Artificial Intelligence and Education

Comment mining project toward improving student learning performance – an Example

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Abstract: In the educational domain, the process of collection, analysis and measurement of data about learners and of giving feedback to the learners is important for understanding and improving learners learning. To accomplish this, employing artificial intelligence techniques, especially, data mining and text mining techniques is indispensable. Considering this, we have been conducting "Comment mining" research since 2011. Unlike other studies related to educational data mining and learning analytics, we have collected student comments after every lesson and applied text mining techniques to them. We give students three to five questions to let them write their comments freely. Predicting final student grade as their learning performance, we found several correlations between final student grades and contents of their comments, in particular, learning attributes. In this paper, we summarize our past researches and discuss our future work.

Keywords: Comment mining, Student Free-style Comment, Text mining, Student Performance Prediction.

1 INTRODUCTION

It is important for teachers and students to know students' learning performance in educational environments. We can apply the knowledge to various application fields such as instruction design, curriculum design, lecture improvements, giving individual instructions or advices to each student, and/or class recommendation in the beginning of every semesters. Therefore, many researchers have tackled to estimate students' learning performance and been conducting a variety of research using educational data mining and/or learning analytics techniques. They have also collected and analysed a variety of data. For example, student profiles, family situations, and academic achievement records (e.g. test marks, credits, attendance, success or fail) are useful for class recommendation at the beginning of a semester. Student access logs to e-book or e-learning system, student comments posted onto electronic bulletin boards or SNSs, and student behaviours such as their eye-movements or attitudes are used for checking of the extent of concentration on their study and finding the correlation with the possibility of success or fail to their class. Finally, answer to questionnaires and student comments on their class are for investigating their attitudes and/or achievements on the class and hints of lesson improvements.

Each data has its own merits and demerits. Analysing student access logs to e-book or e-learning system has become popular these days because they provide big data of a large number of students and afford the typical pattern and tendency of the students. However, it is not easy from the log data to interpret student attitudes and their problems on some topics or subjects in the lecture. Question or comments posted onto SNSs or bulletin boards are good hints to know student problems and knowledge on the topics, but the ratio of students posted is not always high and then it is not easy to know all the students' attitudes and knowledge using the comments posted.

Therefore, we have started our Comment mining project: collecting comments of all students taking a class after every lesson of the class and mining them to estimate students' learning performance, which are final student grades. This paper describes about our Comment mining research project.

2 PCN METHOD AND STUDENT COMMENT

If we just ask students to write their comments on each lesson, they often describe a very short sentence or a word like "did not understand," "nothing," "interesting," which does not tell us any hints to estimate student learning situations and performance, to give the students advice individually, and to improve lessons for next time. Then we need students to describe what and why they do or do not understand concretely. In addition, students study not only in the class, but also outside of the class such as libraries, café, or their home. Then we need to know how long they study before and after the class. The PCN method [Goda & Mine 2011a, Goda & Mine 2011b, Goda & Mine 2013a] comes from this idea.

The PCN method gives a form of student comments consisting of three fields: P, C, and N. The P field asks students to describe their learning activities before the current class such as preparation to the class and reviews of the previous class; we can know student efforts to the class from the descriptions in the P filed. The C filed asks the students to describe the results of learning during the current class such as what topics or subjects they did or did not understand concretely; the descriptions in the C filed are mainly related to their understanding. The N filed asks the students to describe their study plan for the next class; we can estimate student attitudes to the class from the descriptions in the P field. The idea of the PCN method is to have students to describe their learning situations and does not fixate the three fields above. Teachers can freely design the questionnaire form to give students. Actually, we extended from the original three-question form to four- or five-question form according to students. We examined the PCN method by using data collected from undergraduate students in two different classes, but taught the same subject given by the same teacher, data collected from other undergraduate students in a class given by another teacher, data collected in another country than Japan. We sometimes felt the necessity for asking students to describe their comments more concretely and honestly even though we used the PCN method. The students did not describe well their learning situations, attitude, efforts or understanding because they were not used to write comments and did not know how to describe them. At that time, giving examples of comments and/or appropriate teacher interventions to the students were effective to make their comments better. We have also analysed comment data written by junior high school students and confirmed that our Comment mining techniques worked to the data as well. We will report the result in elsewhere.

3 CORRELATION BETWEEN STUDENT COMMENTS AND PCN SCORES

We first manually analysed student comments according to the procedure to evaluate student comments. The procedure takes three steps: 1) if a student comment includes descriptions related to a question in each of P, C, N fields. 2) if a student comment includes concrete descriptions that answer what they did before the class time, what they understood or did not, and 3) the descriptions satisfy the achievement level expected by the teacher. Although the condition in step 3 is quite subjective, we expected that comments of higher-grade level students would pass it. We gave higher points to a student comment in each P, C, and N field as the comment passed the later steps in each field. We call the point in each field, P, C, or N point. Even though this simple procedure told us that comments of students having higher grades achieved greater points and the points of the comments were influenced by the difficulty of lesson subjects. In addition, the C point obtained the highest correlation with students' final grades among the three points [Goda&Mine 2011a, Goda&Mine 2011b, Goda&Mine 2013a].

