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Polytechnic Students' Academic Performance Prediction Based On Using Deep Neural Network

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Students' academic achievement plays a significant role in the polytechnic institute. It is an important task for the technical student to achieve good results. It becomes more challenging by virtue of the huge amount of data in the polytechnic student databases. Recently, the lack of monitoring of academic activities and their performance has not been harnessed. This is not a good way to evaluate the academic performance of polytechnic students in Bangladesh at present. The study on existing academic prediction systems is still not enough for the polytechnic institutions. Consequently, we have proposed a novel technique to improve student academic performance. In this study, we have used the deep neural network for predicting students' academic final marks. The main objective of this paper is to improve students' results. This paper also explains how the prediction deep neural network model can be used to recognize the most vital attributes in a student's academic data

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namely midterm_marks, class_ test, attendance, assignment, and target_ marks. By using the proposed model, we can more effectively improve polytechnic student achievement and success.

Keywords: Artificial Intelligence (AI); Artificial Neural Network (ANN); Deep Neural Network (DNN); Machine Learning (ML); Mean Squared Error (MSE).

1. INTRODUCTION

The countries in the world that have given more importance to technical education have become more economically progressing. Reviewing the development activities of developed and developing countries, it can be seen that technical education has been playing a leading role in the integrated economic development of all classes of educated people in the country. That is, the issue of economic development is directly related to the use of technical and skilled manpower. So that, the annual per capita income of a household depends heavily on the rate of participation of the educated population in technical education. As different countries of the world attach importance to technical education, today they have secured a position in the developed world [1] [2]. This is where Bangladesh lags far behind. To get out of this place, we need to have some specific policies in which our students can embrace technical education.

The use of computers have been increasing day by day, especially for the last three decades and importantly extensive. This has resulted in a huge collection of different types of data that can be used to detect unknown patterns and trends as well as using different machine learning algorithms [3]. The analysis methods of machine learning can be exactly categorized as classical statistics methods regression analysis, supervised technique, discriminant analysis, and cluster analysis artificial intelligence, genetic algorithms, neural computing and fuzzy logic, deep learning. Deep Neural Network(DNN) uses historical data to predict the thing that happens [4] and is used to construct a machine learning model that takes significant trends. That predictive model is then used on present data to know what actions should be taken for optimal outcomes.

This work aims to fill the mentioned different academic gaps, by giving a full guideline, providing easier access to the machine learning model, and qualifying all the actual of their application to the field of technical education in Bangladesh [5]. In this study, we specifically focus on the problem of predicting the academic performance of students of technical education especially Polytechnic Institute in Bangladesh. In our proposed method, we have developed a deep neural network-based model that predicts the students' academic final marks according to their different parameters namely midterm_marks, class_test, assignment, and attendance [6].

We will be compared by the academic success of the polytechnic students, how many marks did the students get in their final exams, and how many marks predicted our proposed deep neural network model for each student depending on their midterm_marks, class_test, assignment, attendance, and final marks. Such predictions play a very important role in assessing students' academic performance [7] [8]. The purpose of our proposed model is to increase the academic performance of polytechnic students in Bangladesh.

The rest of the paper is organized as follows: In section-2 briefly explains the literature review. Section-3, explains the methodology, and dataset. Section-4, the analysis of the results. Section-5 represents the conclusion.

2. LITERATURE REVIEW

In recent times, many works and techniques have been proposed for predicting student academic performance. All of these techniques are discussed here.

Imran et al. [9] developed an educational data mining model for predicting student performance. Here, they used a decision tree as a supervised machine learning technique. The performance of the student predictive model was evaluated on the dataset by a set of classifiers namely J48, NNge, and MLP. The proposed method was applied to the progress of the classifiers. Among these classifiers decision trees (J48) achieved the highest accuracy.

Authors in [10] proposed a machine learning technique to predict the final grade point average. In their proposed method they considered the student's characteristics, university entry scores, gap year, and their academic performance of the first and second year for GPA prediction. Here, they collected data from the graduate students of three different years and data from the student management information system of the University of Vietnam. The dataset consists of 525 students remaining. In this technic, they were used rule-based learners such as OneR, PART, J48, Random tree, Random forest, artificial neural network, Naive Bayes, and support vector machine. Among these algorithms, Naive Bayes has shown the highest performance.

Another student's academic performance prediction was described in [11]. In their proposed method, they used a machine-learning artificial neural network for predicting student academic performance. But the data used is not mentioned here.

