Just Rank: Rethinking Evaluation with Word and Sentence Similarities

Bin Wang, C.-C. Jay Kuo, Haizhou Li

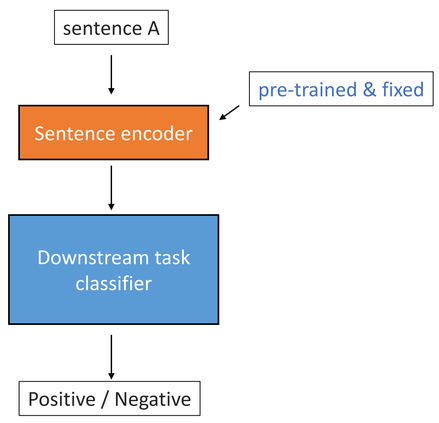
[1]National University of Singapore, Singapore [2]University of Southern California, USA
[3]The Chinese University of Hong Kong, Shenzhen, China [4]Kriston AI

Contributions

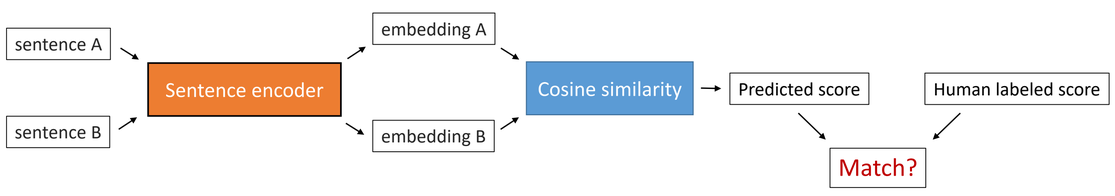
- Rethinking the Pros & Cons for using similarity tasks as the *de facto* evaluation method for word and sentence embedding evaluation.
- Discuss the problems for similarity evaluation by considering the recent development of embedding models.
- Propose a new intrinsic evaluation method *EvalRank* for word and sentence embedding and demonstrate better correlation with downstream tasks.

Background

- Evaluation of embeddings
  - Intrinsic evaluation
    - Similarity
    - Analogy
    - Probing
  - Extrinsic evaluation
    - Sentiment classification
    - Topic classification



- Similarity evaluation scheme (both words & sentences)



Problems with Similarity Evaluation

Multifaceted Relations

- Concept of similarity and relatedness is not well defined
  - Entailment
  - Contradictory
  - Syntactic
- Annotation process is not intuitive to humans[1]

Similarity-level:
synonym > hypernym > antonym
Relatedness-level:
synonym > hypernym ≈ antonym

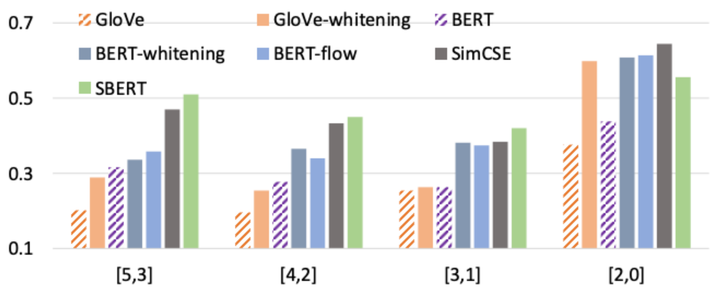
Pairs with score 2:
"share some details"
Pairs with score 1:
"on the same topic"

Weak Corr. w/ Downstream

- Good performance on similarity tasks does not guarantee good performance on downstream tasks
  - Different properties of interest
    - Mimic human perception V.S. Real-world application
  - Different ways of inference
    - Simple metric (cosine) V.S. Non-linear classifier (MLP, LSTM, Transformers)

Overfitting

- Current models are optimizing towards certain evaluation metrics
  - Cosine similarity
  - Whitening tricks



Rank	cos	l_2
SBERT	1	2↓
SimCSE	2	1↑
BERT-avg	5	3↑
BERT-flow	4	4
BERT-whitening	3	5↓

New Method: *EvalRank*

Motivations

- Concept network in Spread Activation Theory (SAT)[2]
  - Most similar pairs are less noisy to label
  - Measurable by simple distance metrics (cosine, l2)
  - More important to downstream tasks

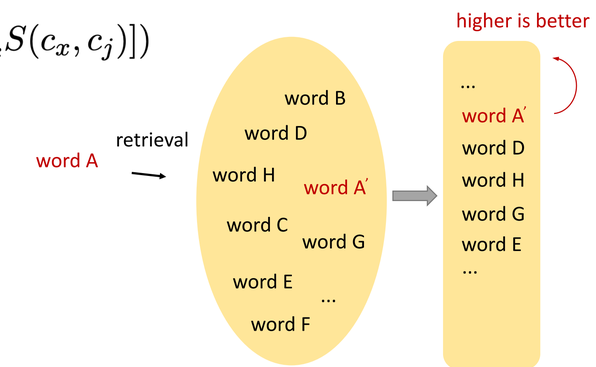
Methodology

- Datasets
  - Word: Pos pairs: 5514; Background: 22,207
  - Sentence: Pos pairs: 6989; Background: 24,957
- Retrieval-based ranking

