FEATURE REDUCTION FOR NEURAL NETWORK IN DETERMINING THE BLOOM'S COGNITIVE LEVEL OF QUESTION ITEMS

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To my beloved father, mother, sisters, aunts and friends

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ABSTRACT

The concept of Bloom's taxonomy has broadly implemented as a guideline in designing a reasonable examination question paper that consist of question items belonging to various cognitive levels which are tolerate to the different capability of students. Currently, academician will identify the Bloom's cognitive level of question items manually. However, most of them are not knowledgeable in identify the cognitive level and this situation will result to miss categorized of question items. To overcome this problem, this study has proposed a question classification model using artificial neural network trained by the scaled conjugate gradient back-propagation learning algorithm as question classifier to classify cognitive level of question items. Several data preprocessing techniques such as word extraction, stop word removal, stemming, and vector representation are applied to transform the text content question item into a numeric form called feature vector. Due to the poor scalability of neural network on high dimensionality of input space contributed by high dimensionality of feature space, several feature reduction methods are proposed to reduce the dimensionality of feature space. In this study, comparison experiments are conducted to investigate the performance of neural network question classifier that applied various feature reduction methods which are whole feature set method, document frequency method, and category frequency – document frequency method. The performance is measured in terms of classification accuracy, convergence time, and convergence error. The outcome indicates that proposed model was able to enhance the convergence speed. Besides that, the results have also illustrated that the document frequency was found to be the most effective feature reduction method among all proposed feature reduction method since it maintained the classification accuracy while enhancing the convergence speed.

ABSTRAK

Konsep taksonomi Bloom telah digunakan secara meluas sebagai garis panduan dalam mereka sesebuah kertas peperiksaan yang terdiri daripada soalan-soalan kepunyaan pelbagai tahap konitif yang bertoleransi dengan keupayaan pelajar yang berlainan. Biasanya, ahli-ahli akademik akan mengenalpasti tahap konitif Bloom sesuatu soalan secara manual. Walaubagaimanapun, kebanyakan ahli akademik adalah tidak mempunyai ilmu yang cukup bagi mengenalpasti tahap konitif soalan dan ini akan menyebabkan kegagalan dalam pengelasan soalan. Bagi mengatasi masalah ini, kajian ini telah mencadangkan penggunaan rangkaian neural yang dilatih dengan algoritma rambatan balik *scaled conjugate gradient* sebagai pengelas soalan bagi mengelaskan tahap konitif soalan. Beberapa teknik pra-pemproses data seperti pengekstrakan perkataan, penyingkiran perkataan perhentian, *stemming*, dan perwakilan vektor telah digunakan untuk mengubah soalan yang berbentuk teks kepada vektor *feature* yang berbentuk angka. Dengan kebolehskalaan rangkaian neural yang akan kurang memuaskan pada dimensi input tinggi yang disumbangkan oleh dimensi set *feature* yang tinggi, beberapa kaedah pengurangan *feature* telah dicadangkan bagi menurunkan dimensi set *feature*. Dalam kajian ini, experimen perbandingan telah dilaksanakan untuk menyiasat prestasi rangkaian neural yang menggunakan pelbagai kaedah pengurangan *feature* iaitu kaedah *whole feature set*, kaeda *document frequency*, dan kaedah *category frequency – document frequency*. Prestasi rangkaian adalah diukur dari aspek ketepatan pengelasan, kadar kepantasan penumpuan, dan kadar ralat penumpuan. Hasil kajian mempamerkan bahawa model yang dicadangkan dapat meningkatkan kadar kepantasan penumpuan. Hasil kajian juga menunjukkan bahawa kaedah *document frequency* adalah kaedah yang paling berkesan kerana kaedah ini dapat mengekalkan kadar ketepatan pengelasan semasa meningkatkan kadar kepantasan penumpuan.