Shahiri et al. [12] developed educational data mining techniques to predict the student's performance. They used cumulative grade point average (CGPA) and internal assessment, gender, age, family background, and disability for considering the student's performance. Also, different types of machine learning models such as artificial neural networks, decision trees, k-nearest neighbor, Naive Bayes, and support vector machine, were integrated to predict the student's academic achievement. Among these algorithms, the neural network has the highest prediction accuracy by (98%).

Hamsa et al. [13] developed students' academic performance predictions for the Bachelor and Master degree student in Computer Science. In this study, two machine learning classification models namely decision tree and fuzzy genetic algorithm were used. Here are the parameters that have been used to predict student performance namely internal marks, sessional marks, final score. In their work, they included an internal, sessional, and final score of 120 and 48 students from the Bachelor and Master degree program respectively. Here, they have used very small student data and for the sack of that machine learning models may provide bias results.

S.A. Oloruntoba et al. [14] developed a model for predicting the student's academic performance of the Federal Polytechnic in the southwest part of Nigeria. The authors used different machine learning algorithms such as support vector machine, decision tree, k-nearest neighbor, and linear regression. Among these algorithms, SVM models achieved the highest accuracy of 98%.

Asraf et al. [15]developed a model so that educational data mining (EDM) for predicting student performance. Here, they considered the different parameters like a final exam, CGPA, internal exam, extra curriculum activities, and knowledge skills for predicting student performance. In their work, they used the machine learning model namely decision tree. The number of data used was not stated.

Sultana et al. [16] proposed an Educational Data Mining (EDM) system to predict the academic performance of the student. In their research work, they used an educational dataset that was collected from an educational institute of the Saudi University. Here, they used two techniques so that deep learning techniques like deep neural networks and data mining techniques like the random forest, support vector machine, decision tree, and Naive Bayes. Among these algorithms, deep neural networks and decision trees displayed the best predicting student performance compared to other techniques.

Prasanalakshmi et al. [17] developed a model for predicting student academic performance. In their study, they were collected around 1880 student academic data from King Khalid University to predict the final marks. They also considered only three attributes like Mid_semester1, Mid_semester2 marks, and Semester_internal marks were taken as dependent attributes for classifying and predicting the results of final exams. Here, they used ten machine learning algorithms for predicting student performance. WEKA (Waikato Environment for Knowledge Analysis) tool was used to lead the test to know the accuracy.

3. METHODOLOGY AND DATASET

In this section, we have briefly described the Deep Neural Network (DNN) algorithm, proposed system, and dataset. This proposed system and deep neural network algorithm are used for predicting student academic performance.

3.1 Dataset Description

This study introduced the dataset including students in the Department of Computer

Technology at Tangail Polytechnic Institute in Bangladesh**.** The data was collected from the 2018-2019 academic session. It includes 200 anonymous student records with 5 features including student midterm_marks, class_test, assignment, attendance, and target marks. This dataset is divided the three parts the training set, validation set, and the rest of the data for the testing set. This dataset is randomly partitioned which 70% of data is used for training,15% of data is used for validation, and also 15% of data is used for testing purposes. Table 1 displays the simple sample of the student dataset.

Dataset Availability: The dataset can be accessed at: https://docs.google.com/spreadsheets/d/1TqjgXnfsnLPbj0ka3cTkpHYpkFU53Bxj/edit?usp=sharing&ouid=114321347753752335543&rtpof=true&sd=true.

Table 1. Ten samples academic student dataset

Roll No	Midterm Marks	Class Test	Assignment	Attendance	Target Marks
1001	16	8	5	4	45
1002	10	5	3	2	24
1003	12	6	3	3	28
1004	16	8	5	5	48
1005	14	7	4	3	32
1006	13	7	3	3	35
1007	10	5	2	2	24
1008	11	6	3	3	27
1009	18	8	5	4	46
1010	18	9	5	4	45

3.2 Proposed System

The proposed system block diagram is displayed here and the block diagram is shown in Fig. 1. The block diagram is divided into three parts. The first part is used for training data and the second and third parts are used for testing validation purposes. The raw data cannot be used directly to train the machine learning (ML) model because the raw data contains errors, and gaps, etc. Then the gaps are removed from the raw data and are integrated to improve the accuracy. Distinct features are extracted and then the deep neural network model is trained to predict the student academic performance. When the training process is finished, the accuracy of the deep neural network model is measured using the test data.

