Debiasing Irrelevant Words in Natural Language Processing

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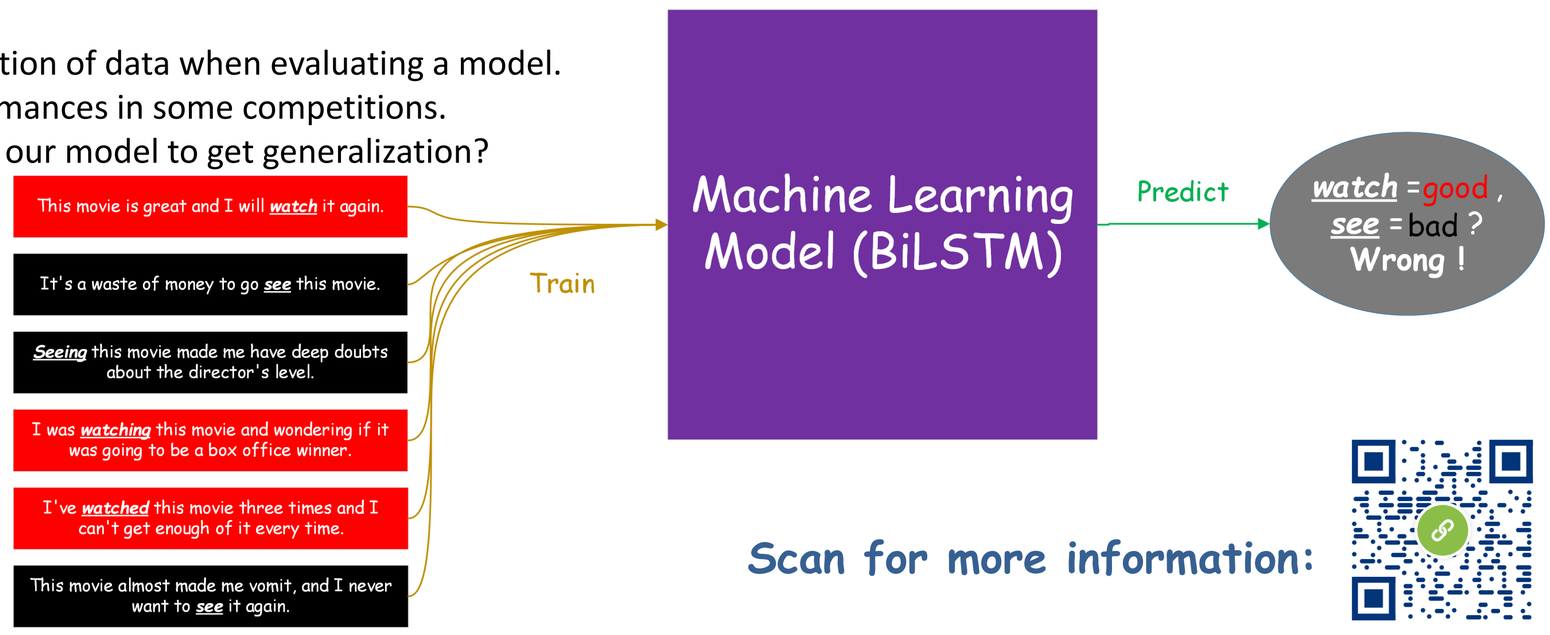
Introduction

Motivation:
- There are some leakage features caused by correlation of data when evaluating a model.
- Some people use them to get extraordinary performances in some competitions.
- How to eliminate the impact of leakage features in our model to get generalization?

Challenge:
- Decouple the leakage features and useful features.
- Compute weights to debias the datasets.

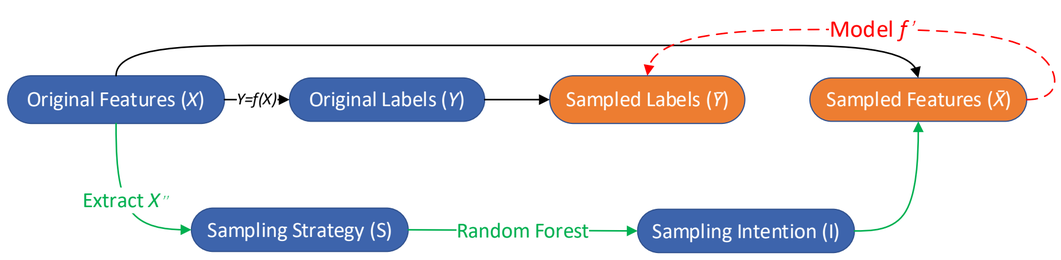
State of the art:
- Writing style debiasing
- Data frequency debiasing

Contributions:
- Visualizing the bias of neutral words.
- Training an unbiased sentiment analysis model.
- Give better performance in general cases.



