Subword-level Word Vector Representations for Korean

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Introduction

Background

- Research on distributed word representations is focused on widely-used languages such as English. Although the same methods can be used for other languages, language-specific knowledge can enhance the accuracy and richness of word vector representations.
- Despite their effectiveness in capturing syntactic features from subword features of diverse languages, decomposing a word into a set of n-grams and learning n-gram vectors does not consider the unique linguistic structures of various languages.

Contribution

- Our first contribution is the method to decompose the words into both character-level units and *jamo*-level units and train the subword vectors through the Skip-Gram model.
- Our second major contribution is the Korean evaluation datasets for word similarity and analogy tasks, a translation of the WS-353 with annotations by 14 Korean native speakers, and 10,000 items for semantic and syntactic analogies, developed with Korean linguistic expertise.
- Using these datasets, we show that our model improves performance over other baseline methods without relying on external resources for word decomposition.

Experiments

Dataset

	# of words	# of sentences	# of unique words
Wikipedia	43.4M	3.3M	299,528
Online News	47.1M	3.2M	282,955
Sejong Corpus	31.4M	2.2M	231,332
Total	121.9M	8.8M	638,708

- We aggregate three sources to make the corpus containing 0.12 billion word tokens with 0.6 million unique words.
- Our model and all of the comparison models for training word vectors are trained over the collected corpus.

Evaluation Tasks

1) Word Similarity & Analogy

- We develop the evaluation datasets.
- Similarity: Spearman's correlation coefficient between the human judgment and model's cosine similarity for the similarity of word pairs are reported.
- Analogy: Rank-based measures may not be an appropriate measure since the total number of unique n-grams/words over the same corpus largely differ from each other. For fair comparison, cosine distances between the vector a+b−c and d of each categories are reported.

2) Sentiment Analysis

- Given a sequence of words, a trained classifier should predict the binary sentiment from the inputs while maintaining the input word vectors fixed.
- Based on part of the Naver Sentiment Corpus, single layer RNN is trained as a classifier for the task.

Subword-level Word Vectors for Korean

Decomposition of Korean Words

- Decompose a word to *jamo* sequence
  *Jamo*s have names that reflect the position in a character:
  1) *chosung* (syllable onset), 2) *joongsung* (syllable nucleus), 3) *jongsung* (syllable coda)
- Add empty jongsung symbol e such that a character always has 3 (jamos)
- Add start/end symbol < / > in the sequence

먹었다(ate) → <, ㅁ, ㅓ, ㄱ, ㅇ, ㅓ, ㅆ, ㄷ, ㅏ, e , >

Extracting n-grams for jamo sequence

- Character-level n-grams, Gct (ㅁ, ㅓ, ㄱ) , (ㅇ, ㅓ, ㅆ) , (ㄷ, ㅏ, e) , (ㅇ, ㅓ, ㅆ, ㄷ, ㅏ, e) ...
- Inter-character *jamo*-level n-grams, Gjt (<, ㅁ, ㅓ) , (ㄱ , ㅇ, ㅓ) , (ㅆ , ㄷ, ㅏ) , (ㅏ, e , >) ...

Subword Information Skip-Gram (SISG, a.k.a FastText)

- Constructing word vector from subword vectors : $z_t = \frac{1}{|G_{ct} + G_{jt}|}(\sum_{g_{ct} \in G_{ct}}^{|G_{ct}|} z_{g_{ct}} + \sum_{g_{jt} \in G_{jt}}^{|G_{jt}|} z_{g_{jt}})$
- SISG Binary Logistic Loss : $\ell = \log\left(1 + e^{-s(w_t, w_{t+j})}\right) + \sum_{n=1}^{n_c} \log(1 + e^{s(w_t, w_{t+j})})$
- Scoring Function : $s(w_t, w_{t+j}) = \frac{1}{|G_{ct} + G_{jt}|}(\sum_{g_{ct} \in G_{ct}}^{|G_{ct}|} z_{g_{ct}}^T v_{t+j} + \sum_{g_{jt} \in G_{jt}}^{|G_{jt}|} z_{g_{jt}}^T v_{t+j})$

Developing Evaluations Sets

Word Similarity (WS-353) for Korean

- 2 native speakers translated the original item pairs.
- 14 other native speakers annotated similarity scores of the pairs.
- Correlation between the original scores and the annotated scores of the translated pairs is 0.82.

