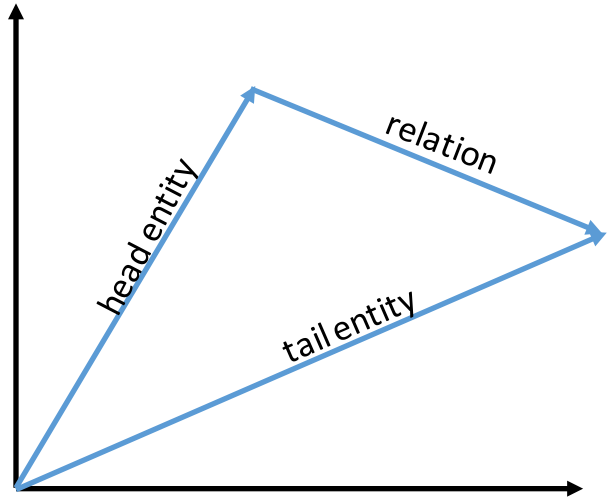
transitive object properties

Diversity of structures ---- Is ORC structures common in KG ?

	C1	C2	C3	ORC
WN18	9(0.00%)	30048(19.84%)	2237(1.48%)	32294(21.68%)
FB15k	2250(0.38%)	52376(8.84%)	59620(10.07)	114241(19.29%)

Table: the number and percent of entities which construct at least one of C1, C2 or C3

Why previous translate-based methods can't encode ORC structures?



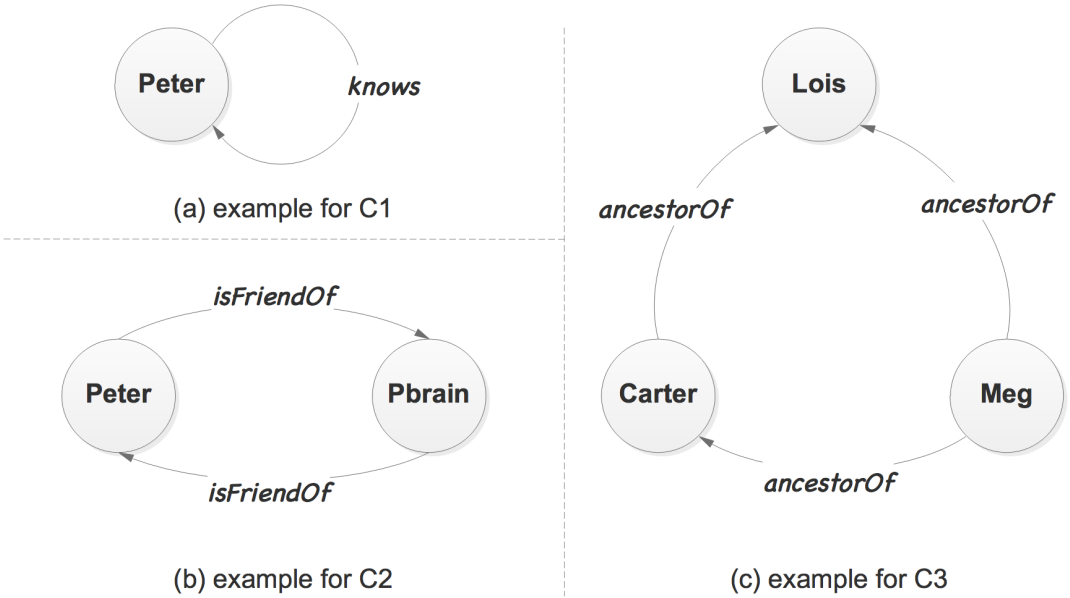
for true triple <e_1 , r , e_2>: $\boldsymbol{e_1 + r = e_2}$

