Predicting Information Technology Competency Using Neural Networks

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Abstract

Neural networks are computational models with the capacity to learn, generalize, or to organize data based on parallel processing. The most commonly used is multilayer perceptron that are capable of representing non-linear functional mapping between inputs and outputs. These networks can be trained with a powerful and computationally efficient method called backpropagation. In this paper, a multilayer perceptron that utilizes backpropagation learning is used to forecast the information technology competency among teacher trainees in the teaching institutes. The system has been developed as a web-based self-assessment information system that can be used to obtain a model for predicting the information technology competency. The system functions as an instrument that generates questionnaires as well as performing rubric assessment online. The data will be entered online using web as a medium. This data will be fed into neural network simulator to obtain a suitable model. Once the model is obtained, it will then be used to predict the information technology competency among the teacher trainees. The data was collected from various teachers' training institutions in Malaysia. The findings indicate that the most suitable forecasting model comprises of eleven input nodes, five hidden nodes and one output node. The performance of the selected model obtained was 99.77% in accuracy. Hence the results show that the developed system can be used as a tool to assist decision-making in education.

Keywords: Information Technology Competency, Neural Network, Prediction

1. Introduction

Neural networks are computational models with the capacity to learn, generalize, or to organize data based on parallel processing. The most commonly used is multilayer perceptron that is capable of representing non-linear functional mapping between inputs and outputs. These networks can be trained with a powerful and computationally efficient method called back-propagation. In education, neural networks have been integrated with intelligent tutoring systems ([1] and [2]) and expert system ([3]). Other researchers such as [4] have used neural networks to predict whether a student is going to pass or fail in the computer adaptive test. In addition, neural networks have been used to determine the students' satisfaction in the school ([5]). [6] recommended that neural network is suitable to be used for online learning, particularly for subjects that used simulation techniques to explain a certain theory.

In information technology era, teachers are recommended to acquire information technology competency (ITC) as they are the driving force in education. In Malaysia, all trainee teachers are required take a subject known as Teaching and Learning Resource Management ([7]). At the end of the course, the trainee teachers are expected to acquire information technology competency (ITC). Since the information technology competency is very important, it is therefore an advantage if the teaching institutions could forecast the trainees' competency prior to their enrolment to Teaching and Learning Resource Management course. The forecasting results could provide some insights and then can be used by the institutions to assist decision-making in education. In this paper, a multilayer perceptron that utilizes backpropagation learning is used to forecast the ITC among teacher trainees in the teaching institutes.

2. Information Technology Competency

According to [8], ITC includes the knowledge about the characteristics, the use of hardware and software, computer system organization structure and its social impact. Information technology competency also refers to integration of intellectual ability with basic concepts and skills with regard to hardware and software applications for efficient use of information technology [9]. Based on the ITC definitions, knowledge and skills are two important elements when measuring ITC. Information Technology Competency's framework for teachers was formulated by four domains, namely:

Domain 1: Basic skills in computer operation, running programs, accessing and editing data using multimedia computer system.

Domain 2 : Communication skills and the ability to solve problems using several available software such as word processing, graphical, database, spread sheet, multimedia application, telecommunication, and software application for education management.

Domain 3: Knowledge in social issues, ethical, law, copyright and intellectual property in using computer software and hardware.

Domain 4: Skills in Information Technology (IT) in teaching such as planning and the ability to create new teaching materials by integrating several software and IT tools to make teaching process more effective and interactive.

The main emphasis of Information Technology Competency (ITC) for trainee teachers in Malaysia is on basic skills in using IT and computer literacy for teaching and learning purposes ([7]). The scope of the knowledge and IT skills for educational institution for trainee teachers in Malaysia includes:

i. Introduction to Information Technology

ii. Word Processing, Internet Access and Networking

iii. Spread Sheet

iv. Electronic Presentation

v. Information Technology Management in Teaching and Learning

vi. Database

vii. Computer Assistants for Teaching and Learning.

viii. Multimedia in Education

ix. Integration of Application.

