



Weighted aspect-based opinion mining using deep learning for recommender system

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ABSTRACT

The main goal of Aspect-Based Opinion Mining is to extract product's aspects and the associated user opinions from the user text review. Although this serves as vital source information for enhancing rating prediction performance, few studies have attempted to fully utilize it for better accuracy of recommendation systems. Most of these studies typically assign equal weights to all aspects in the opinion mining process, however, in practices; users tend to give different priority on different aspects of the product when reaching overall ratings. In addition, most of the existing methods typically rely on handcrafted, rule-based or double propagation methods in the opinion mining process which are known to be time-consuming and often inclined to errors. This could affect the reliability and performance of the recommender systems (RS). Therefore, in this paper, we propose a weighted Aspect-based Opinion mining using Deep learning method for Recommender system (AODR) that can extract product's aspects and the underlying weighted user opinions from the review text using a deep learning method and then fuse them into extended collaborative filtering (CF) technique for improving the RS. The proposed method is basically comprised of two components: (1) Aspect-based opinion mining module which aims to extract the product aspects from the review text to generate aspect rating matrix. (2) Recommendation generation component that uses tensor factorization (TF) technique to compute weighted aspect ratings and finally infer the overall rating prediction. We evaluate the proposed model in terms of both aspect extraction and recommendation performance. Experiment results on different datasets show that our AODR model achieves better results compared to the baselines.

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1. Introduction

RS aims to tackle the problem of information overload in on-line e-commerce transactions and social network platforms. CF is the most popular technique for RS which relies on the similarity among users/items based on their past behaviors. One major shortcoming of the CF methods is the issue of data sparsity, which is typically characterized by the low coverage of user ratings within the items owing to the relatively large number of users and items (Qiu, Gao, Cheng, & Guo, 2016). Recent works (Bao, Hui, & Zhang, 2014; Ling, Lyu, & King, 2014; McAuley & Leskovec, 2013) have shown that user textual reviews can be utilized to effectively alleviate the sparsity problem of CF methods. These opinions are typi-

cally very important in that they explain the user's preference that triggers the purchase decision on a product.

Recently, several methods have been introduced to exploit user's opinions for improving the predictive performance of RS (Wang, Liu, & Yu, 2012; Wu & Ester, 2015). However, most of these methods typically assign equal weights (importance) for all aspects while in real-life applications, aspects are differently treated by the user based on their importance. Intuitively, item rating is a weighted combination of various aspects and that the diverse preference of different users is determined by different weights put by different users. Moreover, most of these methods particularly rely on mechanical approaches such as rule-based and handcrafted methods which are known to be time-consuming and often error-prone in the estimation process.

In view of the above inspirations, this paper proposes a unified method to integrate aspect-based opinion mining and CF method for enhancing the predictive performance of the RS. The model comprises two different components: (1) Aspect-based opinion mining and (2) Recommendation generation. In the first component, we particularly design a Multichannel Convolutional

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Neural Network (MCNN) to deal with the aspect extraction task. Our MCNN model is an extension of the CNN model introduced in (Kim, 2014), however different from the traditional CNN model, our MCNN model specifically utilizes two different input layers, namely, word embedding and POS tag embedding layer (details of the MCNN model is given in Section 4).

In the second component, we specifically use a TF technique to first estimate the weighted aspect ratings and then infer the overall rating of the user on an item. The proposed AODR model is evaluated in terms of both rating prediction and item ranking using Amazon and Yelp datasets. The model is finally compared with the existing approaches and various experiments show better results of the proposed AODR approach compared to the baselines. In the following we highlight the major contributions of the paper:

- We introduce a deep learning based method for better extracting the product's aspects and the underlying user opinions from the user textual reviews for RS.
- We introduce an aspect weighted rating estimation method based on the TF technique to alleviate data sparseness and reduce the number of model parameters for enhancing the predictive performance of the RS.
- We extensively carry out different experiments to assess the effectiveness of our proposed model in terms of both aspect extraction and recommendation performance (rating prediction and item ranking tasks).

The remainder of this paper is arranged as follows: we present the related work in Section 2. Sections 3 and 4 defines the research problem and overviews the proposed model respectively. Sections 5 and 6 presents a series of experiments and conclusion of the paper respectively.

2. Related work

In this section, we review different studies particularly related to this research which can principally be categorized into two directions, namely, aspect-based opinion mining/sentiment analysis and review based RS.