Method

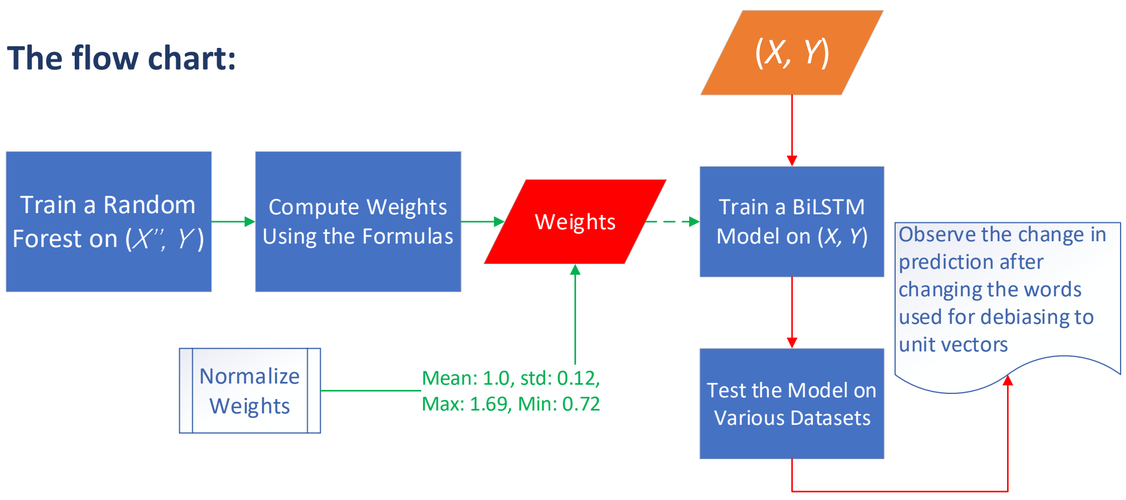
Causal explanation of the data generation process:



Estimate sampling intention I for some sampling strategy:
- Predict sentiment labels by random forest, using $X'' = [word \in sentence]$ as features.
- The model is used for estimating the conditional probability relationship: $P(I = y|s)$.

Calculate the weights of samples, using $P(I = y|s)$:
- $P(I = y|S) = \frac{P(Y=y)P_{\overline{\mathcal{A}}}(Y = 1 - y|S)}{P(Y=0)P_{\overline{\mathcal{A}}}(Y = 1|S)+P(Y=1)P_{\overline{\mathcal{A}}}(Y = 0|S)}$
- Normalize the mean of the weights to 1.

The flow chart:



Theoretical Analysis

Theorem: Suppose the classifier is f' and the training data X is divided into two parts, X' and X''. Here, X'' is the biased features (leakage features) and X' is the useful features that fit the practical problem. We denote the sampling intention and strategy as I, S, then $w = \frac{P(I=Y)}{P(I=y|s)}$ is an unbiased weight. Or equivalently,

$$E_{x,y,s\sim\overline{\mathcal{A}}}\left[wL\left(f'\left(x', g^{-1}(s)\right), y\right)\right] = E_{x,y,s\sim\mathcal{A}}\left[L\left(f'\left(x', g^{-1}(s)\right), y\right)\right]$$

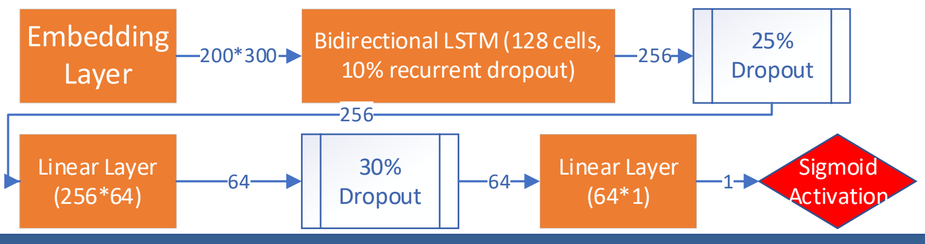
Here, $\overline{\mathcal{A}}$ is the biased joint distribution of X, Y, S, I and A is the original distribution. Moreover, L is the loss function and g is the functional relation between sampling strategy S and biased features X''.