Since the ITC is necessary in teaching and learning, it is important to ensure that the trainee teachers among teaching institutions obtain a common ITC standard. Due to this reason, ***NeuroCite*** has been developed as a tool for educationist to forecast such a competency.

3. Neurocite System

NeuroCite is a Web-based information system whose acronym for represents *Neural Networks for Computer and Information Technology Competency*. The system has been developed as a web-based self-assessment information system that can be used to obtain a model for predicting the information technology competency (see also [10]). The system functions as an instrument that generates questionnaires as well as performing rubric assessment online. The data will be entered online using web as a medium. This data will be fed into neural network simulator to obtain a suitable model. Once the model is obtained, it will then be used to predict the information technology competency among the trainee teachers. In this research, the data was collected from various teachers' training institutions in Malaysia.

3.1 Data Preparation

The data for ***NeuroCite*** was collected from the respondents using the questionnaires that comprises of two parts. The first part deals with the respondants' background that will be used as part of input parameters for the forecasting model. According to Groth ([5]), the selection of predicting variables can be based on the experts knowledge in the research domain. Hence in this study, the respondent background information is listed as follows:

I_1 = Sex

I_2 = Race

I_3 = Type of School

I_4 = Level of Education

I_5 = Grade for Modern Mathematics at Malaysian Education Certificate Level

I_6 = Computer Club Member at School

I_7 = Personal Computer at Home

I_8 = Access to Internet at Home

I_9 = Computer training

I_{10} = Programmed of Study

I_{11} = Semester of Study

The above respondents' background can be classified into 3 categories, namely the information related to the school, the information that is related to experience and the information about the teaching institution.

The second part of the questionnaires consists of self-evaluation items on information ITC that will be used as part of input parameters for the forecasting model. These items were constructed based on the Association for Educational Communication and Technology (AECT) and the International Society for Technology in Education (ISTE). The

scores were evaluated and adopted from Microsoft Office Rubrics ([11] and [12]). The self-evaluation part consists of 12 items that have been classified into 4 categories:

i. Basic competency in file management using the current operating system.
ii. Competent in using application packages in Microsoft Office.
iii. Competent in using the Internet for communication and searching information.
iv. Level of knowledge with regard to ethics in using the computer software

Rubric scales were used to represent the scores in ITC self-evaluation. The scores and their corresponding weights were used in this study since the score's range is able to distinguish the level of ITC effectively compared to the scores without the weights. Once the scores are calculated, the neural network's target will be assigned accordingly. To test the system, respondents from the teaching institutions in the North Zone of Malaysia were requested to answer the questionnaires. As a result, a neural network model for forecasting the ITC of trainee teachers is illustrated in Fig 1.