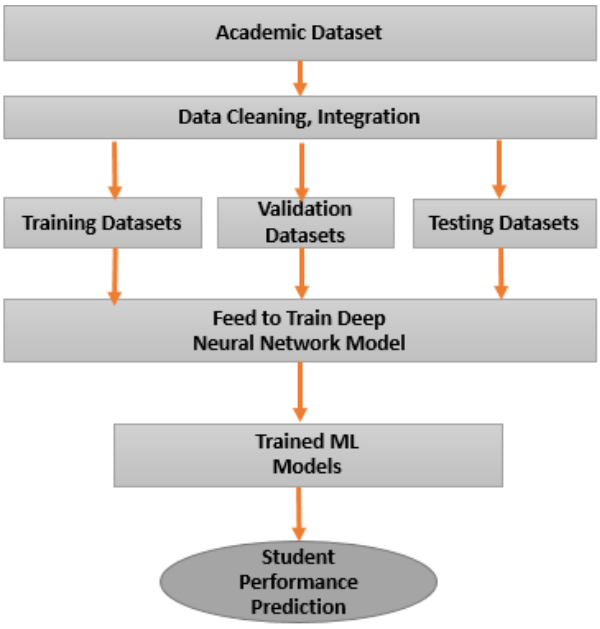

Fig. 1. Proposed system block diagram

3.3 Machine Learning

Machine learning (ML) is a part of artificial intelligence (AI) that helps to progress the model. The machine model finds the patterns in data [18]. The machine learning model tries to predict the meaningful output. It especially focuses on the use of data and models to emulate the way that humans learn, little by little progressing its accuracy.

3.4 Proposed Deep Neural Network (DNN) Model

Deep Neural Network (DNN) is one kind of Artificial Neural Network (ANN) with many layers among input and output layers [19]. It helps the network to learn complex patterns in the raw data. There are various types of neural networks but they constantly consist of some common ingredients namely input layer, hidden layers, weights, biases, functions, and output layer or final layer. These ingredients operate similarly to human intellect as any other machine learning (ML) model.

In DNN, each layer consists of twenty-three neurons with three hidden layers. These neurons are also called nodes. Everyone is attached through a connection link. The main purpose of the activation function is to mention non-linearity in the output of a neuron. It is also deciding.

what is to be fired to the next neuron. The following block diagram illustrates the model of DNN followed by its student performance prediction. The net input can be calculated as follows

$$Y_{in} = x_1 w_1 + x_2 w_2 + x_3 w_3 + \ ... \ + \ x_n w_n \quad (1)$$

$$Y_{in} = \sum_i^n x_i \, w_i \quad (2)$$

where, x_i is the input coming to the neuron, w_i is the connection weight and Y_{in} is the output of the node. The output can be computed by applying an activation function F over the net input:

$$Y = F(Y_{in}) \quad (3)$$

The output of each layer goes through an activation function to produce the output of the layer which passes through the next node to produce the final output of the deep neural network. The deep neural network is learned repetitively to decline the mean square error (MSE) between the network outputs and the similar target values.

4. RESULT ANALYSIS

In this section, we conduct various experiments to evaluate the performance of our proposed deep neural network for predicting students' academic achievement. The data was collected for the academic session 2018-2019 of the computer department at Tangail Polytechnic Institute in Bangladesh. It consists of 200 anonymous student records with 5 features namely student midterm marks, class_test mark, assignment, attendance, and target marks. This dataset is randomly divided 70% for training to teach the proposed network. The training process continues as long as the network progresses on the validation set. In this network, 15% of data is used for validation and 15% is used testing network. The test dataset provides a fully independent measure of network accuracy or performance.

4.1 Proposed Deep Network Performance

The network performance is calculated by mean squared error (MSE) and displayed on the log scale. It quickly reduced as the network was trained. The network performance graph is illustrated in Fig. 2 for each of the training data set, validation data set, and test data set.

The final network is performed best on the validation set. The best validation performance of the network is calculated (26.8458). The mean squared error (MSE) of the proposed trained deep neural network can be measured concerning the testing samples.

4.2 Proposed Network Error Histogram and Plot Regression Line

Another second measure of how well the neural network has fit data is the error histogram [20]. An error histogram is the histogram of the errors between target values and predicted values after training the neural network. The error histogram displays how the error sizes are given away.

In Fig. 4.(a) most errors are near zero and with very small errors outlaying from that. The bins are the number of vertical bars we are watching on the error histogram. The total error range is partitioned into 20 smaller bins here. The Y-axis

illustrates the number of samples data from our dataset, which lies in a certain bin.

