Improving Hypernymy Prediction via Taxonomy Enhanced Adversarial Learning

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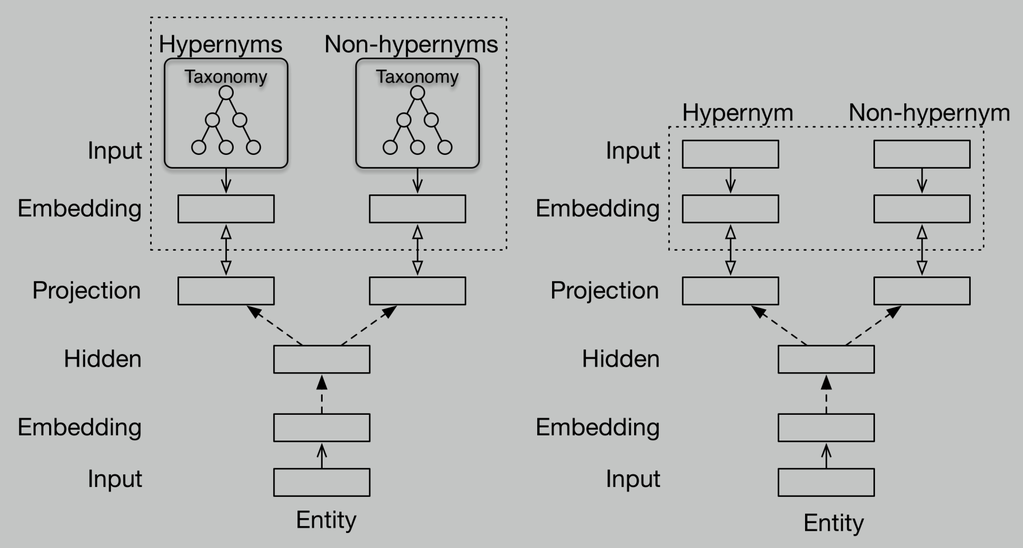
Introduction

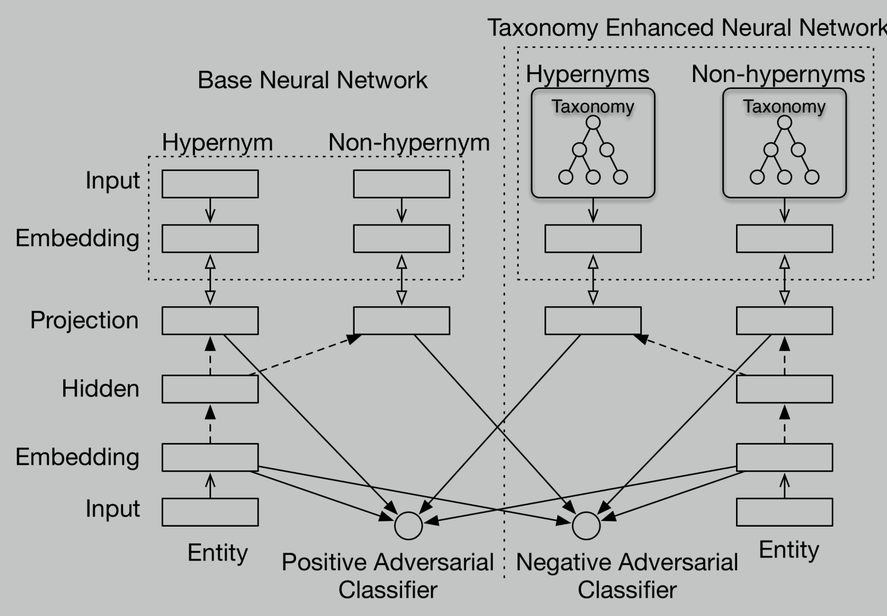
- Learning hypernymy relations is essential for taxonomy construction, fine-grained entity categorization, knowledge base population, etc.
- Few methods have fully exploited the large number of hypernymy relations in Web-scale taxonomies to improve the performance of hypernymy prediction.
- We introduce the Taxonomy Enhanced Adversarial Learning (TEAL) framework for hypernymy prediction.