2.1. Aspect-based opinion mining

Aspect-based opinion mining/sentiment analysis basically deals with the extracting of aspects and the underlying sentiment polarity classification from the review text of a given item (Wu & Ester, 2015). For the past years, several methods have been introduced to investigate Aspect-based opinion mining on user text reviews. These include unsupervised methods such as rule-based (Guang & Bing, 2009) and topic modeling (Jia, Zhang, Lu, & Wang, 2014). Although these methods have gained many achievements, one of the shortcomings of these approaches is that they ignore the contextual information of words which has been shown very important in the Natural Language Processing (NLP) tasks. Other methods include supervised approaches (Lafferty, McCallum, Pereira, & Pereira, 2001) which typically consider aspect extraction as a sequence labeling task. One major drawback of the traditional supervised methods such as Conditional Random Field (CRF) (Shu, Xu, & Liu, 2017) is that they are linear models as such they require relatively larger datasets for effective training.

With the recent achievements of deep learning, several attempts have been made to utilize deep learning techniques for aspect-based opinion mining (Irsoy & Cardie, 2014; Liu, Joty, & Meng, 2015; Poria, Cambria, & Gelbukh, 2016; Xu, Liu, Shu, & Yu, 2018). For example, Irsoy (Irsoy & Cardie, 2014) used a recurrent neural network (RNN) model for the aspect extraction and demonstrated the superior performance of the model over the CRF

based methods. For better improvement, an approach introduced in Liu et al. (2015) utilized a more advanced variant of the RNN model for the aspect extraction. A multilayer CNN based method was proposed by Poria (Poria et al., 2016) for aspect extraction. The authors used additional syntactic and linguistic features for better performance of the model. Another CNN based model was proposed in Xu et al. (2018) using a double embedding architecture that exploits domain dependent and domain independent word embeddings for aspect extraction.

Different from the above approaches, this paper introduces a deep MCNN method for extracting product's aspects using two different input channels: word embedding (Mikolov, Yih, & Zweig, 2013) for capturing the semantic information of the words, and Part of Speech (POS) tag embedding for improving the sequential labeling of the aspects.

The second task of aspect-based opinion mining is to classify the polarity scores associated with each aspect in a sentence. Generally, the approaches for classifying the user sentiment polarity can be achieved using either supervised approaches such as Support Vector Machine (SVM), Neural Network (Devi, Kumar, & Prasad, 2016; Yoon & Kim, 2017) or lexicon based approaches (Titov & McDonald, 2008). In this paper, we specifically adopt the strategy used in Wang and Chen (2015) for computing the sentiment polarity scores associated with the different aspects of products in the user textual reviews.

2.2. Review-based recommender system

Over many years, several works have been introduced to exploit user text reviews for improving the performance of RS (Diao et al., 2014; Jakob & Ag, 2009; Ling et al., 2014; McAuley & Leskovec, 2013). One of the earliest work to exploit reviews for RS typically uses manually designed ontologies to generate free text (Jakob & Ag, 2009). However, this method is generally not suitable for integrated RSs as it is time-consuming and domain independent. To integrate fine-grained information for improving predictive performance, some topic modeling methods (Ling et al., 2014; McAuley & Leskovec, 2013) have been introduced. For example, McAuley (McAuley & Leskovec, 2013) used topic modeling to combine latent topics with the latent factor for rating prediction. A method has been proposed in Ling et al. (2014) to use topic modeling for learning features from user reviews together with factorization machine for rating prediction. Diao et al. (2014) proposed a joint modeling method to simultaneously model aspect ratings and user sentiments for improving the overall rating prediction. Another method proposed in Zhang et al. (2014) integrated explicit product features into a TF machine for RS. One major limitation of all the above methods is that they mostly ignore the user-specific sentiment on the different aspects of the product.

With the recent achievements of representation learning, many deep learning-based RSs have been proposed. These include a method that uses CNN model. For example, Zheng, Noroozi, and Yu (2017) exploited the deep learning method for RS. The authors used two parallel CNN models for modeling user and item representation exploiting user and item review respectively. This method was later improved by Catherine and Cohen (2017) by introducing an additional layer to better learn user/item representation. Some studies used RNNs model for feature representation learning to build RS. For example, Lu, Smyth, Dong, and Smyth (2018) introduced a coevolutionary latent model for capturing the coevolution of the user/item latent features. Jing and Smola (2017) used LSTM models for multitasking learning to simultaneously predict the returning times of user and recommend-items. Da'u and Salim (2019) exploited RNN model with attention for sentiment aware recommendation. The authors used a semi-supervised topic modeling to extract product's aspects from the

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