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# Students Graduation on Time Prediction Model Using Artificial Neural Network

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***Abstract:****The declining rate of student graduation in today's higher institutions of learning has become a major source of concern to educational authorities, school administration and parents. While school administrators are trying to increase the rate of graduation, students are dropping out at an alarming rate. The ability to correctly predict student's graduation time after admission into graduate program is critical for educational institutions because it allows for developing strategic programs that will aid or improve students' performances towards graduating on time (GOT). This paper explores predictive nature of artificial neural networks (ANN) to design a model based on cognitive and non-cognitive measures of students, together with background information, in order to predict students' graduation time. Synthetic data was used to test and verify the effectiveness of the proposed model. The results shows that artificial neural network is a promising tool for prediction.*

***Keywords:****Prediction, Artificial neural networks, Graduation on Time.*

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## I. Introduction

The declining rate of student's performances in institutions of higher learning has posed a significant threat to the educational system around the globe. Several factors are contributory to this menace. Some of these factors may include a poor prior academic background, lack of interest or focus, improper selection during admission process and distraction from campus activities[1, 2]. The declining performance of students has led to inability of students to graduate within postulated graduation time. School management/administrators are searching for means to improve graduation rates of students. This will improve the economic prosperity of a nation, to prove the effectiveness of the institution to accrediting bodies and government [2]. Hence, predicting student's graduation is of great importance not just to the school administrators but to the entire nation.

Prediction of students' academic performance has been proposed using different methodologicalstrategies. Some of the conventional techniques include traditional statistical methods, such as discriminant analysis and multiple linear regressions [3], Structural Equation Modelling (SEM) [4], and machine learning techniques [5]. Furthermore, predicting students graduation on time have also been proposed using different approaches. Some of these proposals include the use of Bayesian model [6], random forest classifier [7] and ensemble learning [8].

The use of conventional statistical methods has been proven not to always yield accurate predictions [9]. Application of ANN for the purpose of prediction, selection, and classification suggests that this technique can increase predictive validity and accuracy of educational outcomes [9]. Furthermore, ANN has been employed and proven successful in many fields of endeavour. It has also been considered a vital technique for classification, pattern recognition and prediction [9].This work proposes a scheme for predicting student graduation on time using artificial neural network (ANN). Some contributions of this work include:

i. A review on students graduation prediction strategies
ii. Description of ANN and its application areas
iii. Identification of the need for predicting students GOT
iv. A model for predicting students graduation using ANN

The remainder of this paper is structured as follows. Section two presents related worksusing artificial neural network for prediction purposes in education. The concept of artificial neural network is presented in section three. Section four presents the implementation methodology and dataset used. Results are presented in section five. Conclusion and recommendation in presented in Section six.

## II. Related Works

There are several attempts recently by researchers and administrators to mine student's data. These attempts are to either predict students enrollment rates, failure rates, dropout rates and/or graduation rates [2]. Some of these approaches include, factor analysis[10], multiple regression analysis [11, 12], path analysis [13], and discriminant analysis [25]. These techniques have shown different levels of success. However, in the case of detecting patterns and prediction they are not as effective as artificial neural networks [2].

Artificial neural networks have been employed by several researchers to mine students' datasets for different purposes. E-learning outcomes prediction based on scorecard using ANN was proposed in [14]. A neural network based software for the prediction of students performance in mathematics have been proposed in [15], which shows the superior performance of ANN compared to Resilient Backpropagation (Rprop), modified spectral Perry (MSP), Bayesian networks and support vector machines etc. Factors that affect students' performance using artificial neural network was proposed in [16]. Prediction of students results using a multilayered perceptron was proposed in [17].

Neural networks shows superiority in prediction and classification of results; chiefly when large datasets with nonlinear characteristics are involved. Also, if the inter-correlation among variables in datasets are ambiguous and complex ANN is suitable for prediction [9]. These qualities of ANN qualifies the algorithm as a tool for large data where they can simultaneously use all variables in a research. Neural networks can work with noisy, incomplete, overlapping, highly nonlinear and non-continuous data because the processing is spread over a large number of processing entities [18]. Hence, neural networks can be said to be robust wide non-parametric application.

## III. Artificial Neural Networks

Artificial Neural Networks are mathematical models that try to simulate the basic actions of the human brain[19]. Information to be processed are passed among neurons based on the structure and synapse weights, hence producing a network behaviour. ANN contains nonlinear interactions amidst several datasets which cannot be identified using conventional investigation techniques. They are artificial intelligence computing algorithms used for solving complex optimization problems.