C1: <e_1, r, e_1>
$\boldsymbol{e_1 + r = e_1} \Rightarrow \boldsymbol{r = 0}$

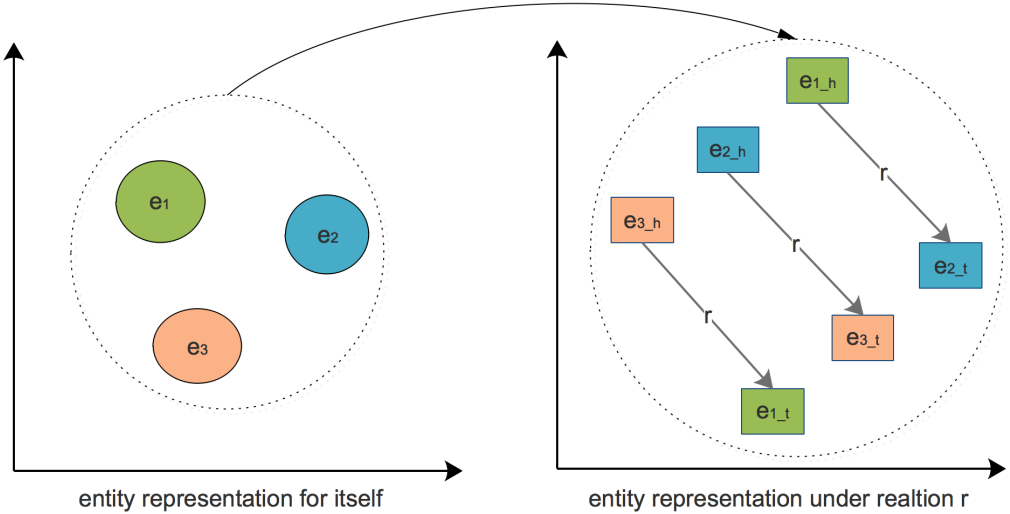
C2: <e_1, r, e_2>, <e_2, r, e_1>
$\boldsymbol{e_1 + r = e_2,\ e_2 + r = e_1} \Rightarrow \boldsymbol{r = 0}$

C3: <e_1, r, e_2>, <e_2, r, e_3>, <e_1, r, e_3>
$\boldsymbol{e_1 + r = e_1,\ e_2 + r = e_3,\ e_1 + r = e_3} \Rightarrow \boldsymbol{r = 0}$

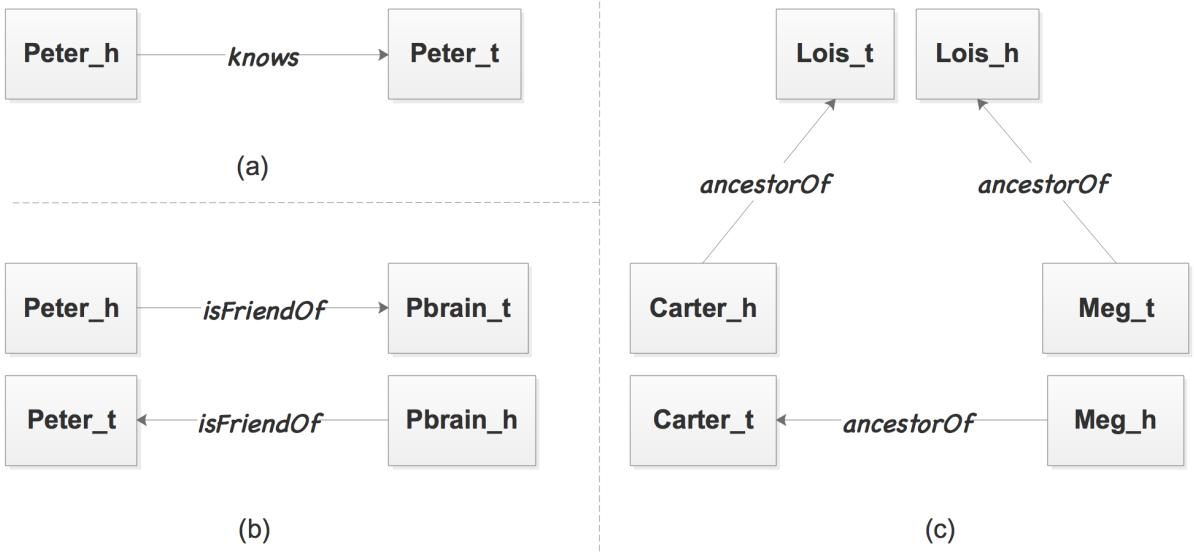
Why previous translate-based methods can't encode ORC structures?



