

Recommender System for Predicting the Academic Status of Students of Bangladesh Using Artificial Neural Network

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Abstract

Today, information technology in different areas produces a large amount of data every day. In recent years, many researchers have started to extract knowledge from data to make data-based decisions and improve the quality of processes in various organizations. Educational data mining helps educational institutions to operate effectively and efficiently by leveraging data from all stakeholders. It can help students at risk; create recommendation systems and alert students at different levels. Recently, neural network has received much attention in the educational sector compared to other methods. In this article, a study has been done using neural network on the dataset of Bangladesh University. The evaluation criteria for performance comparison are MAE (mean absolute error) and MSE (mean square error). The MAE and MSE of the neural network in the first run are 0.1357 and 0.026123, respectively. With the neural network, a recommender system has been presented to predict the students' academic status, which considers the student's status in four states: "excellent", "good", "needs more effort" and "needs guidance".

Keywords: Data mining, Educational Data Mining, Recommendation System, Neural Network.

1. Introduction

In recent years, the application of data mining in the field of education has increased dramatically. Educational data mining is an emerging interdisciplinary scientific branch that deals with the development of methods for data discovery, also educational data mining discovers useful knowledge from educational information systems, such as admission systems, registration systems, learning management systems, etc [1]. Educational data mining can be used for various purposes, such as predicting student enrollment in a course, predicting student performance and their final results, strengthening the understanding of the learning process, identifying and supporting students at risk of dropping out [2-4], warning students at risk before final exams, improving the performance of graduate students, improving the efficiency of higher education institutions and optimizing curriculum renewal and maximum use of university resources [5-8]. The measure of students' academic performance is a challenging issue that the use of educational data mining in education can be useful in formulating a student-centered strategy and providing the necessary tools for institutions to achieve their goals. The main goals of educational data mining are to create teaching materials, predict student performance, make recommendations for students, recognize student behavior, provide feedback for support instructors and plan courses based on student characteristics and apply deep learning strategies to predict students' internal assessment scores from Other goals are educational data mining [9,10].

In the field of educational data mining, various scientific works have been done in the past, in decision tree and regression analysis with automatic detection algorithm and Chi-Square analysis are used to identify students' academic satisfaction with academic experiences, social integration and university services [11]. to be The results obtained using the decision tree show that social integration is a determining factor for students' satisfaction and that university services and facilities have less effect on their satisfaction. In students' performance has been studied using deep learning techniques such as neural networks and data mining techniques such as random forest, support vector machine, decision tree and simple Bayes [12]. In linear regression is used to model the amount of accumulated knowledge [13]. In using step-by-step regression and decision tree from data mining techniques, the factors that affect the teaching performance of professors in the university are identified and the results show that the attitude of the instructor, the status of the teacher, the presence of students, and the feedback of students. It affects teaching performance [14].

Using a statistical approach, Srimani and Patil developed a simple linear regression model for educational data mining, the results of which help educational management [15]. Goa et al. developed a classification model to predict student performance using deep learning that automatically trains multiple levels [16]. Gadvi and Patel used a simple linear regression model to help students know their performance in advance, so this model presented to predict the final exam score in a specific subject helps

students to know how many scores in An internal test is required to get a certain grade [17]. Zhou et al. used various machine learning techniques such as simple Bayes, logistic regression and decision tree to predict students who were at academic risk in computer science departments of Chinese universities [18]. Also, this study predicts accuracy in decision tree algorithm and analysis. It examines logistic regression. Xing used deep learning to build a student dropout prediction model, and this method creates a more accurate dropout prediction model compared to basic algorithms [19].

Hossein et al. calculated precision-recall, accuracy and kappa statistics to predict students' results based on internal assessment scores, and Sediq Hossein et al. a regression model to analyze students' academic performance using learning Deeply designed [20,21]. There are various techniques for data mining, and neural networks are one of the most powerful tools among these techniques. Things are often done better by neural networks compared to traditional statistical methods, and researchers are increasingly using this method. The popularity of neural networks among data mining users is because they demonstrate their predictive power by comparing them with other statistical techniques and they have proved it by using real data sets, and the neural network is chosen as one of the best forecasting methods in terms of the accuracy of the results.

The accuracy of various data-mining methods in order to predict students' attitudes towards self-regulated learning and their academic performance are unequal, with the neural network having the highest prediction accuracy (98%) followed by the decision tree. (91%) is Next, the support vector machine and K-nearest neighbor showed the same accuracy which is (83%) and the method with lower prediction accuracy is Naive Bayes with 76% [22].