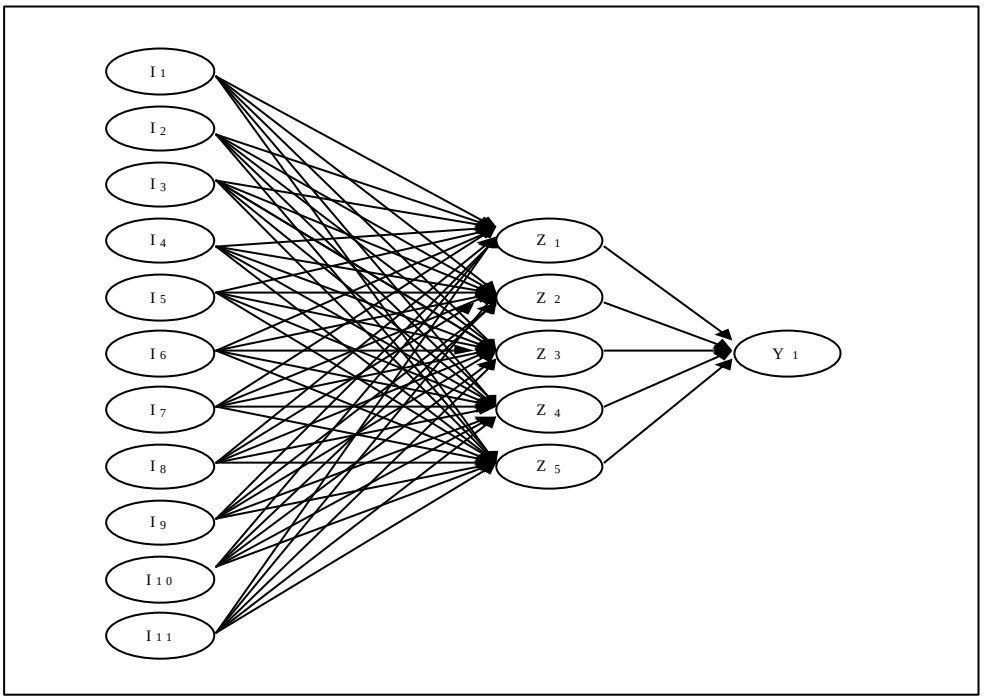

Fig. 1 Neural Network Model for Forecasting ITC

3.2 System Development

Neural network approach has been used in this system as an engine to predict and evaluate the performance level of ITC among trainees in the teaching institutes. ***NeuroCite*** system has five main integrated modules, viz.:

- **Self Evaluation Editor Module:** is used to develop the research item and evaluation item.
- **Self Evaluation Module**: is used to collect research item and evaluation item on-line.
- **Pattern Analysis Module:** is used to pre-process data prior to neural network training.
- **Backpropagation Simulator Module**: Backpropagation algorithm is used for training and testing purposes. The prediction model will be obtained.
- **Neural Predicting Module**: uses the results obtain from Backpropagation Simulator Module to predict the ICT level of the trainee teachers.

Module 1: Self-Evaluation Editor

This module is provided so that the lecturers can construct questionnaires items online according to the specified format (see Fig 2). In addition, the lecturers can also access available questionnaires from the server.

Fig. 2 User Interface for Self-Evaluation Editor Module

Module 2: Web Self Evaluation Module

To control the quality of the data, the respondents were required to key-in the input using web-based questionnaires. The questionnaires will be uploaded from the server and the interface is shown in Fig 3. The respondents were not allowed to add or edit the data representation in the system. The radio buttons were used to enable the system to accept and store only the authorized data into the system's database. The stored data will be preprocessed before it is sent to the next module.