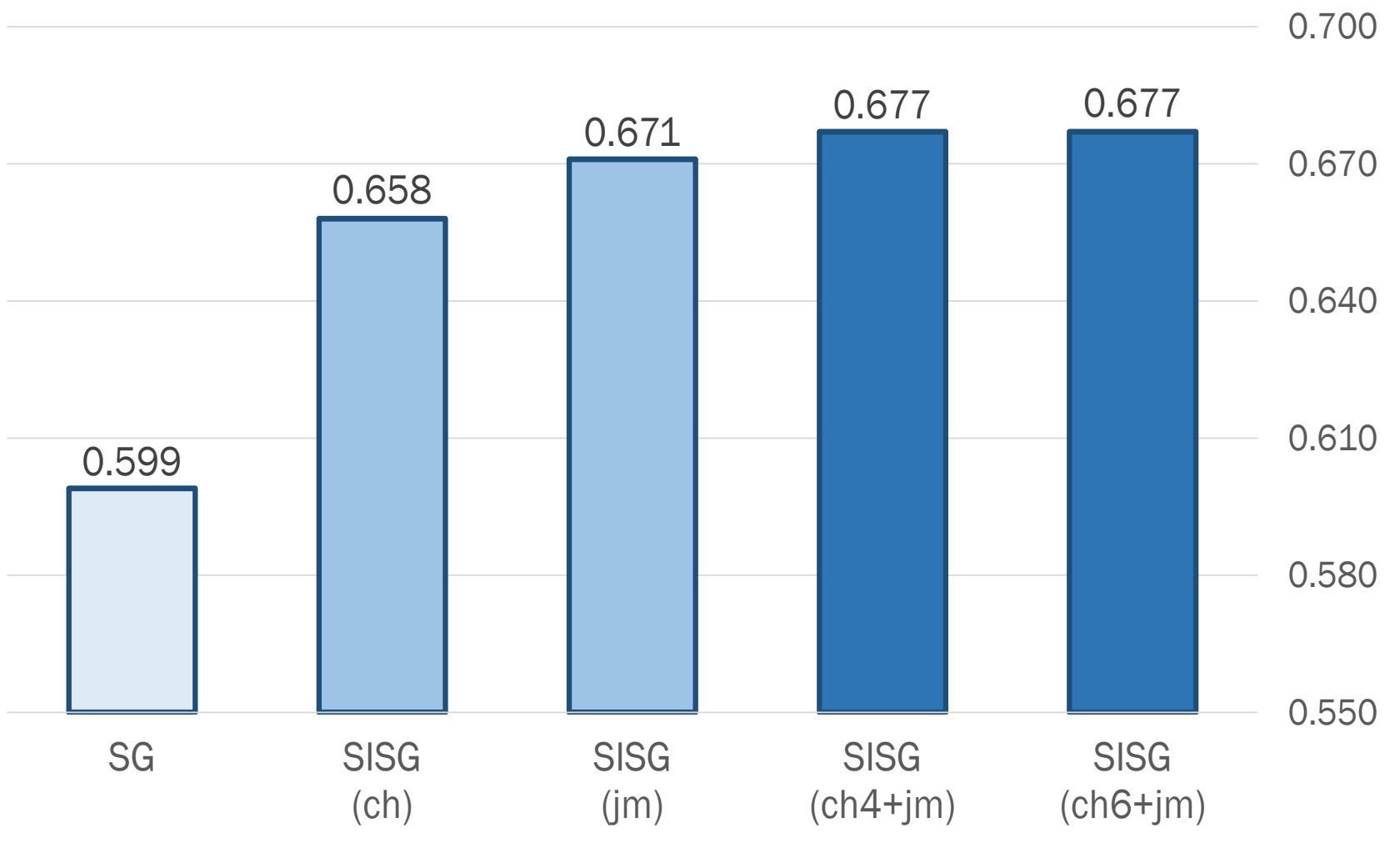
Word Analogy for Korean

- Semantic Features (5,000 items)
  - ○ *Capital-Country* : 아테네Athens : 그리스Greece = 바그다드Baghdad : 이라크Iraq
  - ○ *Male-Female* : 왕자prince:공주princess = 신사gentlemen:숙녀ladies
  - ○ *Name-Nationality* : 간디Gandhi : 인도India = 링컨Lincoln : 미국USA
  - ○ *Country-Language* : 아르헨티나Argentina : 스페인어Spanish = 미국USA : 영어English
  - ○ *Miscellaneous* : 개구리Frog : 올챙이tadpole = 말horse : 망아지pony
- Syntactic Features (5,000 items)
  - ○ *Case* : 교수Professor : 교수가Professor+case가 = 축구soccer : 축구가soccer+case가
  - ○ *Tense* : 싸우다fight : 싸웠다fought = 오다come : 왔다came
  - ○ *Voice* : 팔았다sold : 팔렸다be sold = 평가했다evaluated : 평가됐다was evaluated
  - ○ *Verb* : 가다go : 가고go+form고 = 쓰다write : 쓰고write+form고
  - ○ *Honorific* :도왔다helped : 도우셨다helped+honorific시 = 됐다done : 되셨다done+honorific시

* Publicly available at : https://github.com/SungjoonPark/KoreanWordVectors

Results

Word Similarity



- Decomposing words into *jamo*-level is helpful to learn good Korean word vectors.
- Spearman correlation with human evaluation is improved to 0.677.
  (1-4 characters n-grams / 3-5 jamo n-grams included)

Word Analogy

	Semantic					Syntactic				
	Capt	Gend	Name	Lang	Misc	Case	Tense	Voice	Form	Honr
SG	0.460	0.551	**0.537**	0.435	0.574	0.521	0.597	0.594	0.685	0.634
SISG(ch)	0.469	0.584	0.608	0.439	0.614	0.422	0.559	0.550	0.656	0.489
SISG(jm)	0.442	0.515	0.574	0.362	0.565	0.228	0.421	0.434	0.537	0.367