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
CF-DF	-	Category Frequency – Document Frequency
DF	-	Document Frequency
SCG	-	Scaled Conjugate Gradient
TFxIDF	-	Term Frequency – Inverse Document Frequency

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CHAPTER 1

PROJECT OVERVIEW

1.1 Introduction

Recently, the use of text classification technique has received much attention in all sectors of education especially in assessment part. Many E-learning systems and question banks had been converge to apply text classification approach in order to classify the question item in the database into a set of predefined categories. It has been admitted that the categorized question items can help in designing more reasonable examination question paper since the academician or system can use the category information of the question items to design or revise the examination question paper so that it meets the educational objective.

Generally, question classification systems are designed to categorize question item into their corresponding category. In this case, the Bloom's cognitive levels are used as the criteria for the category information. Whenever an academician wants to produce an examination question paper, he/she will check the Bloom's cognitive level of question items that deposited in the exam paper so that a paper that consist

of various cognitive levels will be created in order to tolerate the different capability of students. Therefore, a question classification approach is considerably has great influence on designing a new desired examination question paper since it determine the cognitive level of the question item for the exam paper designer.

Bloom's cognitive domain is one of the three part of Bloom's taxonomy of educational objective that is used for classification of cognitive educational objectives. Objectives in this domain pertain to intellectual knowledge, skills, and abilities which are classified from the simple recall or recognition of fact as the lowest level to the highest evaluation level through increasingly more complex and abstract mental levels. The six Bloom's cognitive levels that occur in increasing complexity are knowledge, comprehension, application, analysis, synthesis, and evaluation.

There are two main processes are involved in order to classify the question items into their corresponding cognitive level. Firstly, a question item that is desired to be classified will be processed with some data preprocessing techniques in order to transforms it into a form that can be fed as input to machine learning. These data preprocessing methods include word extraction, stop words removal, stemming, and vector representation. These data preprocessing techniques extract the term or word called feature from the question item and converts it into a form called feature vector so that it can feed as input to machine learning.

Secondly, a question classifier is used to perform a classification task in order to category the question item into their corresponding cognitive level. An artificial neural network is a well known machine learning that perform well in classification task. Therefore, in this case, an artificial neural network will be treated as a question classifier since this machine learning is able to predict the category of an input vector belongs.

1.2 Problem Background

Bloom's taxonomy has broadly implemented in the sector of education. It has been used as a guideline in planning and designing an educational objective. In order to determine the achievement of student on certain learning objectives, the assessment such as quiz and exam plays an important role. In general, academicians will prepare test questions for various assessments which match the learning outcome and the instructional objective in order to determine whether a student has achieved certain learning objectives. However, the process of preparing and designing test question on relevant learning objective has been realized is always time consuming and difficult to be implemented.

Currently, lecturer will identify the Bloom's cognitive level of question items manually. However, most of them are not knowledgeable in identify the cognitive level and this situation will result to miss categorized of question items. In fact, it is sometimes conflict to determine the Bloom's cognitive level of question by human expert due to the keyword using in the question since same keyword may categorized in different level. Moreover, the process of determination Bloom's cognitive level of question item will be a very time consuming and tedious job since the number of question desired to be classified in an exam paper are always high.

Therefore, this study is attempts to categorize question item by using artificial neural network and to do a comparative study between three different feature reductions methods that is used to reduce the dimensionality of initial feature space which will be fed as input to the artificial neural network. Although artificial neural network is good in categorizing object, we need to study on how artificial neural network to classify a textual context object that is the cognitive level of question items.

1.3 Problem Statement

In a conventional approach, the process of classification of question item into their corresponding Bloom's cognitive level is done by manually. In general, most of the lecturers especially for those less experience lecturers are not knowledgeable to classify the cognitive level of question items. Since the purpose of designing and generating question items in examination paper is to determine the achievement of student on certain learning objective, this conventional method can be consider as a inefficient solution especially for those less experience lecturers because they can't identify the cognitive level of question item correctly.