2. Data Mining

Data mining is a way to obtain useful information from a large amount of data, and the rapid growth of data worldwide has increased the importance of data mining. It can be simply stated that data mining refers to the extraction of knowledge from a large amount of data, for this reason many people consider this term a synonym for the word discovery of knowledge [23]. Data mining is used to identify new, correct, comprehensible and potentially useful relationships and patterns within data, by combining data sets and extracting complex patterns for humans. Data mining is an important step in discovering and extracting knowledge. This term means exploring large data sets to extract unknown patterns between data [24].

2.1 Educational Data Mining

Educational data mining is a branch of data mining that seeks to discover the knowledge contained in the data of the educational system. One of the applications of educational data mining is to predict the academic performance of students. Predicting the academic performance of students in order to know the academic

status and prevent poor performance and then to improve it, is of particular importance in the success of educational systems and in the knowledge and correct decision-making of managers and trainers to increase the efficiency of the educational system and better performance of students. It can play an effective role. In the field of data mining, Baker and Yasef have identified data prediction based on educational data mining as the most widely used field [25]. Also, Pina Ayala conducted a comprehensive review research in the field of educational data mining, which studies and researches of the type they identified forecasting as the most common research in this field [26]. Educational data mining is the process of transforming raw educational data into information that can be useful in design decisions or answers to research questions. The purpose of educational data mining depends entirely on who is going to use the results. For example: education director, lecturer, student or other officials. The used techniques are diverse and sometimes combined and have been designed and implemented according to different goals [27]. The use of different data mining techniques is considered as a potential field for a systemic change that can help higher education institutions to have the most significant positive impact [28]. Therefore, the results of data mining programs can provide valuable support for the decision-making process [29].

2.2 Recommender Systems

Today, due to the ever-increasing growth of the Internet and the massive amount of information, we need systems that can offer the most suitable services to the user. The systems that perform this task are called recommender systems. One of the important challenges in this field is the existence of little knowledge against a large amount of data; therefore, the existence of a strong tool to extract useful information from mass data is a vital issue [30]. There are two ways to use the recommender systems, one way is to use the existing data of the system directly, which is called the memory-based method, and the other way, which is a little smarter, is to use a model in the system and to It is called the model-based method (using genetic algorithms, neural networks, fuzzy) [31]. In this research, to create a recommender system, we use a model-based method, using a neural network, which is an intelligent solution, to predict the academic status of students.

2.3 Neural Networks

Neural networks are mathematical computational models that simulate the learning mechanism like the natural neural network of the human brain structure. A neural network forms a layer by putting several neurons together. The neural network calculates the calculation of the function by propagating the calculated values from the input neurons to the output neurons and using the weights as intermediate parameters. By analyzing data and the relationship between input and real outputs, neural networks can discover hidden aspects of science and hidden relationships in data [32]. The block-mathematical model of a neural network is shown in Figure 1 [33-43].

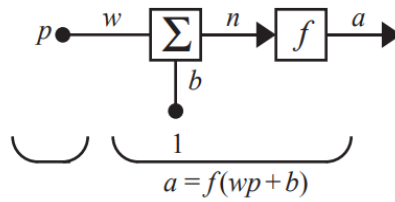


Figure 1: Block-Mathematical Model of the Neural Network

In Figure 2, the variables p , w , b , f , and a are the input matrix, the weight matrix of the neurons, the bias value, the transfer function, and the output matrix, respectively. Also, the neural network can have multiple inputs or multiple layers or multiple outputs. be Neural networks are used in two types and feed-forward, where in the feed-forward network, the signal is only allowed to move in one direction and cannot return to the neuron of the previous layer. In fact, the processing of input data is forward and the processing path does not return to the neurons of the previous layer, and the output of each layer will only affect the next layer, and in feedback networks it has at least one feedback signal, that is, the output of the neuron, except for the current input, depends on its previous output. Therefore, in this type of network, the signal can move in two directions and all connections between

neurons are allowed, that's why loops are used a lot in this type of network.

2.3.1 Transfer Function

Transfer functions can be a linear or non-linear function depending on the variable n , which are: Hard limiting function, Hardlims function, linear function, Log-Sigmoid function, Tan-Sigmoid function. The selection of the transfer function affects the accuracy of the network output, therefore, in order to determine the best combination of transfer functions in a neural network with one or more hidden layers, different transfer functions are used to develop the network. Table 1 shows transfer functions with conventional signs [33].

