Tbilisi 2022 Abstract Submission

Title
Deep Learning with Multiple Instance Classification for Word-specific Sentiment Analysis in Wine Reviews

I want to submit an abstract for:
Conference Presentation

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Keywords
Text analysis; deep learning; multiple instance classification; sentiment analysis; wine reviews

Research Question
How to add interpretability to neural network models for wine review classification?

Methods
We are going to incorporate the attention mechanism from deep learning into a relatively simple statistical model, to provide more interpretable results in wine text analysis.

Results
The proposed approach can combine the best of two worlds: the interpretability of a statistical model and the high predictive performance of neural-network models in wine reviews classification.

Abstract
There is an ongoing debate on whether wine reviews provide meaningful information on wine properties and quality. The authors have conducted different studies to address this question. By comparing different models, we provided strong evidence that wine review descriptors are more accurate in predicting wine quality classifications than the various numerical covariates—including the wine's price. Specifically, BERT, a deep learning framework recently developed by Google, has the best performance. In the two-class classification (i.e., based on wine ratings in two categories 90–100 and 80–89), BERT achieves an accuracy of 89.12%, followed by BiLSTM (88.69%) and CNN (88.02%). However, the accuracy from these high-performance deep learning algorithms often comes at the expense of interpretability due to their complex inner-workings. In practice, it can be a limitation because interpretability is crucial for understanding and acceptance of prediction or classification outcomes. To meet this challenge, in this study, we propose to incorporate the attention mechanism from deep learning into a relatively simple multiple instance learning statistical model. By doing so, we can combine the best of the two worlds: the interpretability of a statistical model and the high predictive performance of deep learning algorithms.

As a branch of machine learning, multiple instance learning (MIL) algorithms learn from a collection of labeled bags, each bag containing a set of instances, where each instance is described by a feature vector. Since its emergence, MIL has been applied to solve various problems including content-based image retrieval, object tracking/detection, and computer-aided diagnosis. Text classification can be conducted in the MIL framework, where each text document is treated as a bag, the words in each document as the instances and word embeddings as the instance features. In the two-class wine review classification, we build the model based on the assumption that the reviews express more positive sentiment for the wines with ratings between 90 to 100 than the 80 – 89 rating wines. In addition, the individual words carry different sentiment in the review texts, so that the reviews for the 90 – 100 rating wines have words with more positive sentiment. Eventually, the word-level sentiment can be used to explain how the text review can be used to provide accurate wine classification based on deep learning algorithms.

The first component in the proposed method is a hierarchical latent variable MIL model. The model has a two-layered structure. The first layer identifies whether a word is essential or not (i.e., primary instance for wine classification), and the second layer assigns a sentiment score over the individual primary instance words of a document. The inner-workings of the MIL model is very clear, and the parameters, such as the sentiment score for individual words, are meaningful. Together, the model structure can provide clear interpretability to the classification outcomes.

The second component in the proposed method is the attention mechanism from deep learning incorporated into the MIL model. Instead of treating the words in an isolated manner, the attention mechanism permits the natural language algorithms to utilize the most relevant parts of the input sequence in a flexible manner, so that it can identify the information in an input most pertinent to accomplishing the text analysis task. We use the embeddings based on the attention mechanism as the features for the individual words to estimate their sentiment score in the second layer of the MIL model.

We have applied the proposed deep learning statistical model to the text data from close to 300,000 wines reviewed by Wine Spectator. The results show that the model has competitive classification accuracy to the "black box" deep learning algorithms. More importantly, it does provide meaningful explanation to the classification outcomes based on the word-specific sentiment measure.

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