6ZH-02

Function enhancement of class questionnaire response analysis system using Japanese Sentiment Polarity Dictionary

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1. Introduction

Under the class innovation policy of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), much attention is being paid to class support using ICT. In recent years, university classes increasingly use Web services to confirm attendance and accept assignment submissions. These Web services often include class-evaluation-questionnaire functions and functions that display and summarize students' responses to questions, opinions, and impressions of discussions in classes in real time. We have reported a class-support system that can classify and search free-description questionnaire responses collected from students during a class in real time [1].

In this study, we first measured the execution speed of each function of the free-description questionnaire response analysis system (QRAS) reported in Reference [1] and demonstrated that the system is practical for use in real time. We then added a new function to the system to determine the polarity of free-description questionnaire responses on the basis of the Japanese Sentiment Polarity Dictionary [2].

2. QRAS

2.1 Overview of processing

An outline of the processing of the QRAS developed in this study is given below. We used Python to implement the system, Genism to read the dictionary, scikit-learn and SciPy packages for clustering, and oseti [3] for polarity determination.

Process 1: Divide questionnaire responses into word strings with the morphological analysis tool MeCab.
Proc.2: Perform data cleansing (removing stop words, converting to basic forms, eliminating duplicates, etc.).
Proc.3: Extract the distributed representation of each word from Wikipedia Entity Vectors [4] and calculate the distributed representation’s average as the distributed representation of the questionnaire response sentence.
Proc.4: Cluster questionnaire response sentences on the basis of distributed expressions. The k-means++ method is used for non-hierarchical clustering; Ward’s method and the group average method are used for hierarchical clustering.
Proc.5: Obtain a distributed representation of the teacher's question sentence by executing Proc. 1 to 3. Search questionnaire answer sentences with high cosine similarities to the teacher’s question and display them.
Proc.6: Classify the questionnaire response sentences (processed with Proc.1 and 2) into positive, neutral, and negative categories with the Japanese Sentiment Polarity Dictionary.

2.2 Execution time of each function

Assuming the use of the QRAS for analyzing questionnaire response sentences in a small class or a large-scale lecture, we prepared experimental data sets consisted of 500, 1,000, 5,000, and 10,000 sentences, in which each sentence consists of about 10 to 70 characters. For these data, we measured the time required to obtain the distributed representation (vectorize), to execute the k-means++ method (kmeans), and to retrieve the similar responses (retrieval). This research was executed with an Intel Core i7-6567U CPU, 8GB memory and SSD storage.

Table 1 shows the measurement results for the processing time of each function. Their results are graphed in Figure 1.

Table 1. Processing time of each function (sec)

Function \ Size	100	500	1000	5000	10000
vectorize	0.024	0.063	0.109	0.532	0.881
kmeans	0.046	0.049	0.093	0.363	0.637
retrieval	0.001	0.005	0.015	0.061	0.156

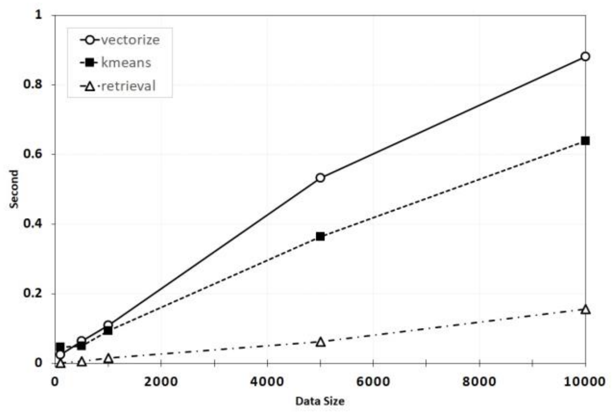

Figure 1. Graph of processing time of each function

Table 1 and Figure 1 show that the computation time for the acquisition of distributed representation, execution of the k-means++ method, and retrieval of similar sentences increases linearly with the number of sentences (data size). For 10,000 sentences, a distributed-representation acquisition is executed in about 0.88 seconds, a k-means++ method is executed in about 0.64 seconds, and a retrieval of similar responses is executed in about 0.16 seconds. These experimental results show that the QRAS classification and retrieval functions can be used for real-time analysis of free-description questionnaire responses in large-scale lectures.

2.3 Polarity classification function

This system’s response-sentence classification and similar-response-sentence retrieval are processed using semantic distributed representation. Although this method is suitable for classifying and searching by topic or genre, it is not suitable for

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determining the polarity of a sentence. For example, the two sentences "プログラミングの授業が好きです" and "プログラミングの授業が嫌いです" have very similar semantic distributed representations, but one expresses a positive sentiment and the other a negative sentiment.