Artificial neural networks are effective instruments for simulating a number of non-linear systems. They have been successfully employed to a variety of research problems with substantial complexity in different research fields of endeavours. Some of these application areas include education [19], engineering [20], agriculture[21], education[22], medicine[23], aviation[24].

The conventional structure of ANN is the perceptron-type neural networks which is made up of artificial neurons nodes, serving as information processing elements arranged in layers and interconnected by synaptic weights (connections). Neurons have the ability to filter and transmit information in a supervised manner. This capability makes it possible to create models that can mine, classify and predict situations in stored data. A standard ANN model consists of three-layered interconnected network nodes: the input layer, the hidden layer, and the output layer. Figure 1 presents a standard ANN structure.

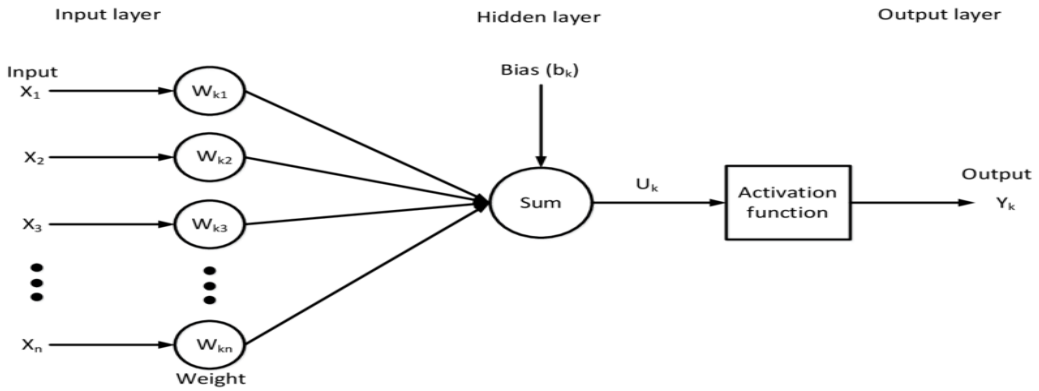


**Figure 1:** Standard Neural network structure

The hidden layer can be one or more depending on problem formulation. Every neuron in one layer has a link to every other neuron in the next layer, but neurons belonging to the same layer have no connections between them Figure 2. The input layer receives information from the outside world, the hidden layer perform the information processing and the output layer produces the class label or predicts continuous values. The values from the input layer entering a hidden node are multiplied by weights, a set of predetermined numbers,

and the products are then added to produce a single number. This number is passed as an argument to a nonlinear mathematical function, the activation function, which returns a number between 0 and 1.

There are different activation functions depending on the model to be used. Some of these mathematical activation functions include: the Threshold function or Heaviside function, the sigmoid function and the Piecewise-linear function.

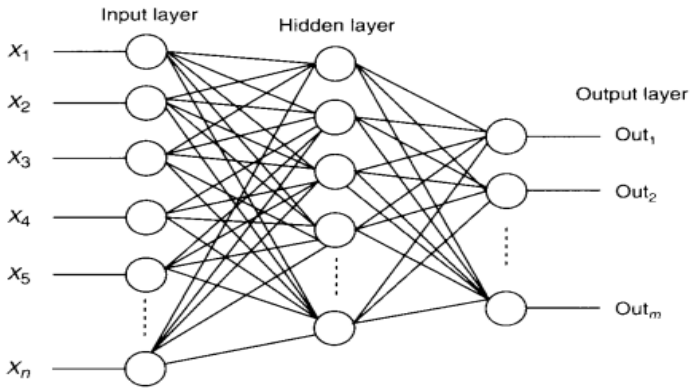


**Figure 2:** Neural network architecture

Figure 3 presents a neural network active node [25], with weighted inputs ingoing a node j given by and activation function (sigmoid function) output defined by .

The neural network neuron is thus characterized by two phases of operation, the training and the testing mode. The training stage involves a data set with real inputs and outputs used as instances to learn and furnish the system with the required knowledge for prediction. This method of training is referred to as supervised learning. The process starts with a set of randomly generated weights, which are adjusted specified algorithms like gradient descent search algorithm. The results obtained are compared to the expected results and the difference in results used as input to the error function for learning [25]. After obtaining a good and satisfactory set of weights, the trained model is ready to predict automatically any set of given dataset.