Function	Symbol	Input/output	Name of function
hardlim		$a = 0, n < 0$ $a = 1, n \geq 0$	Hard Limit
hardlims		$a = -1, n < 0$ $a = +1, n \geq 0$	Symmetrical Hard Limit
purelin		$a = n$	Linear
satlins		$a = -1, n < -1$ $a = n, -1 \leq n \leq 1$ $a = 1, n > 1$	Symmetric Saturating Linear
logsig		$a = \frac{1}{1 + e^{-n}}$	Log-Sigmoid
tansig		$a = \frac{e^n - e^{-n}}{e^n + e^{-n}}$	Hyperbolic Tangent Sigmoid

Table 1: Transfer Functions in Neural Network

2.3.2 Neural Network Learning

Working with the neural network becomes possible through teaching and learning in line with the goals. Learnability means the ability to adjust time-varying parameters, with the aim that the network can be efficient for new conditions with brief training. In most neural networks, learning rules are used to train the network, and neural network learning is done in two types, supervised and unsupervised, which is shown in Table 2

comparing these two learning methods [34-37].

2.3.3 Mean Square Error

The mean square error is a method to estimate the amount of error and is one of the most famous error functions that calculates the mean squared difference between the actual and predicted values by the following equation(1)

$$MSE = \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 \quad (1)$$

\hat{y}_i The real data y_i is the simulated (predicted) data and N is the total data in which $\frac{1}{N} \sum_{i=1}^N$ performs the averaging operation and $(y_i - \hat{y}_i)^2$ calculates the squared error value of Each data. The MSE result is always positive, and the closer its value is to zero, the lower the error; Therefore, in an accurate model, the MSE value is close to zero

$$MAE = \frac{1}{N} \sum_{i=1}^N |y_i - \hat{y}_i| \quad (2)$$

The performance of the proposed model in the paper is evaluated using the mean squared error (MSE), mean absolute error (MAE).

3. Creating Recommender System with Neural Network for the Studied Data

Some researchers, by reviewing the articles in the field of educational data mining, have come to the conclusion that the

2.3.4 Average Absolute Error

This function calculates the average absolute value difference between the actual and predicted values by the following equation:

most common studies in this field are predictive studies that we need a set of data collected from the database to create a predictive system. The data in this article belongs to the grades of students in Bangladesh University, which has 15165 samples, related to 6 semesters (3 years) and is based on 9 characteristics, which are included in Table 3.

The number of students	Attributes	data set
15165	Semester 1 2nd semester Semester 3 Semester 4 Semester 5 Semester 6 Candidate's overall score based on internal evaluation Candidate's overall score based on internal evaluation Final	academic records of Bangladesh University students

Table 3: Characteristics of the Used Dataset

3.1 Configuration of Recommender System with Neural Network

The dataset of our research is the educational records of the University of Bangladesh. This data set has 9 columns and 15165 rows, out of the 8 rows, 7 of them are considered as our features in the neural network as training input and column 8 as the training target. Due to the fact that the training course of Bangladeshi students in the field is 3 years, it is actually 6 semesters, 6 columns of grades of each semester and 1 column of the student's overall grade are based on internal evaluation. The number of students is 15165, and 8 columns of our data are actually their academic records. Due to the dispersion of the data and the fact that each one is in different intervals, the neural network training process is not performed well because

the difference in the size of the numbers is effective in modifying the weights of the network, and as a result, the number of experimental data must be very large to adjust the weights and obtain the desired result. For this purpose, in order to improve the performance of the neural network and also to ensure that the weights and biases of the network are close to each other in order to avoid the complexity of the network, all the input data are converted into data in the specified range and the data are normalized. The data set of this research is divided into two sets of training and test set, where 55% of the data are the training set and 45% of the data are the test set. Using the training data set, the proposed system is presented and the test data set is used to validate and correct the proposed model. Table 4 is the information about the neural network used in the article.