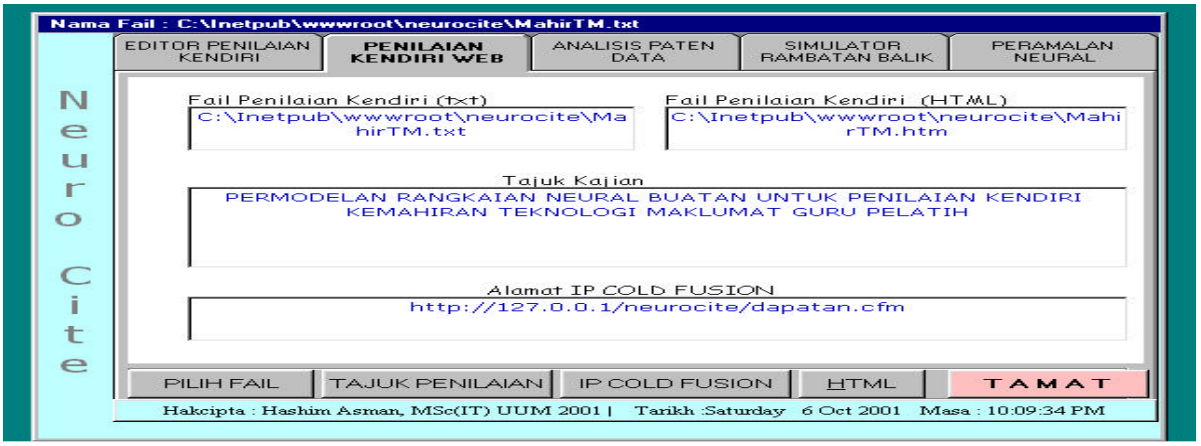

Fig. 3 User Interface for Self Evaluation Module

Module 3: Pattern Analysis

This module allows the administrator to set the composition of training and test sets. By default, 80% of the data will be chosen randomly to represent the training patterns while the rest will be used for testing (see Fig 4). The total number of training and test patterns as well as the data distribution will be displayed on the screen. All data will be converted to comma separated values prior to training and testing.

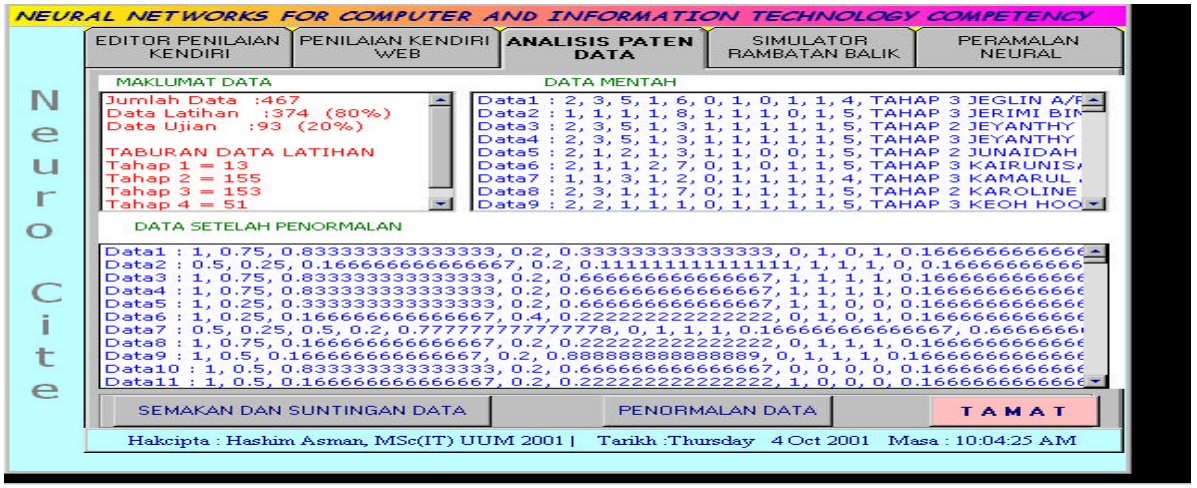

Fig. 4 User Interface for Data Pattern Analysis

Module 4 : Back Propagation Simulator

This module allows the administrator to train and test data using backpropagation learning algorithm. Neural network training can be performed by adjusting adjustment training parameters such as the number of hidden unit, learning rate AND momentum rate (see Fig 5).