By applying the artificial neural network to classify cognitive level of question items, it will provide an approach to help the lecturer to classify the cognitive level of question items and then let lecturer to evaluate the achievement of student on certain learning objective based on these different level of question items. Some different feature reduction methods will be applied in the classification process in order to improve the scalability of the artificial neural network and their corresponding result will be compared in order to find out the most efficiency feature reduction among them.

Therefore, the research question of this study is how effectiveness the artificial neural network to classify the cognitive level of the question items with different feature reduction methods.

1.4 Project Aim

The aim of this project is to propose a question classification model that based on scaled conjugate gradient neural network that can help the lecturer to classify the cognitive level of question items and to investigate the performance of neural network question classifier which applied various feature reduction methods to classify the cognitive level of the question items.

1.5 Objectives of the Project

The objectives that are required to be achieved in this project are defined as follows:

1. To investigate and analyze the process of the artificial neural network to classify text form object.
2. To compare the effectiveness of artificial neural network that applied whole feature set, document frequency (DF), and category frequency – document frequency (CF-DF) feature reduction method to classify Bloom's cognitive level of question items.
3. To determine the Bloom's cognitive level of question items using the artificial neural network.

1.6 Scopes of the project

The scopes of the project are defined as follows:

1. The network architecture is three layers feed-forward neural network and the training paradigm is supervised scaled conjugate gradient back-propagation algorithm.
2. The feature reductions used are whole feature set, document frequency method (DF), and category frequency – document frequency method (CF-DF).
3. Process of classification only does on cognitive domain of Bloom's Taxonomy.
4. There are Bloom's verbs appear in all the question items used in this study.

1.7 Significance of the Project

The main purpose of this project is to propose a question classification model that based on scaled conjugate gradient back-propagation neural network and to investigate the performance of artificial neural network to classify cognitive level of question with three different feature reduction methods that are whole feature set, document frequency method (DF) and category frequency – document frequency method (CF-DF). The results of this project can be used to verify the efficiency of each feature reduction method in order to find out the best of them. Furthermore, this project provides an approach to help the lecturer to classify the cognitive level of question items and then let lecturer to evaluate student based on these different level of question item.

1.8 Project Plan

This project will be carried out in two semesters. In the first semester, gathering information for this project is done by studies the related resource such as journal, article, reference book, and relevance thesis in order to gain more understanding of methodology that will be used. Some data preprocessing methods will also be carried out on the question set. In the second semester, all question items in the question set are preprocessed and feed to the artificial neural network in order to train and test the network. After that, the output of the artificial neural network with different feature reduction methods is analyzed and compared.

1.9 Organization of the Report

This report consists of five chapters. The first chapter presents introduction to project, problem background, and objectives, scopes and significant of the project. Chapter 2 provides review on the process of text classification process, artificial neural network, Bloom's taxonomy, and some related research. Chapter 3 discusses the methodology that will be carried out in this project. Chapter 4 provides experimental result and associate discussions. Chapter 5 is the conclusion and suggestion for future work.

REFERENCES

Caudill, M. and Butler, C. (1992). *Understanding Neural Network: Computer Explorations*. USA: MIT Press.

Charytoniuk, W. and Chen, M.S (2000). Neural Network Design for Short-term Load Forecasting. *International Conference on Electric Utility Deregulation and Restructuring and Power Technologies 2000*. 4-7 April. City University,London, 554-561.

Demuth, H., Beale, M., and Hagan, M. (2008). *Neural Network Toolbox 6 User's Guide*. United States: MathWorks.

Fernandez-Redondo, M. and Hernandez-Espinosa, C. (2001). Weight Initialization Methods for Multilayer Feedforward. *Proceeding of European Symposium on Artificial Neural Networks*. 25-27 April. Belgium, Bruges, 360 - 365.

Forman, G. (2003). An Extensive Empirical Study of Feature Selection Metrics for Text Classification. *Journal of Machine Learning Research*. 3, 1289-1305. Association of Computing Machinery.

Ikonomakis, M., Kotsiantis, S., and Tampakas, V. (2005). Text Classificaiton using Machine Learning Techniques. *WSEAS Transactions on Computers*. 4(8), 966-974.