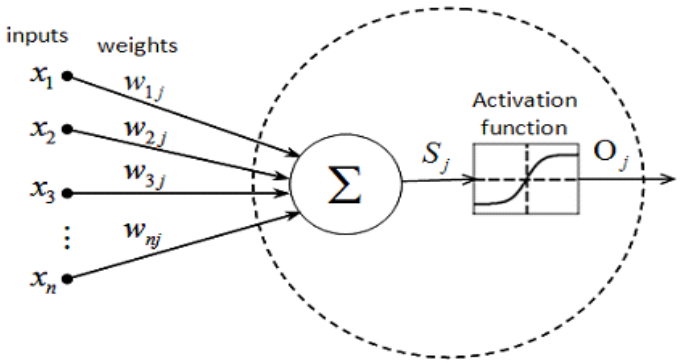


**Figure 3:** Artificial neural network active node[25]

## IV. Methodology

**Dataset**

For testing and evaluation, synthetic data was generated and used. Data was generated based on student's previous academic history and performance. The factors used for data generation include:

- Masters study period (in semesters)
- Masters GPA
- Number of Deferred semesters (During Masters study)
- Bachelor Study period
- Bachelor GPA
- Number of Deferred semesters (During Bachelor study)

**Table 1:** Example of some samples of data generated

| Period | Gender | G | MSc Study Period | MSc GPA | MSc # Def. Sems | MSc # TM Sems. | BSc Study Period | BSc GPA | BSc # Def. Sems. |
|---|---|---|---|---|---|---|---|---|---|
| 11 | male | 1 | 7 | 3.2 | 2 | 0 | 8 | 3.62 | 0 |
| 9 | male | 1 | 8 | 3.16 | 1 | 0 | 6 | 3.78 | 2 |
| 10 | female | 0 | 6 | 3.23 | 0 | 2 | 10 | 3.64 | 1 |
| 5 | female | 0 | 6 | 3.23 | 0 | 2 | 7 | 3.68 | 2 |
| 4 | male | 1 | 2 | 3.04 | 1 | 1 | 7 | 3.34 | 0 |
| 11 | male | 1 | 4 | 3.61 | 0 | 1 | 8 | 3.06 | 1 |
| 5 | female | 0 | 3 | 3.14 | 0 | 1 | 9 | 3.04 | 2 |

**Problem Formulation and Implementation**

To predict whether PhD students can accomplish GOT, this study's focus is more on the Academic Performance Indicators, namely, Gender (G), MSc Study Period, MSc GPA, Number of Deferred Semesters in Master period, Number of Semesters with Unsatisfactory results in Master period, BSc Study Period, BSc GPA and Number of Deferred Semesters in Bachelor Studies.

MATLAB ANN toolbox software was used for the experiment.

**System Architecture and Components**

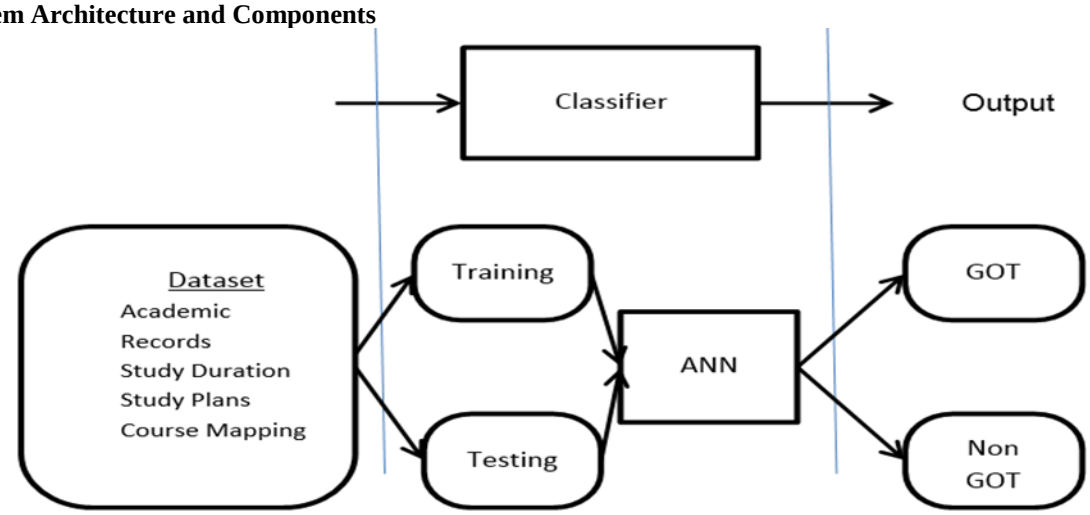


**Figure 2:** Architecture and components

## V. Results and Discussion

The results of the training phase of the simulation is presented in Figure 3. The number of iterations, performance and validation are as shown in Figure 3.