Experimental Settings

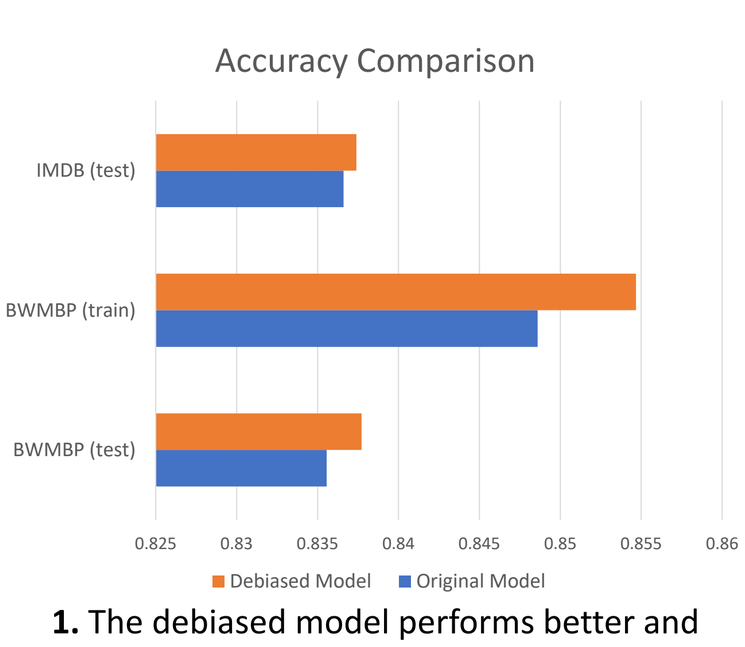
Neural Words: which, would, could, car, tree, etc.

Datasets:
- Training set: training set of *IMDB Review* (IMDB).
- Test sets: test set of *IMDB review;* training set and test set of *Bag of Words Meets Bags of Popcorn* (BWMBP); training set and test set of *515K Hotel Reviews Data in Europe*.

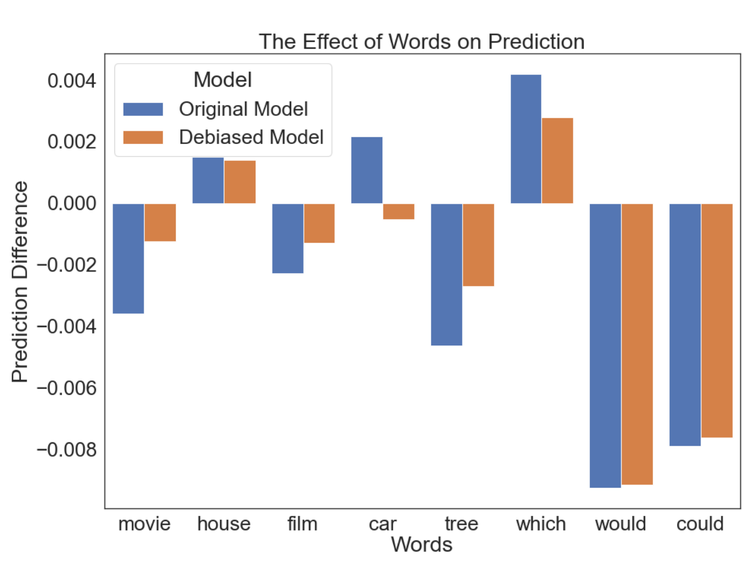
Models:
- Model used to calculate the weights: random forest with maximum depth of 6.
- Main Model: BiLSTM with *GoogleNews-vectors-negative300* as the pre-trained word vectors.



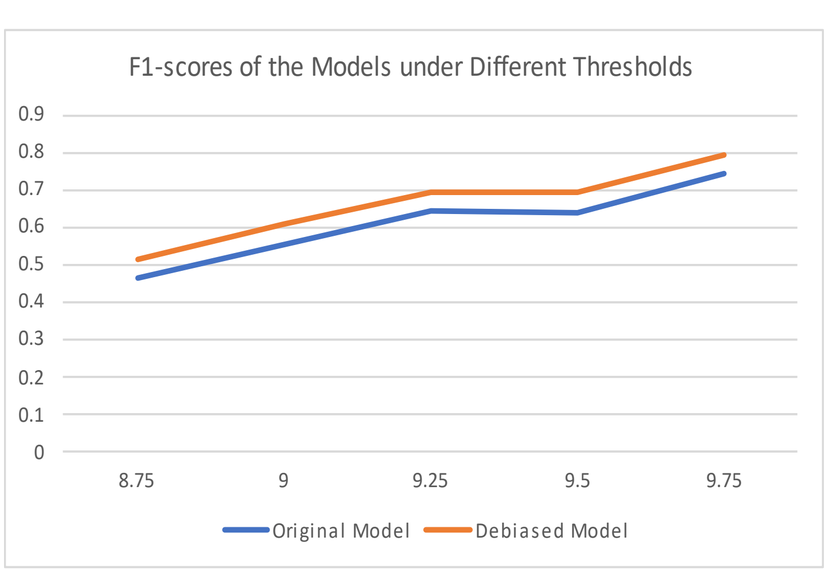
Empirical Results



1. The debiased model performs better and generalizes better than the original model on data sets other than the training set.



2. After the model being debiased, the effect of irrelevant neutral words in the prediction has been significantly reduced. The new model can be used for a wider range of tasks.



3. The model performance we obtain in hotel evaluation dataset, using different thresholds (used to discriminate between positive and negative). The generalization of the model after debiasing is better.

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