Effective criteria in recommender system with neural network	selected in this research
network type	Feedback
Transfer function	tansig, purelin
learning type	Supervised
learning function	traingdx, learngdm
The number of hidden layers	3

Table 4: Introduction of Selected Criteria in the Proposer System

4. Results

The neural network taught in this article includes 7 inputs and 1 output. If we check the desired academic characteristics of the students during their academic career, then we can predict the academic status of other students based on this. In this article, 6 semesters, actually 3 years of the students' study period were examined (the entire study period was 3 years), which will be

taught the process of converting input to output, in order to predict. Figure 3 shows the progress of program implementation in order to reach the best solution of the neural network based on the least error and the highest accuracy. In Figure 4, the horizontal axis and the vertical axis indicate the number of repetitions and MSE, respectively. The best performance validation is the numerical value of MSE equal to 0.026 in iteration 8.

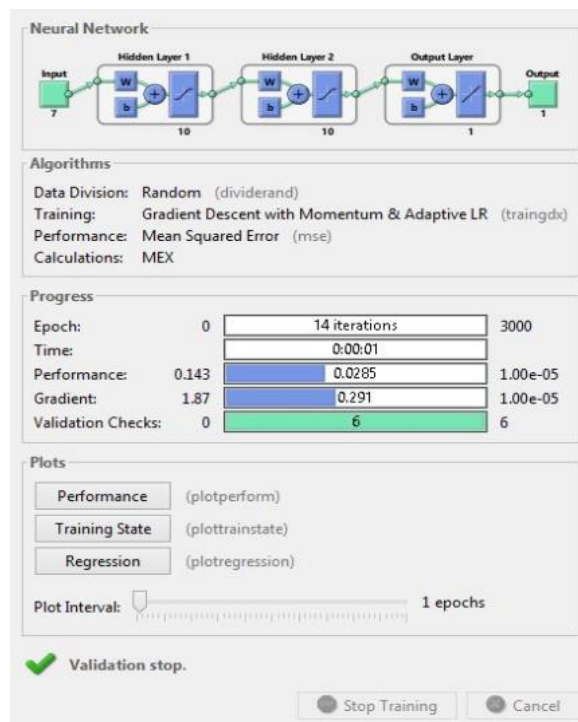


Figure 2: Performance Output with Neural Network

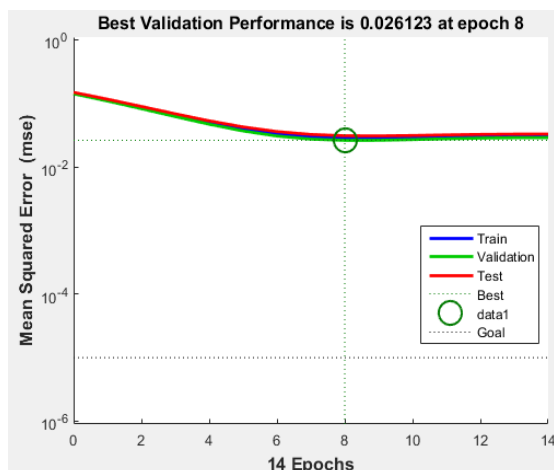


Figure 3: Neural Network Performance

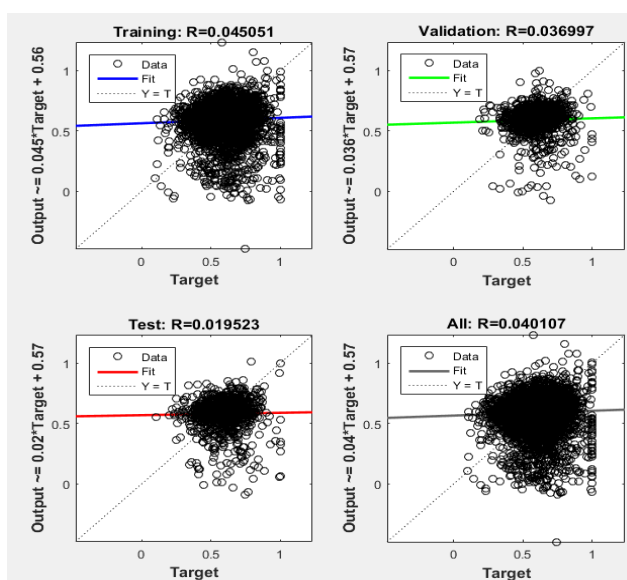


Figure 4: Output of Regression Method

In Table 5, a comparison is made between the training data and the test data in MATLAB according to MAE, and these results confirm the accuracy of the recommender system based on the neural network.

```
Train_error=mae(train);
```