$$rank_i = rank(S(c_x, c_y), [||_{j=1, j\neq x}^{n} S(c_x, c_j)])$$

$$MRR = \frac{1}{m}\sum_{i=1}^{m}\frac{1}{rank_i}$$

$$Hits@k = \frac{1}{m}\sum_{i=1}^{m}\mathbb{1}[rank_i \leq k]$$



Experimental Results

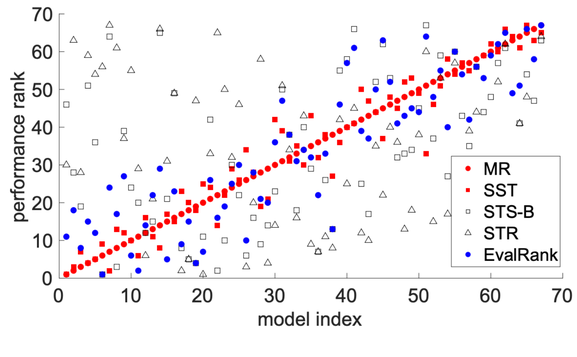
- Measuring correlation with downstream tasks
- Word-level (38 word embedding variants)

		SCICITE	MR	CR	MPQA	SUBJ	SST2	SST5	TREC	MRPC	SICK-E
WS-353-All		62.87	43.68	40.94	37.50	15.57	41.65	45.03	34.70	8.98	57.96
WS-353-Rel		66.13	47.92	45.15	41.77	11.65	47.25	48.18	26.36	20.56	61.83
WS-353-Sim		67.86	45.94	43.97	38.68	17.41	44.03	50.32	34.85	10.67	56.13
RW-STANFORD		75.56	74.65	55.35	66.08	46.82	81.50	68.25	45.91	13.08	43.29
MEN-TR-3K		66.91	44.15	45.37	39.14	1.70	38.51	42.11	22.82	28.63	**71.26**
MTURK-287		68.48	65.95	48.01	52.36	31.94	71.96	58.01	29.22	7.54	36.23
MTURK-771		79.93	60.87	49.45	57.92	24.04	62.75	62.03	29.14	17.44	60.23
SIMLEX-999		68.20	48.02	40.90	46.43	19.03	47.30	50.95	38.14	15.32	60.26
SIMVERB-3500		65.13	45.60	36.95	47.04	21.57	45.16	48.56	41.74	10.70	58.08
EvalRank	MRR	89.96	87.91	68.23	78.03	51.35	91.54	83.36	48.15	25.70	61.34
	Hits@1	85.91	83.69	66.93	81.43	**55.95**	89.74	79.46	43.53	28.82	53.86
	Hits@3	**90.11**	**88.82**	**69.92**	**82.05**	54.52	**93.32**	**84.41**	**48.44**	**30.87**	62.77

- Sentence-level (67 sentence embedding variants)

		SCICITE	MR	CR	MPQA	SUBJ	SST2	SST5	TREC
STS12		32.96	38.62	44.77	31.52	21.76	33.79	35.68	30.79
STS13		22.04	32.62	41.23	12.39	7.64	26.45	22.98	12.16
STS14		25.91	34.77	41.89	19.23	10.13	29.20	26.82	17.70
STS15		31.84	40.64	48.11	25.12	16.48	35.50	33.30	24.70
STS16		29.56	40.14	51.66	14.35	16.53	33.61	29.44	21.43
STS-Benchmark		32.99	46.03	52.78	21.09	26.47	40.41	36.75	34.64
SICK-Relatedness		40.38	38.51	50.68	29.87	18.87	34.54	36.73	25.25
STR		-14.48	-8.38	-7.79	-29.57	-23.91	-16.33	-22.77	-14.30
EvalRank	MRR	65.95	83.43	87.08	43.93	72.72	80.97	74.16	76.74
	Hits@1	**69.01**	**85.39**	**89.36**	**45.81**	**74.93**	**82.65**	**76.65**	**78.72**
	Hits@3	63.35	83.92	85.43	41.24	70.98	80.36	72.05	74.70

- Visualization



Conclusion and Future Work

- Discussion the potential problems with only using similarity evaluation as the intrinsic evaluation method for word and sentence embeddings.
- Propose a new evaluation method called *EvalRank* which frames the evaluation as a retrieval task.
- Future work
  - Dataset expansion; Domain/Task/Relation-specific retrieval;

[1] Abdalla, Mohamed, Krishnapriya Vishnubhotla, and Saif M. Mohammad. "What Makes Sentences Semantically Related: A Textual Relatedness Dataset and Empirical Study." arXiv:2110.04845 (2021).
[2] Collins, Allan M., and Elizabeth F. Loftus. "A spreading-activation theory of semantic processing." Psychological review 82.6 (1975): 407.

Code: https://github.com/BinWang28/EvalRank-Embedding-Evaluation

Correspondence: Bin Wang, National University of Singapore
Email: bin.wang@nus.edu.sg