Jones, K. O., Harland, J., Reid, J. M. V., and Barlett, R. (2009). Relationship Between Examination Questions and Bloom's Taxonomy. *39th ASEE/IEEE Frontiers in Education Conference*. 18-21 October. San Antonio, Texas, USA.

Khairuddin, N. N., and Hashim, K. (2008). Application of Bloom's Taxonomy in Software Engineering Assessments. *Proceedings of the 8th WSEAS International Conference on Applied Computer Scince*. 21-23 November. Venice, Italy, 66-69.

Lam, L.Y. (1996). *Learned Text Categorization by Backpropagation Neural Network.* Master. Thesis. The Hong Kong University of Science and Technology.

Lam, S.L.Y. and Lee, D. L. (1999). Feature Reduction for Neural Network Based Text Categorization. *Proceedings of the Sixth International Conference on Database Systems for Advanced Applications*. 19 – 21 April. Hsinchu, Taiwan, 195-202.

Lee, C. H., and Park, S. C. (2006). *Text Categorization Based on Artificial Neural Networks*. Lecture Notes in Computer Science. (302-311). Berlin: Springer.

Li, C. H., and Park, S. C. (2008). Combination of Modified BPNN Algorithms and an Efficient Feature Selection Method for Text Categorization. *Information Processing and Management*. 45(3), 329-340. Association of Computing Machinery.

Liao, C., Alpha, S., and Dixon, P. *Feature Preparation in Text Categorization*. Oracle Corporation.

Moller, M. F. (1993). A Scaled Conjugate Gradient Algorithm for Fast Supervised Learning. *Neural Network*. 6(4), 525-533. Association of Computing Machinery.

Negnevitsky, M. (2005). *Artificial Intelligence: A Guide to Intelligent Systems*. (2nd ed.). Great Britain: Pearson Education Limited.

Parsons, R. D., Hinson, S. L., and Brown, D. S. (2001). *Educational Psychology: A Practitioner-Researcher Model of Teaching*. Canada: Wadsworth.

Porter, M. F. (1980). An Algorithm for Suffix Stripping. *Program*. 14(3), 130-137. Association of Computing Machinery.

Remeikis, N., Skucas, I., and Melninkaite, V. (2004). Text Categorization Using Neural Networks Initialized with Decision Trees. *Informatica*. 15(4), 551-564. Association of Computing Machinery.

Roy, D., Sarkar, S., and Ghose, S. (2005). Document Type Identification for Use with Intelligent Tutoring System. *ICDE International Conference*. 19-23 November. New Delhi, India.

Sebastiani, F. (2002). Machine Learning in Automated Text Categorization. *ACM Computing Surveys*. 34 (1), 1-47. Association of Computing Machinery.

Tanalol, S. H., Fattah, S., Sulong, R. S., and Mamat, M. (2008).Mining Exam Question based on Bloom's Taxonomy. *Proceedings of Knowledge Management International Conference*. 10-12 June. Langkawi, Malaysia, 424-428.

Thompson, E., Luxton-Reilly, A., Whalley, J. L., Hu, M., and Robbins, P. (2008). Bloom's Taxonomy for CS Assessment. *Proceedings of the Tenth Conference on Australasian Computing Education*. Wollongong, NSW, Australia, 155-161.

Ting, F., Wei, J. H., Kim, C. T., and Tian, Q. (2003). Question Classification for E-Learning by Artificial Neural Network. Information, *Communications and Signal Processing, 2003 and the Fourth Pacific Rim Conference on Multimedia. Proceedings of the 2003 Joint Conference of the Fourth International Conference***.** 3, 1757- 1761.

Zu, G., Ohyama, W., Wakabayashi, T., and Kimura, F. (2003). Accuracy Improvement of Automatic Text Classification based on Feature Transformation. *Proc: the 2003 ACM Symposium on Document Engineering*. 20-22 November, 118-120