Exploring Semantic Properties of Sentence Embeddings

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Introduction

• Sentence Embeddings:
  • Encode a variable-length input sentence into a constant size vector

• Examples:
  • Based on Word Embeddings:
    (I) Glove Averaging (Wieting et al., 2015)
    (II) Concatenated P-Mean Embeddings (R’uckl’e et al. 2018)
    (III) Sent2Vec (Pagliardini et al. 2018)
  • Based on RNNs:
    (I) SkipThought Vectors (Kiros et al. 2015)
    (II) InferSent (Conneau et al., 2017)
Goal

- Exploring what specific semantic properties are directly reflected by such embeddings.
- Focusing on a few select aspects of sentence semantics.
- Concurrent related work: Conneau et al. ACL 2018
  
(i) Their work studies what you can learn to predict using 100,000 training instances

(ii) Our goal: Directly study the embeddings (via cosine similarity)
Minor alterations of a sentence may lead to notable shifts in meaning.

(i) A rabbit is jumping over the fence ( $S$ )

(ii) A rabbit is hopping over the fence ( $S^=$ )

(iii) A rabbit is not jumping over the fence ( $S^*$ )
Sentence Modification Schemes

- Not-Negation
- Quantifier-Negation
- Synonym Substitution
- Embedded Clause Extraction
- Passivization
- Argument Reordering
- Fixed Point Inversion
Negation Detection

• Original Sentence:
  • A person is slicing an onion.

• Synonym Substitution:
  • A person is cutting an onion.

• Not Negation:
  • A person is not slicing an onion.
Negation Variant

- Not Negation:
  - A man is not standing on his head under water.

- Quantifier Negation:
  - There is no man standing on his head under water.

- Original Sentence:
  - A man is standing on his head under water.
Clause Relatedness

- Original Sentence:
  - Octel said the purchase was expected.

- Extracted Clause:
  - The purchase was expected.

- Not Negation:
  - Octel said the purchase was not expected.
Argument Sensitivity

• Original Sentence:
  • Francesca teaches Adam to adjust the microphone on his stage

• Passivization:
  • Adam is taught to adjust the microphone on his stage

• Argument Reordering:
  • Adam teaches Francesca to adjust the microphone on his stage
• Original Sentence:
  • A black dog in the snow is jumping off the ground and catching a stick.

• Synonym Substitution:
  • A black dog in the snow is leaping off the ground and catching a stick.

• Fixed Point Inversion(Corrupted Sentence):
  • In the snow is jumping off the ground and catching a stick a black dog.
### Models and Dataset

| Dataset    | Embedding Dim | # of Sentences | From                        |
|------------|---------------|----------------|-----------------------------|
| Glove Avg  | Common Crawl  | 300            | SICK, SNLI                  |
| P Means    | Common Crawl  | 300            | SICK, SNLI                  |
| Sent2Vec   | English Wiki  | 600            | Penn Treebank, MSR Paraphrase |
| SkipThought| Book Corpus   | 600            | SICK, MS Paraphrase         |
| InferSent  | SNLI          | 4096           | SICK                        |
Negation Detection

- Average of Word Embeddings is more easily misled by negation.

- Both InferSent and SkipThought succeed in distinguishing unnegated sentences from negated ones.
Both averaging of word embeddings and SkipThought are dismal in terms of the accuracy.

InferSent appears to have acquired a better understanding of negation quantifiers, as these are commonplace in many NLI datasets.
• Both SkipThought vectors and InferSent works poorly when sub clause is much shorter than original one.

• Sent2vec best in distinguishing the embedded clause of a sentence from a negation of that sentence.
None of the analyzed approaches prove adept at distinguishing the semantic information from structural information in this case.
• Methods based on word embeddings do not encode sufficient word order information into the sentence embeddings.

• SkipThought and InferSent did well when the original sentence and its semantically equivalence share similar structure.
Conclusion

• RNN based sentence embeddings better at identifying negation compared with word embedding based models

• Both SkipThought and InferSent distinguish negation of a sentence from synonymy.

• InferSent better at identifying semantic equivalence regardless of the order of words and copes better with quantifiers.

• SkipThoughts is more suitable for tasks in which the semantics of the sentence corresponds to its structure
Thank you!

Questions?
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