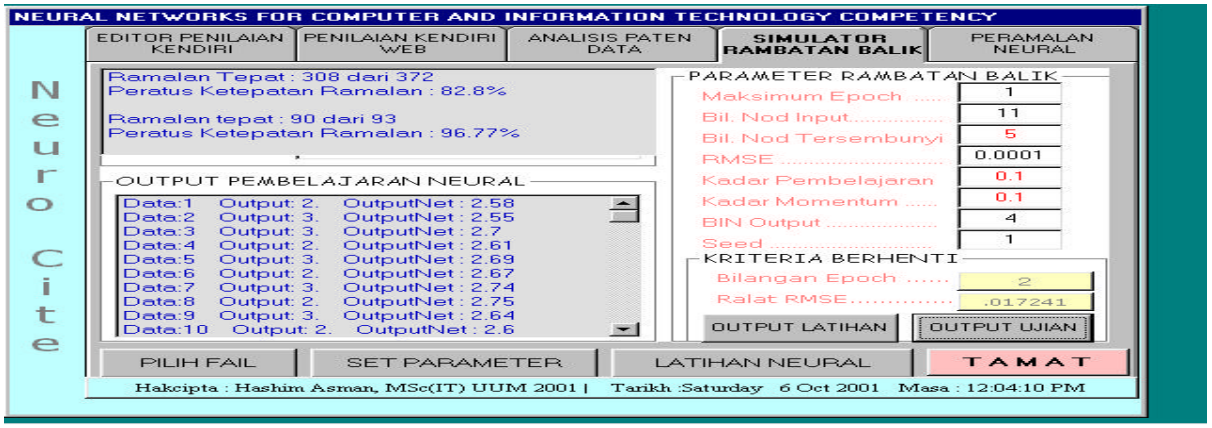

Fig 5 User Interface for BackPropagation Simulator

Module 5 : Neural Prediction

Once the suitable neural network model has been acquired from the Backpropagation Simulator, the system is ready to make prediction for the new data. When the trainee enters the data using the web-based questionnaires, the system will predict the particular trainee's ITC based on the built model (see Fig. 6).

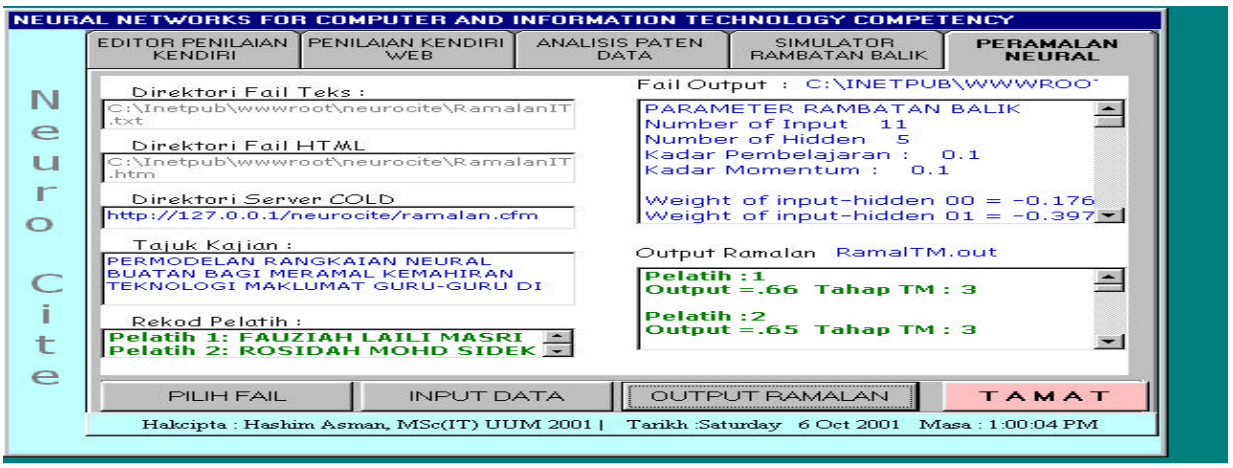

Fig. 6 User Interface for Neural Prediction

4. Results

As ***NeuroCite*** was developed for a web-based self-assessment information system, it can be used to obtain a model for predicting the ITC. The system functions as an instrument that generates questionnaires as well as performing rubric assessment online. The data will be entered online using web as a medium. This data will be fed into neural network simulator to obtain a suitable model. Once the model is obtained, it will then be used to predict the information technology competency among the teacher trainees. The data was collected from various teachers' training institutions in Malaysia and the findings are summarized in Table 1. The results indicate that the most suitable ITC forecasting model for this problem comprises of eleven input nodes, five hidden nodes and one output node. The results also exhibit that the number of epoch that provide the highest generalization with accuracy of 99.77%. Hence the results show that the developed system can be used as a tool to assist decision-making in education.