In this study, we added a new function to the QRAS to classify the questionnaire response sentences into positive (+1), neutral (0), and negative (−1) categories. First, a questionnaire response sentence is divided into words by MeCab, and the polarity of each word is extracted from the Japanese Sentiment Polarity Dictionary. The sentence polarity is classified by averaging the polarity values of each word. The sentence is classified as positive if the averaged value is equal to or greater than the positive threshold (set to 0.5), as negative if said value is equal to or less than the negative threshold (set to −0.5), and as neutral if said value is greater than the negative threshold and less than the positive threshold.

2.4 Experiment using polarity classification function

We prepared subjectively labeled evaluation data with positive, neutral, and negative labels to evaluate the performance of the polarity classification function. Each sentence is about 10 to 30 characters long, and there are 120 sentences in total. Figure 2 shows part of the results of the polarity classification experiment, and Table 2 shows a confusion matrix for this experiment.

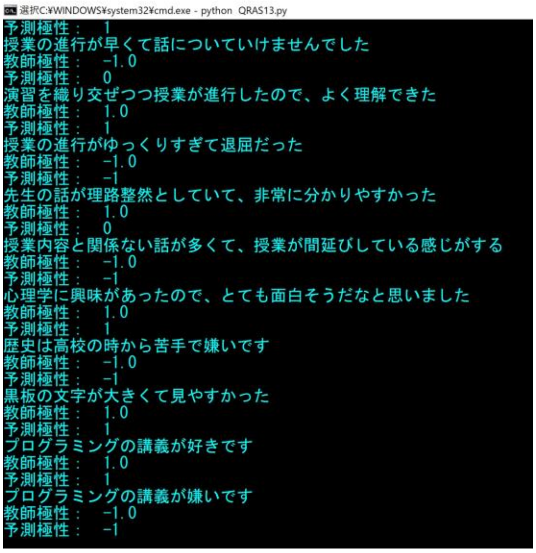

Figure 2. Part of polarity classification results

Table 2. Confusion matrix for evaluation of polarity classification

true \ predict	positive	Neutral	negative
positive	42	9	2
neutral	8	4	2
negative	4	18	31

As shown in Table 2, 77 out of 120 sentences were correctly identified, the classification accuracy was 0.64. Two positive sentences were erroneously classified as negative, and four negative sentences were erroneously classified as positive. Therefore, in this experimental data, 95% of the response sentences can be found by searching among the positive and neutral categories if one wants to find a positive-answer sentence and among the negative and neutral categories if one wants to find a negative-response sentence. The processing time of the polarity classification is shown in Table 3 with its graph shown in Figure 3.

Table 3. Execution time of polarity classification (sec)

Function \ Size	100	500	1000	5000	10000
polarity	0.168	0.882	1.639	8.229	16.644

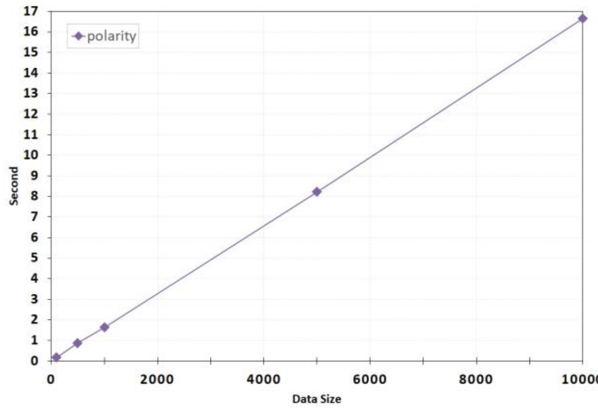

Figure 3. Graph of processing time of polarity classification

Table 3 and Figure 3, show that the computation time for the polarity classification increases linearly with the number of sentences. These experimental results show that the polarity classification function of the QRAS can be used for real-time analysis of free-description questionnaire responses for lectures with thousands of participants.

3. Conclusion

The QRAS supports collaborative and interactive classes more effectively than before with classification and retrieval functions based on semantic representation and a newly added polarity classification function for free-description questionnaire responses.

Acknowledgments

We are conducting this research as part of the ICT Education and Research Project of the Development of AI Functions for Education group at the Institute of Social Sciences, Toyo University. We sincerely thank the members of this project for their various helpful comments.

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