The TEAL Framework

- Model 1: U-TEAL
  - Unsupervised neural network-based hypernymy measure
- Model 2: S-TEAL
  - Supervised neural network-based hypernymy classifier
- Model 3: AS-TEAL
  - Adversarial supervised neural network-based hypernymy classifier
  - Fusing hypernymy relations from training training data and existing taxonomies by learning two adversarial classifiers



(a) U–TEAL: Neural Network + Unsupervised Measure (b) S–TEAL: Neural Network + SVM



(c) AS–TEAL: Two Neural Networks + Two Adversarial Classifiers + SVM

Important References

[1] Fu et al. Learning semantic hierarchies via word embeddings. *ACL* 2014.

[2] Luu et al. Learning term embeddings for taxonomic relation identification using dynamic weighting neural network. *EMNLP* 2016.

[3] Nguyen et al. Hierarchical embeddings for hypernymy detection and directionality. *EMNLP* 2017.

[4] Wang et al. Transductive non-linear learning for Chinese hypernym prediction. *ACL* 2017.

[5] Wu et al. Probase: a probabilistic taxonomy for text understanding. *SIGMOD* 2012.

[6] Yu et al. Learning term embeddings for hypernymy identification. *IJCAI* 2015.

Experiments

- Taxonomy Data
  - Source: IS-A relations sampled from Microsoft Concept Graph
  - Statistics: 2,844,951 IS-A relations (after confidence-based filtering)
- Task 1: Unsupervised Hypernymy Prediction
  - BLESS: Hypernymy vs. Non-hypernymy
  - WBLESS: Hypernymy vs. Other relations

Method	BLESS	WBLESS
Santus et al. (2014)	0.87	-
Weeds et al. (2014)	-	0.75
Kiela et al. (2015)	0.88	0.75
Nguyen et al. (2017)	0.92	0.87
Roller et al. (2018)	0.96	0.87
U-TEAL	0.96	0.88

- Task 2: Supervised Hypernymy Detection
  - BLESS and ENTAILMENT: General-domain datasets

Method	BLESS	ENTAILMENT
Mikolov et al. (2013)	0.84	0.83
Yu et al. (2015)	0.90	0.87
Tuan et al. (2016)	0.93	0.91
Nguyen et al. (2017)	0.94	0.91
S-TEAL	0.95	0.87
AS-TEAL	0.96	0.91

  - ANIMAL, PLANT and VEHICLE: Domain-specific datasets

Method	ANIMAL	PLANT	VEHICLE
Yu et al. (2015)	0.67	0.65	0.70
Mikolov et al. (2013)	0.80	0.81	0.82
Tuan et al. (2016)	0.89	0.92	0.89
S-TEAL	0.89	0.93	0.91
AS-TEAL	0.92	0.94	0.93

- Task 3: Graded Lexical Entailment
  - Goal: Predicting the degree of hypernymy in the form of a real number (e.g., chemistry-science: 10.0, ear-head: 0.0)

Model	ρ (Spearman's rank correlation)
FR	0.283
PARAGRAM	0.267
SLQS	0.228
VIS	0.253
U-TEAL	0.463

- Task 4: Experiments over Chinese Language

Dataset	FD			BK		
Method	Pre	Rec	F1	Pre	Rec	F1
Fu et al. (2014)	0.66	0.59	0.62	0.72	0.67	0.70
Mirza et al. (2016)	0.67	0.75	0.69	0.80	0.75	0.78
Wang and He (2016)	0.69	0.64	0.66	0.73	0.69	0.71
Wang et al. (2017)	0.72	0.70	0.71	0.83	0.80	0.82
U-TEAL	0.68	0.62	0.65	0.83	0.82	0.83
S-TEAL	0.69	0.68	0.69	0.78	0.86	0.83

- Task 5: Enriching Microsoft Concept Graph
  - Goal: Discovering new hypernymy relations for concepts in Microsoft Concept Graph
  - Evaluation: "#Corr" and "#Tot" refer to the numbers of extracted correct and all relations

Concept	#Corr/#Tot	Pre	Concept	#Corr#Tot	Pre
material	78/102	0.76	goods	20/20	1.00
person	17/19	0.89	sector	18/20	0.90
group	37/43	0.86	component	76/80	0.95
technology	12/14	0.86	individual	24/24	1.00
provision	12/15	1.00	location	8/9	0.89
Total	302/346	0.87			

Conclusion

- We present the TEAL framework to address a series of hypernymy prediction tasks, including three models, i.e., the unsupervised model (U-TEAL), the supervised model (S-TEAL) and the adversarial supervised model (AS-TEAL).
- The adversarial learning algorithm in AS-TEAL enhances the performance of hypernymy predication by leveraging the knowledge in taxonomies.