Exploring Methods of Metaphor Detection Using Similarity

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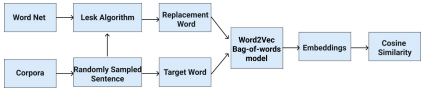
Introduction

Metaphors like "This is the *price* of citizenship" are frequently used in political speeches as powerful persuasive devices. The aim of this project is to detect such uses of metaphors in a corpora of speeches by former President Barack Obama (compiled from The Grammar Lab). We explore different methods of metaphor detection by using Word2Vec and BERT to find word embedding features, finding synonyms with the Lesk algorithm and KNN algorithm, and determining the metaphoricity of a sentence with cosine similarity.

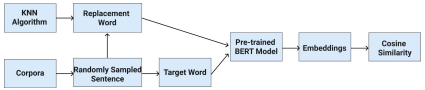
Methodology

We primarily explored three different methods of metaphor detection: Word2Vec alongside the Lesk algorithm, BERT alongside the Lesk algorithm, and BERT alongside the KNN algorithm. We used a pre-trained BERT model and utilized a public corpora of texts for our Word2Vec model and KNN algorithm.

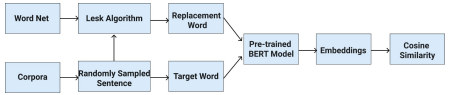
1) Word2Vec and Lesk Algorithm



2) BERT and KNN Algorithm



3) BERT and Lesk Algorithm



For the first and second methods, we computed cosine similarity between the target word and its context embedding as well as the replacement word and its context embedding. We determined whether or not the sample was a metaphor if the difference between the two values met a certain threshold. For the third method, we computed cosine similarity solely between the target word's context-based embedding and the replacement word's context-based embedding.

Results

We randomly sampled about forty sentences to evaluate each method and manually tagged them as a metaphorical or non-metaphorical sentence.

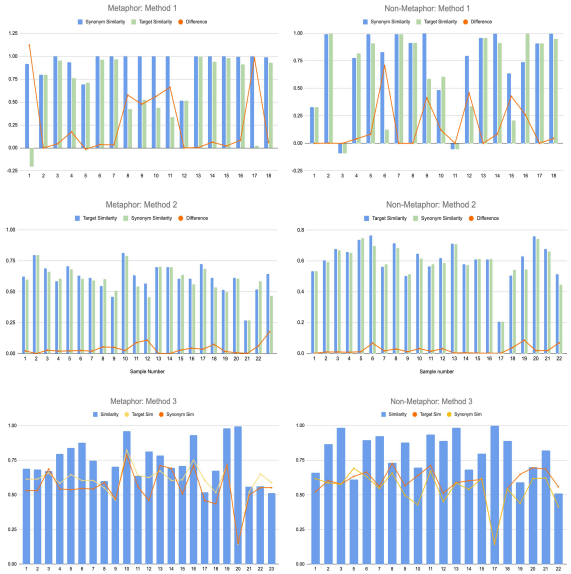
- Our accuracy percentages were: 52.78% for Method 1, 60% for Method 2, and 59.1% for Method 3.
- Sample metaphorical sentence detected by Methods 1, 2, and 3: *For we know that our patchwork heritage is a strength, not a weakness*, with "patchwork" being the target word (i.e., the word that is being used non-literally).
- Sample non-metaphorical sentence detected by Methods 1, 2, and 3: *Well, it's time for them to own their failure*, with "failure" being the target word (i.e., the word that is being used literally).
- Methods 1 and 2 were heavily skewed towards non-metaphorical sentences, which you can see the "Predicted: No" columns of the confusion matrices below.

For further analysis, we visualized the breakdown of performance for metaphorical and non-metaphorical sentences in the bar charts below

Method 1	Predicted:Yes	Predicted:No
Actual: Yes	33.33%	66.67%
Actual: No	27.78%	72.22%

Method 2	Predicted: Yes	Predicted: No
Actual: Yes	39.13%	60.87%
Actual: No	18.182%	81.82%

Method 3	Predicted: Yes	Predicted: No
Actual: Yes	60.87%	39.13%
Actual: No	42.86%	57.14%



Conclusions

Performance of our methods:

- Method 1 had the worst performance, which was most likely due to the embeddings computed by Word2Vec's bag-of-words model.
- Methods 2 and 3 had a better performance simply because the BERT embeddings incorporated context.
- Between Methods 2 and 3, the former had a marginally better performance. This is most likely due to the quality of synonyms found by Method 2 using the KNN algorithm instead of the Lesk algorithm.

The Lesk algorithm used in Methods 1 and 3 relies on an overlap between WordNet's definitions, examples, and hypernym sentences and the target word's context, but because the corpora used is so political in nature, overlaps were few to none. Method 2 uses a KNN algorithm to find synonyms commonly associated with the target word from a public corpora, which increases the chance that the synonym being pulled will match the literal sense of the target word.

Analysis of confusion matrix:

- The confusion matrices for Methods 1 and 2 show a bias towards non-metaphorical sentences.
- For Method 3, the true positive and true negative rates were high and the false negative and false positive rates were relatively low in comparison to the previous methods. This is due to the fact that Method 3 computes the similarity between the target and replacement word directly by taking advantage of BERT's context-based embeddings.

The concept behind Method 3 that resulted in its better performance is that the synonym is the more literal sense of the metaphor, and its similarity with the target word will be lower once the context is taken into account. If the similarity between the two was below a threshold of 0.76, the sentence was a metaphor.

We tried the same methods once more but trained our Word2Vec embeddings on the corpora of political speeches and pulled synonyms using the KNN algorithm from the same corpora. But due to the high metaphoricity of the corpora, the methods tended to replace the target words with synonyms that were associated with the metaphor rather than its literal meaning. This usually resulted in a performance that was marginally worse.

References

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