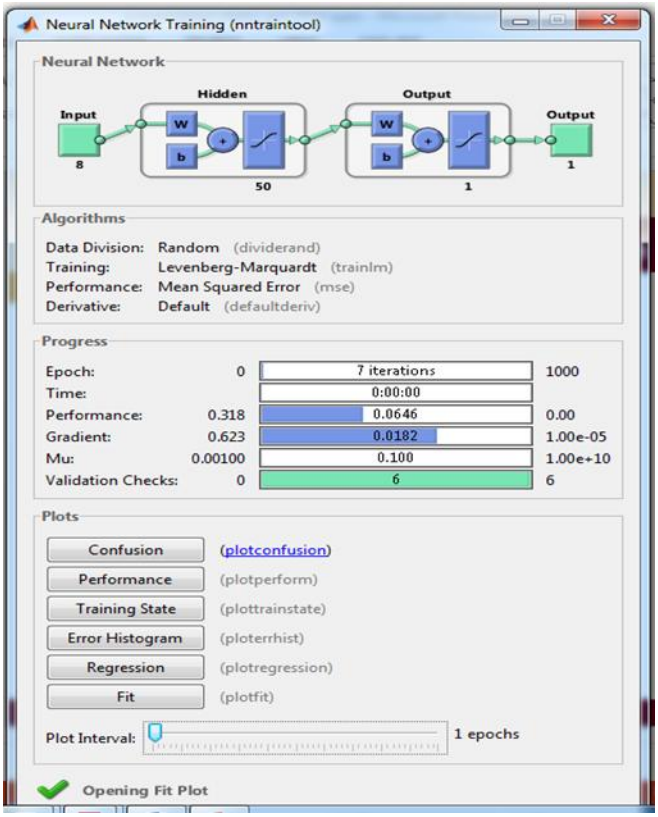


**Figure 3:** Results of Training Neural Network

The overall performance of the designed algorithm with the following inputs NN 80% of the data for training and 10% for validation and testing, using 50 neurons in the hidden layer of the NN is presented in Figure 4.

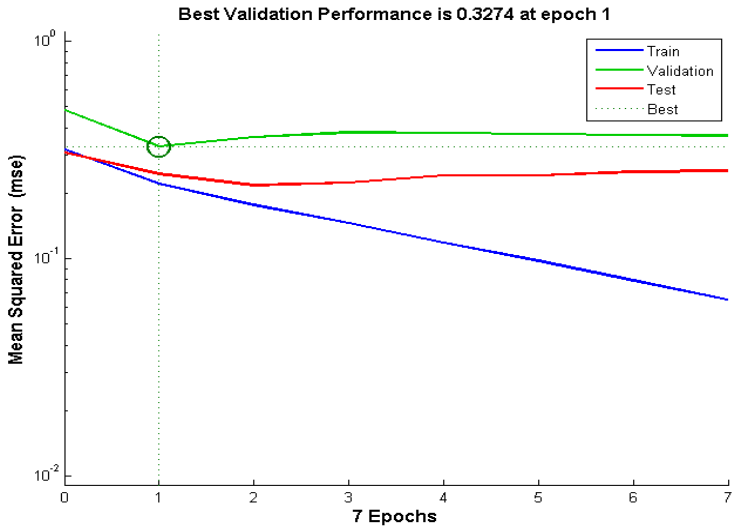


**Figure 4:** Network Performance

**Figure 5:** presents the confusion matrices for training. Figure 6 presents the training status, and the error histogram is presented in Figure 7. A confusion matrix, also known as a contingency table or an error matrix, is a specific table layout that allows visualization of the performance of an algorithm, typically a supervised learning one (in unsupervised learning it is usually called a matching matrix). Each column of the matrix represents the instances in a predicted class, while each row represents the instances in an actual class. The name stems from the fact that it makes it easy to see if the system is confusing two classes (i.e. commonly mislabelling one as another).


