HyTE: Hyperplane-based Temporally aware Knowledge Graph Embedding

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Related work

- TransE: Minimize margin loss

$$f(h, r, t) = \|e_h + e_r - e_t\|_{l_1/l_2},$$

- TransH: Minimize distance loss with respect to a given hyperplane determined by relation

$$f_\tau(h, r, t) = \|P_\tau(e_h) + P_\tau(e_r) - P_\tau(e_t)\|_{l_1/l_2}.$$

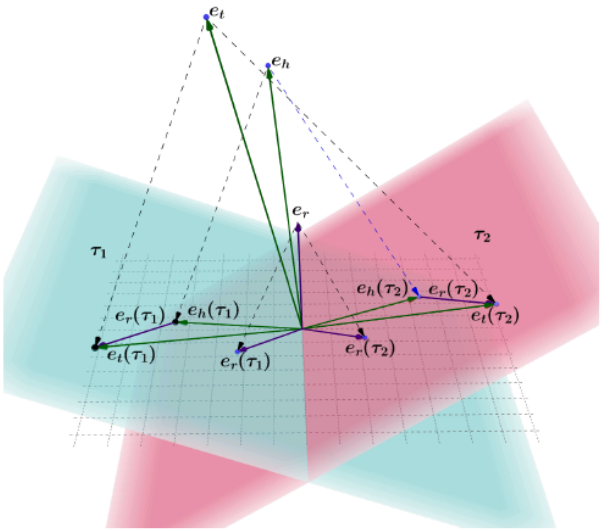
Motivation

- The past methods including TransE, TransD, GCN mainly focus on static graph.
- However, in some Knowledge Graphs like YAGO and Wikidata, the temporal scopes information is increasingly available.
- Represent relations in quadruples (*h, r, t,* $[\tau_s, \tau_e]$) instead of triples (*h, r, t*), which means triple (*h, r, t*) is valid during $[\tau_s, \tau_e]$ timestamps.
- How to incorporate the time information in order to understand and utilize the Knowledge Graph better?

Proposed Method: HyTE

- Represent time as a hyperplane (in fact, is a normal vector).
- Project embedding of each triple to the time hyperplane when the triple is valid.
- The optimize the global loss:

$$\mathcal{L} = \sum_{\tau \in [T]} \sum_{x \in \mathcal{D}_\tau^+} \sum_{y \in \mathcal{D}_\tau^-} \max(0, f_\tau(x) - f_\tau(y) + \gamma),$$



Experiment Result

- It outperforms the baseline methods, but is not comparable to the state-out-the-art method.
- It can deal with **temporal scoping of facts** task, which other model can not.
  To be specific, **temporal scoping of facts** is a link prediction task constrained in a given time interval.

Dataset	YAGO11K				Wikidata12K			
Metric	Mean Rank		Hits@10(%)		Mean Rank		Hits@10(%)	
	tail	head	tail	head	tail	head	tail	head
Trans-E (Bordes et al., 2013)	504	2020	4.4	1.2	520	740	11.0	6.0
TransH (Wang et al., 2014)	354	1808	5.8	1.5	423	648	23.7	11.8
HolE (Nickel et al., 2016b)	1828	1953	29.4	13.7	734	808	25.0	12.3
t-TransE (Jiang et al., 2016)	292	1692	6.2	1.3	283	413	24.5	14.5
HyTE	**107**	**1069**	**38.4**	**16.0**	**179**	**237**	**41.6**	**25.0**

Reflection on our task

- Use YAGO and Wikidata to get the time-aware dataset.
- Compete with baseline rather than state-of-the-art work(?)