Table 1 Neural Network Model for predicting Information Technology Competency Among Trainee Teachers

Parameter	
Neural Network Architecture	Multilayer perceptron
Learning Algorithm	Backpropagation
No. of input node	11
No. of hidden units	5
No. of output node	1
Learning rate	0.1
Momentum rate	0.1
Activation Function	Sigmoid
Stopping criteria	500 epochs

For comparison purposes, the same data has been tested using nonlinear regression. The prediction model using nonlinear regression yields

$$O_1 = -0.0880I_1 - 0.112I_2 + 0.007418I_3 + 0.164I_4 - 0.135I_5 + 0.06503I_6 + 0.02293I_7 + 0.08874I_8 + 0.08318I_9 + 0.066I_{10} + 0.06629I_{11} + 0.538$$

The results for both neural networks and nonlinear regression are displayed in Table 2. The results indicate that the generalization obtained by neural networks is 9.67% higher than the one obtained by nonlinear regression. The results also imply that neural network can be used as a prediction tool to assist decision making in education.

Table 2 The generalization results using neural networks and Nonlinear Regression

Approach	Generalization (%)
Neural Networks	96.77
Nonlinear Regression	87.10

5.0 Conclusion

NeuroCite has been been tested and proved successful in providing the evaluation on the information technology competency online, particularly for the intranet environment. The preprocessing module that has been incorporated in Neurocite enables the model to be accomplished in a more systematic manner. Based on the results produced by neural networks, the system can be used as a prediction tool for education purposes. In this study, neural networks results outperform nonlinear regression. This indicates that neural networks have good potentials to be used as forecasting models in the future. Since research in using neural networks as forecasting tools in education is not many, future research may focuses on its use in education management as well as in teaching and learning evaluation.

References

[1] Mengel, S., Lively, W., Gesture recognition using recurrent neural networks, In Proceedings of CHI '91: Human factors in computing systems, 1991.

[2] Carlson, P.A.., Artificial neural networks and instructional technology, Journal of Computing in Higher Education. 3(1), pp. 3-22, 1991.

[3] Lively, S. M. W., Using a neural network to predict student responses, Proceedings of the ACM/SIGAPP symposium on Applied Computing, 2, pp. 669-676, 1992.

[4] Nelson, V. C., Henriksen, L. W., Using neural network technology to enhance the efficiency of a computer adaptive testing application. A paper presented at the Mid-Western Educational Research Association Meeting, October 12-15, 1994, Chicago, IL, ERIC document #387122, 1994.

[5] Linnakyla, P. & Malin A., Profiling students on the quality of school life by neural networks. Paper submitted for the journal Social Indicators Research, 1998.

[6] Lang, T.. *Introduction to Neural Networks*, http://www.computerteacher.org/neural_nets.htm., 2001.

[7] Ministry of Education, Malaysia, Kuala Lumpur: Bahagian Pendidikan Guru. Sukatan Pelajaran Pengurusan Sumber, 2001.

[8] Westfall, R.D., Evaluation and Assimilation Skills as Key Knowledge aspects of Information Technology Literacy, http://www.cyberg8t.com/westfalr/it_litrc.htm, 1997.

[9] Young, J., Learning to Learn: Assessing Information Technology Literacy, National Research Council's Committee on Information Technology Literacy. Being Fluent with Information Technology, 1997.

[10] Patterson, D.W., *Artifical Neural Networks : Theory and Applications*, Singapore: Prentice Hall, 1995.

[11] Descy, D., Johnson, D., *Microsoft Rubrics*, http://www.ga.k12.pa.us/curtech/stucours/offrubr.htm, 1998.

[12] Microsoft Office Rubrics: http://www.ga.k12.pa.us/curtech/stucours/offrubr.htm