SISG(ch4+jm)	0.431	0.504	0.570	0.361	0.556	0.212	0.415	0.434	**0.501**	**0.364**
SISG(ch6+jm)	**0.425**	**0.498**	0.561	**0.354**	**0.554**	**0.210**	**0.414**	**0.426**	0.507	0.367

- Overall, decomposing words help to capture semantic/syntactic features.

Sentiment Analysis

	Acc.(%)	Prec.	Rec.	F1
SG	76.15	0.746	0.792	0.768
SISG(ch)	76.26	0.774	0.741	0.757
SISG(jm)	76.53	**0.790**	0.722	0.754
SISG(ch4+jm)	76.28	0.755	0.776	0.765
SISG(ch6+jm)	**76.54**	0.750	**0.795**	**0.772**

- Decomposing a word to 1-6 character n-grams and 3-5 jamo n-grams show slightly higher performance over comparable models.

Effect of n in n-grams

		# of chars			
		4	5	6	all
# of *jamos*	2-4	0.660	0.655	0.659	0.651
	3-4	0.660	0.650	0.652	0.660
	3-5	**0.677**	0.672	**0.677**	0.675
	3-6	0.665	0.663	0.664	0.669

- *n* of jamo-level *n*-grams, including n=5,6 of *n*-grams and excluding bigrams show higher performance.
- Including all of the character *n*-grams while decomposing a word does not guarantee performance improvement.

Conclusion and Discussion

- We demonstrated the effectiveness of the jamo- and character-level Korean word vectors in capturing the semantic and syntactic information by evaluating these vectors with newly developed word similarity and word analogy tasks.
- We plan to apply these vectors for various neural network based NLP models, and apply the same idea to other syntactic tasks such as POS tagging and parsing.

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