Research on extraction of thesis research conclusion sentences in academic literature *

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ABSTRACT

The extraction of sentences with specific meaning in academic literature is an important work in academic full-text bibliometrics. This research attempts to establish a practical model of extracting conclusion sentences from academic literature by using SciBERT. In this research, SVM and SciBERT models were trained and tested using academic papers published in JASIST from 2017 to 2020. The experimental results show that SciBERT is more suitable for extracting thesis conclusion sentences and the optimal F1-value is 77.51%.

CCS CONCEPTS

Theory of computation~Theory and algorithms for application domains~Machine learning theory~Models of learning

KEYWORDS

SVM, BERT, academic full text, thesis research conclusion, text mining, deep learning

1 INTRODUCTION

Full-text data of academic literature mainly contains external characteristics and content characteristics. Since the creation of citation index by Garfield, citation analysis based on external characteristics of literature has been widely applied in various fields. However, due to the limitations of data and technology, the previous bibliometric have many defects, including rough statistical method and single indication ability (Lu et al., 2017). Today, increasingly rich full-text data and evolving machine learning and deep learning techniques allow researchers to investigate the content characteristics of academic literature in depth.

Entity extraction and sentence extraction are two important basic works of full-text bibliometric analysis. At the entity level, the relevant research mainly includes theory method entity extraction (Zhang & Zhang, 2021), algorithm entity extraction (Wang & Zhang, 2020) and software entity extraction (Pan et al., 2015). At the sentence level，there are mainly four research directions, including extraction of experimental result sentences, extraction of research question sentences, extraction of research conclusion sentences and extraction of future work sentences. At present, there are more researches related to entity extraction and less researches on sentence extraction.

The research conclusion sentence refers to the sentence that contains the research conclusion. In the academic full text, research conclusion sentences are divided into citation research conclusion sentences and thesis research conclusion sentences. citation research conclusion sentences refer to experimental results and conclusions in quotation sentences, such as 'Taylor's work shows that the special purpose syntactic parsers perform well on morphological descriptions.'. Thesis research conclusion is the author's statement of his own research results, such as 'In this way, we extended earlier work to the case that the impact factor can have a value lower than one.'. Automatically extracting thesis research conclusion sentences can promote the development of automatic summarization and save readers' reading time.

Therefore, this research attempts to construct an automatic recognition model of the thesis research conclusion sentence based on the deep learning techniques.

2 CORPUS AND METHOD

2.1 Corpus

This research obtained all the full texts of academic papers published in JASIST from 2017 to 2020 by using self-made Python program.

As for data annotation, first, we use NLTK module to segment the full text of the paper in sentence units. Then, 7 postgraduates

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majoring in information science manually annotated the sentences, and the experimenter completes the final review. The discriminant criteria of the thesis research conclusion sentence are as follows: (1) Semantically, the content of a sentence is a concise summary of the above or the following and the sentence does not appear in the introduction section. (2) The sentence is a straightforward description of the data of the experimental results, but it can be based on the reasoning and qualitative interpretation of the experimental results. (3) The subject of the sentence is not an object from a cited literature, such as a citation author.

After the annotation is completed, the thesis research conclusion sentences only account for 3% of the total corpus (more than 130 thousand sentences in total). In order to alleviate the problem of data imbalance, we negatively sampled non-research conclusion sentences to increase the proportion of thesis research conclusion sentences to 8.9%. The basic information of the final corpus is shown in Table 1.

Table 1. Basic Information of the Corpus

Num.	Type	Count
1	Total article	502
2	Total Sentences	54,479
3	Thesis research conclusion sentences	4,870
4	Average number of marked sentences in each article	9.7
5	Average words number in each sentences	27.99
6	The longest sentence words number	255

2.2 Method

SVM and SciBERT are used in this research. SVM is called support vector machine and it is a classic model for text classification. In its simplest form, an SVM is able to perform a binary classification finding the 'best' separating hyperplane between two linearly separable classes. SciBERT (Beltagy et al., 2019) is a deep learning model based on the BERT architecture (Devlin et al., 2018), which is trained on the full text corpus of 1.14 million scientific and technological documents. SciBERT uses the same configuration and size as BERT-base (Devlin et al., 2018) in the construction process, and it performs better than BERT-Base on natural language processing tasks in scientific literature.

3   EXPERIMENT

After comprehensively considering the results of the pre-experiment and the performance of the computer, the final hyper parameters are set as follows. SciBERT (scibert-scivocab-uncased): 256 for Maximum sequence length, 64 for batch size, 2e-5 for learning rate, 3 for training epoch, case insensitive. The penalty function of SVM is set to 2, the kernel function is RBF,

and TF-IDF is used to vectorize the text. The research uses a ten-fold cross-validation strategy, and the operating effect of the model is measured by Precision, Recall and F1-Value. Table 2 shows the results of the experiment.

Table 2. Results of 10-Fold Cross-Validation on SciBERT

Model		Precision	Recall	F1-Value
SciBERT	MAX	85.86%	78.61%	77.51%
	MIN	73.41%	44.13%	58.22%
	AVG	79.86%	64.51%	70.74%
SVM	MAX	98.19%	64.51%	77.03%
	MIN	90.37%	37.08%	53.80%
	AVG	95.97%	52.14%	67.24%

Table 2 shows that the SVM model has a high precision rate for extracting thesis research conclusion sentences and a low recall rate. The SciBERT model has a relatively high recall rate and a relatively low precision rate. From the perspective of the average F1-Value, the performance of SVM and SciBERT are both around 70%. SciBERT is relatively superior.

Compared to the sentences extracted by the SciBERT model with the manually labeled sentences, recognition errors of the SciBERT that have been discovered are as follows: (1) Recognizing the sentence describing the graph as the thesis research conclusion sentence. The possible reason for this problem is that the sentence describing the graph normally has phrases such as "as shown in" at the beginning, and these words are also important features of the thesis research conclusion sentence. (2) Recognizing research hypothesis sentences as thesis research conclusion sentences. According to observations, the thesis conclusion sentence is similar to the hypothesis sentence in terms of grammar and semantics. (3) Recognizing citation conclusion sentences without quotation mark as thesis research conclusion sentence. Some special words or symbols affect the judgment of the model.

4   CONCLUSION & FUTURE WORK

This research shows that SciBERT is relatively superior for automatically extracting thesis conclusion sentences. This research provides an idea for extracting thesis research conclusion sentences in academic full text. This research uses a negative sample strategy to alleviate the problem of data imbalance and to enable faster model optimization, data augmentation can be achieved by adding more positive samples in the future. In addition, some research conclusion sentences extracted contains pronouns and do not have perfect semantics when read alone, therefore, research on reference resolution should be carried out.

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