Key idea to decompose ORC structures



Key idea to decompose ORC structures



Our method

Score function for triple <e_1, r, e_2>:

$$f_r(e_1, e_2) = \| e_{1h} + r - e_{2t} \|_{L1/L2}$$

Loss function:

$$L = \sum_{(e_1, r, e_2) \in \Delta} \sum_{(e_1', r', e_2') \in \Delta'} [f_r(e_1, e_2) + \gamma - f_r(e_1', e_2')]_+$$

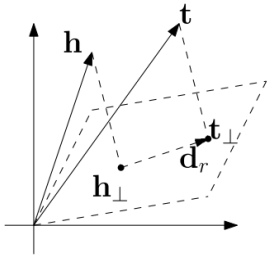
where:

$$[x]_+ = \max(0, x)$$

Apply our method to TransH, TransR and TransD

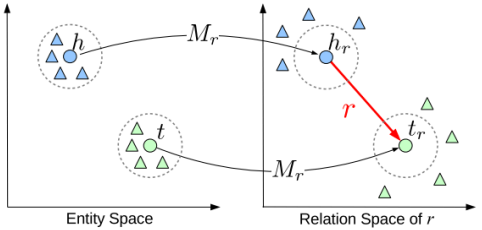
TransH(dORC)

$$e_{1h} = e_1 - w_{rh}^{\top} e_1 \cdot w_{rh}$$
$$e_{2t} = e_2 - w_{rt}^{\top} e_2 \cdot w_{rt}$$



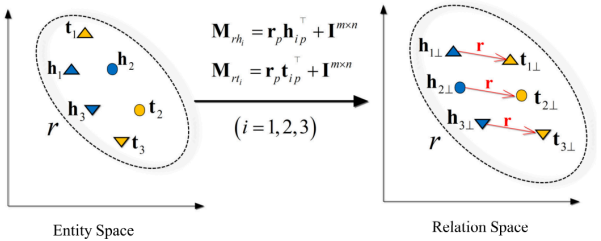
TransR(dORC)

$$e_{1h} = M_{rh} \cdot e_1$$
$$e_{2t} = M_{rt} \cdot e_2$$



TransD(dORC)

$$e_{1h} = M_{rh} \cdot e_1, \quad e_{2t} = M_{rt} \cdot e_2$$
$$M_{rh} = r_h e_{1p}^{\top} + I^{d \times d}, \quad M_{rt} = r_t e_{2p}^{\top} + I^{d \times d}$$



Experiment results

Link prediction:
<e1, r, ?> or <?, r , e2>

mean rank & hit@10

Table 3: Results on WN18 for Link Prediction

Method	Mean Rank		Hit@10(%)	
	Raw	Filter	Raw	Filter
Unstructured [1]	315	304	35.3	38.2
RESCAL [13]	1180	1163	37.2	52.8
SE [2]	1011	985	68.5	80.5
SME(linear) [1]	545	533	65.1	74.1
SME(Bilinear) [1]	526	509	54.7	61.3
LFM [17]	469	456	71.4	81.6
TransE [6]	263	251	75.4	89.2
TransH(unif) [29]	318	303	75.4	86.7
TransH(bern) [29]	401	388	73.0	82.3
TransR(bern) [26]	238	225	79.8	92.0
TransR(unif) [26]	232	219	78.3	91.7
CTransR(unif) [26]	243	230	78.9	92.3
CTransR(bern) [26]	231	218	79.4	92.3
TransD(unif) [9]	242	229	79.2	92.5
TransD(bern) [9]	224	212	79.6	92.2
TransH(dORC)(unif)	298	286	79.4	**93.3**
TransH(dORC)(bern)	278	271	80.2	93.0
TransR(dORC)(unif)	224	212	79.3	92.1
TransR(dORC)(bern)	231	219	**80.9**	92.5
TransD(dORC)(bern)	**205**	**192**	79.7	92.4

Thanks