We then applied text mining techniques to student comments and calculated correlation between student comments and P, C, N scores, and that between PCN scores and final student grades, automatically [Goda+ 2013b, Goda+ 2013c., Goda+ 2015]. These results encouraged us to start research of estimating student learning performance by applying various machine learning techniques to student comments.

4 COMMENT MINING FRAMEWORK

Our framework of Comment mining consists of four phases: 1) Comment data collection, 2) Data preparation, 3) Prediction model building, and 4) Evaluation.

Here the phase of comment data collection consists of two steps: 1) definition of comment data format based on the PCN method and 2) comment data collection after every lesson.

In the data preparation phase, we create input vectors to build prediction model. We first extract word features from student comments by applying an morphological analyser to the comments and then create input vectors based on the extracted word features. In creating input vectors, we use the attribute-based or topic-based methods by transforming word feature vectors into student learning attribute vectors using an attribute dictionary built from student comments or into topic vectors by using topic-based models such as LSA, pLSA or LDA. We can use multiple student comments obtained from consecutive lessons in creating input vectors to apply multi-instance learning (MI).

In the phase of building prediction model, we build a prediction model using machine learning classifiers such as Support Vector Machine (SVM), Decision Tree (DT), Random Forest (RF), Naïve Bayes (NB), and Artificial Neural Network (ANN). When creating input vectors from multiple student comments from consecutive lessons, we take a stacking technique combining MI and a classifier such as SVM or ANN and apply the combination of MI and the classifier to the vectors. The stacking technique is also useful to improve performance of a prediction model based on a white-box model by combining a black-box model such as SVM or ANN when we need to see classification rules.

Finally, in the evaluation phase, we conduct testing to evaluate the prediction model built. We usually conduct k-fold cross validation, create a contingency table and calculate micro- and/or macro-average F1 measure or Accuracy.

5 EMPIRICAL RESULTS: A SUMMARY

We proposed various methods of predicting final student grades and validated them by showing experimental results. We used LSA and k-means [Sorour+ 2014a, Sorour+ 2014b, Sorour+ 2015c], ANN [Sorour+ 2014d], ANN and SVM [Sorour+ 2014c, Sorour+ 2014e] and Topic Models[Sorour+ 2015a, Sorour+ 2015b]. We considered not only individual lesson data, but also consecutive lessons data and proposed a method based on Majority Vote called MV method [Sorour+ 2015d, Luo+ 2015e, Sorour+ 2015f, Sorour+ 2015g, Sorour+ 2015h, Sorour+ 2017]. We also tried to use Multiple-Instance Learning and compared with the MV method[Sorour&Mine 2016a]. Further, we transformed word features into student learning attributes and created attribute-based vectors as inputs of prediction model. We called it Attribute-based Model [Sorour&Mine 2016b]. We verified the effect and necessity of Teacher Interventions [Sorour+ 2016c], and created an understandable prediction model by stacking of a whitebox model and a blackbox model [Sorour+ 2016d].

6 CONCLUSIONS

This paper presented our Comment mining project that we have conducted since 2011. We collected student comments after every lessons from several classes not only in Japan, but also in other country. Using the collected comments, we have investigated highly accurate methods to estimate final student grades by applying various machine learning techniques to the collected comments. We have found that stacking of several machine learning models is promising to improve the accuracy of estimating final student grades. In addition, using multiple comment data in consecutive lessons is also effective way. Employing both techniques, we obtained over 90% F1 measure.

However, we still have a lot of work to do. So far, we have not verified if there is any effect to give students individual feedback. On an empirical basis, we believe there is, but we have to verify how much extent the individual feedback earns for improving student learning attitudes or performance. Although we gave individual feedback to students by replying to their comments manually, it is time consuming and requires lots of efforts and patients for teachers. To overcome the problem and give students feedback automatically, we develop educational chat bots that interacts with students. We believe interaction results between chat bots and the students give teachers good hints to improve their lessons and to provide better advice to students.

We also have to verify if we can predict final student grade using past student comment data. We have conducted experiments to estimate final grades of students in one class using the data of students in other class, but in the same semester. The results were worse than using the student data in the same class. However, the students in the two classes belong to different schools, respectively. So we should investigate if we can estimate final student

grade with high accuracy by using the past student data in the same school or the same department, but different semesters or years.

The other problem is to verify if we can apply Comment mining techniques to younger students such as junior high-school students. Unlike undergraduate students, some of them still have difficulty for reading and writing. Through analysing student comments, we have found the quality of student comments affects prediction accuracy of final student grades. Therefore, in analysing comments of junior high school students, we may have to take care of grammatical correctness of sentences in the comments and to detect incorrect expressions in the comments. We are tackling these problems. We hope to report some of highlighted results soon.

ACKNOWLEDGEMENTS

We thank Prof. Sachio Hirokawa who introduced text mining techniques to the project. Prof. Tsunenori Ishioka gave us valuable advice on statistical analysis. We thank Hirotaka Kawahara, Carolin Guenzel, and Jingyi Luo who engaged in the project. We also thank Takayuki Nagai, Ichiro Niiya and Jihed Makhlouf who are now studying in the project. This work is partially supported by JSPS KAKENHI No. JP16H02926.

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