**Figure 5:** Confusion Matrix

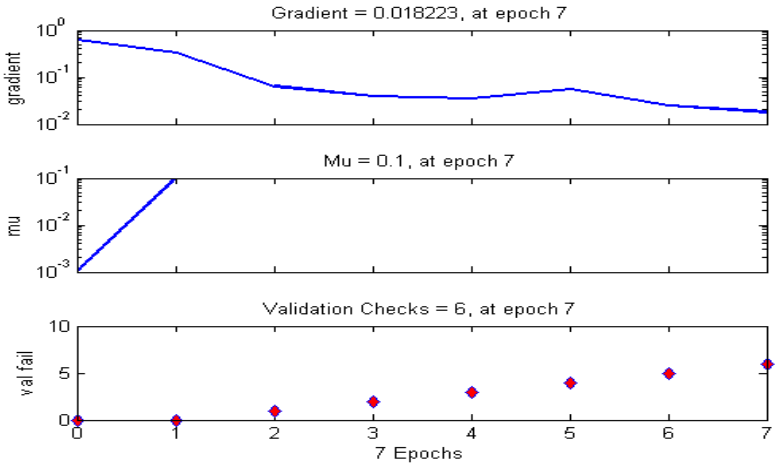


**Figure 6:** Training Status

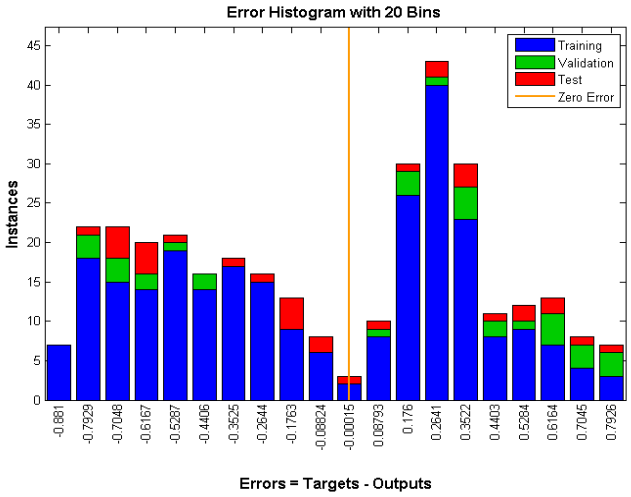


**Figure 7:** Error Histogram

Several experiments were conducted to evaluate the performance of the solution, based on changing the number of neurons in the hidden layer of the NN while changing the size of data samples used in the training of the network. Figure 8 presents the mean performance of different experiments using different number of neurons.

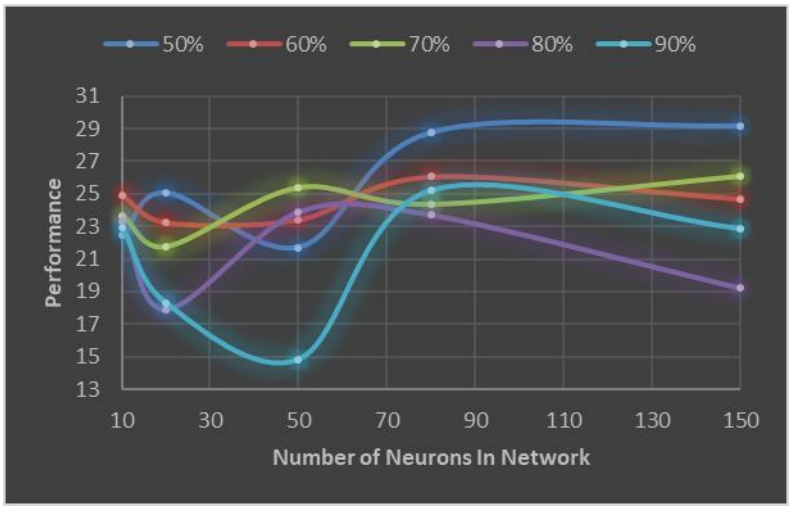


**Figure 8:** Mean Performance for different experiments

## VI. Conclusion

Motivated by the necessity for predicting student's graduation using fast and accurate scheme, this paper proposed a neural network strategy to predict students graduation on time. The system predicts student graduation time based on both cognitive and non-cognitive measures of students, together with their background information. In contrast to existing methods, our technique exploited the capabilities of ANN to predict students graduation on time. The performance of our technique was estimated with synthetic dataset. The experimental results show that we are able to accurately predict students graduation successfully with minimal errors. This shows that ANN is a promising tool for prediction. As a future work, the system will be implemented with real datasets.

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