Name ▲	Value	Min
Train_error	0.1214	0.1214

```
Test_error=mae(test);
```

Name ▲	Value	Min
Test_error	0.1357	0.1357

Table 5: Training and Test

4.1 Checking the Results of the Recommender System

Due to the fact that the final grades for checking the academic status were considered out of 100, in order to check the academic status with the recommender system, the scores are in four grade ranges, greater than 60 is equal to "excellent" status, scores

between 50 and 60 are "good" status, scores between 40 and 50 with the status of "need more effort" and scores below 40 with the status of "need guidance", which are shown in Table 5 of the desired situations for prediction:

Forecast status	Score range
'Excellent'	$60 \leq \text{output}$
'Good'	$50 \leq \text{output} < 60$
'Need More Effort'	$40 \leq \text{output} < 50$
'Need guidance'	$\text{output} < 40$

Table 6: Predicted Status of Students

In order to check the educational status and compare the results, the actual percentage of the test data outputs in these four intervals and the predicted percentage of the test data outputs with the neural network have been taken into account in such a way that the percfail variable means the predicted percentage of Need guidance and percfailreal is the actual percentage. Need

guidance. Percfir is the predicted percentage of Excellent and percfirreal is the actual percentage of Excellent. Other variables are also defined in the same way, which can be seen in Table 6, the introduction of the variables of the output percentage of the actual results and the output percentage of the predicted results:

Variable	Meaning
percfail	Predicted Percentage of Need guidance
percfailreal	Real Percentage of Need guidance
percfir	Predicted Percentage of Excellent
percfirreal	Real Percentage of Excellent
percpass	Predicted Percentage of Need More Effort
percpassreal	Real Percentage of Need More Effort
percsec	Predicted Percentage of Good
percsecreal	Real Percentage of Good

Table 7: Introducing the Variables of Percentage Output of Actual Results and Percentage Output of Forecast Results

The percentage obtained from the output of the actual results of the test data and the percentage of the output of the predicted

results of the test data with the neural network are displayed in Figure 6 and Table 7:

percfail	1.2308
percfailreal	3.5604
percfir	48.6007
percfirreal	48.2930
percpass	11.9707
percpassreal	16.9963
percsec	38.1978
percsecreal	31.1502

Figure 5: The Percentage of the Results of the Recommender System with the Neural Network in the MATLAB Output and the Actual Percentage

Variable	Percentage
percfail	% 1.2308
percfailreal	% 3.5604
percfir	% 48.6007
percfirreal	% 48.2930
percpass	% 11.9707
percpassreal	% 16.9963
percsec	% 38.1978
percsecreal	% 31.1502

Table 8: Percentage of Results of Recommender System with Neural Network and Actual Percentage

According to the forecast percentages, 1.2308% of students are in Need guidance status, 48.6007% are in Excellent status, 11.9707% are in Need More Effort status and 38.1978% are in Good status. Due to the fact that the prediction to determine the status of students at the border of 60, 50 and 40 grades can affect the range, it seems that the difference between the actual percentage of the data and the predicted percentage has an acceptable difference.

5. Conclusion

In this article, a recommender system with a neural network was presented, which was able to perform well based on minimal error, and the suggested system based on the neural network in this article has values of MAE=0.1357 and MSE=0.026123, which indicates the proper performance and high accuracy of this The system is recommended. In order to check the academic status with the proposed recommender system, scores in four ranges, greater than 60 with Excellent status, scores between 50 and 60 with Good status, scores between 40 and 50 with Need More Effort status and scores below 40 with Need guidance status , it is considered that 1.2308% of students are in Need guidance status, 48.6007% are in Excellent status, 11.9707% are in Need More Effort status and 38.1978% are in Good status. arerealAccording to the outputs of the proposed system in the article, educational data mining by using the data can create a proposed system to help students at risk and warn students at different academic levels.

Declarations

Ethical Approval

I hereby declare that this thesis represents my own work which has been done after studying at university of Bojnourd, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have read the research ethics guidelines, and accept responsibility for the conduct of the procedures in accordance with Springer journal. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We further confirm that any aspect of the work covered in this manuscript that not has involved either

experimental animals or human patients. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

Competing Interests

This research is sponsored by [university of bojnord] and may lead to development of products.

Authors' Contributions

The authors confirm contribution to the paper as follows: all of the works are done by Ehsan Shirzad.

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Availability of Data and Materials

No datasets were generated or analysed during the current study

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