In this contribution, at the mid of our plot, we have a bin similar to the error of (-0.454) and the height of that bin for the training dataset lies below but close to 40, and validation and test dataset lies between 40 and 50. It means that many tests from our dataset have an error that lies in that imitating range.

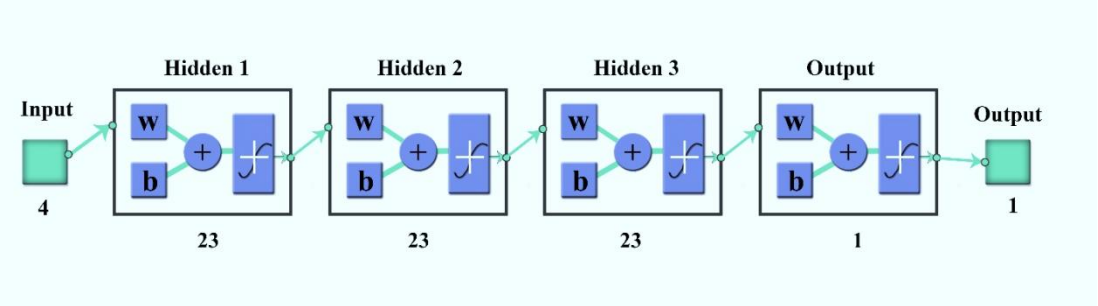

Fig. 2. Proposed deep neural network architecture

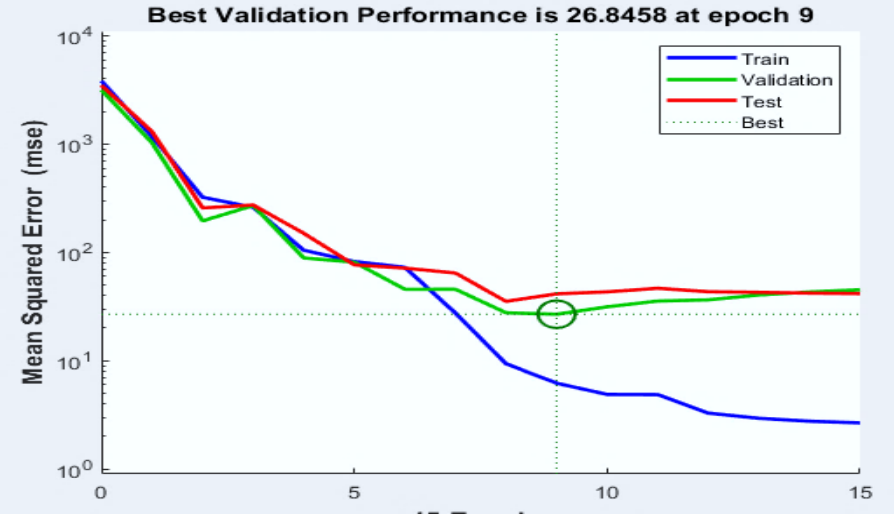

Fig. 3. Proposed network performance

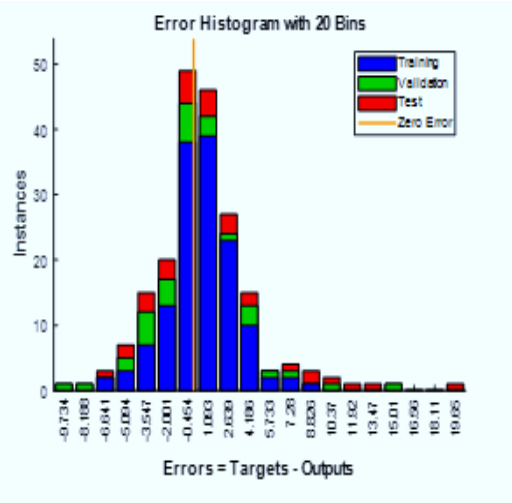

Fig. 4(a). Error histogram

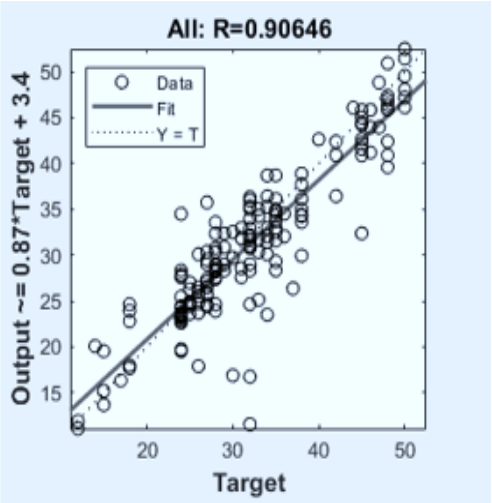

Fig. 4(b). Regression line

Table 2. Display all students the target marks and our proposed deep network predicted marks

Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks
1001	45	34.42	1051	32	36.30	2001	48	50.21	2051	28	29.35
1002	24	23.71	1052	35	31.60	2002	34	33.56	2052	48	44.39
1003	28	27.60	1053	24	23.71	2003	45	48.20	2053	32	31.60
1004	48	39.58	1054	27	26.51	2004	24	23.68	2054	35	36.20
1005	32	31.60	1055	46	43.93	2005	28	27.35	2055	24	23.14
1006	35	34.97	1056	45	44.44	2006	48	49.20	2056	27	28.96
1007	24	23.46	1057	50	43.09	2007	32	31.59	2057	46	47.10
1008	27	26.51	1058	38	34.37	2008	35	35.69	2058	45	46.10
1009	46	43.93	1059	18	17.68	2009	24	23.41	2059	50	48.20
1010	45	44.44	1060	34	30.09	2010	27	28.90	2060	38	39.00
1011	50	48.06	1061	26	23.71	2011	46	43.20	2061	18	17.15
1012	38	34.37	1062	24	23.54	2012	45	48.20	2062	34	33.50
1013	18	16.68	1063	25	24.92	2013	50	52.31	2063	26	26.98
1014	34	30.09	1064	27	27.06	2014	38	39.50	2064	24	23.54
1015	26	23.71	1065	28	28.19	2015	18	17.60	2065	25	26.10
1016	24	23.54	1066	25	23.61	2016	34	33.69	2066	27	29.30
1017	25	24.92	1067	33	35.04	2017	26	25.87	2067	28	28.97
1018	27	27.06	1068	35	34.27	2018	24	23.54	2068	25	24.69
1019	28	28.19	1069	29	32.37	2019	25	26.12	2069	33	34.28
1020	25	23.61	1070	24	27.66	2020	27	26.35	2070	35	36.20
1021	29	28.99	1071	24	28.34	2021	28	28.98	2071	29	29.96
1022	30	29.73	1072	26	25.51	2022	25	26.26	2072	24	25.36
1023	32	16.75	1073	28	29.01	2023	29	28.30	2073	24	24.37
1024	34	38.36	1074	32	32.92	2024	30	31.25	2074	25	25.38
1025	38	34.27	1075	31	32.71	2025	32	35.54	2075	24	24.36
1026	32	28.37	1076	27	28.61	2026	34	33.45	2076	24	23.11
1027	28	30.34	1077	18	18.21	2027	38	37.36	2077	28	27.20
1028	24	23.32	1078	32	31.90	2028	32	33.20	2078	27	29.20
1029	27	24.65	1079	31	30.56	2029	28	27.90	2079	34	34.70

Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks	Student Roll No	Target Marks	Predicted Marks
1030	48	46.92	1080	38	36.89	2030	24	23.74	2080	18	18.90
1031	45	44.19	1081	35	34.56	2031	27	28.40	2081	48	52.30
1032	47	43.93	1082	24	23.28	2032	48	50.60	2082	45	41.30
1033	32	35.95	1083	35	35.36	2033	45	46.20	2083	44	44.39
1034	15	13.68	1084	38	37.39	2034	47	47.90	2084	32	29.38
1035	12	11.10	1085	25	24.69	2035	32	33.20	2085	17	16.90
1036	31	31.88	1086	24	24.28	2036	15	16.10	2086	15	14.90
1037	50	52.47	1087	26	27.52	2037	12	11.89	2087	38	39.20
1038	48	45.85	1088	24	23.36	2038	31	32.20	2088	14	15.20
1039	32	35.04	1089	24	24.58	2039	50	52.10	2089	36	36.85
1040	33	34.27	1090	34	36.25	2040	48	43.20	2090	35	34.26
1041	28	32.37	1091	30	31.96	2041	32	33.30	2091	28	29.30
1042	24	27.66	1092	38	42.38	2042	33	30.28	2092	26	25.96
1043	24	28.34	1093	42	46.23	2043	28	29.74	2093	25	25.41
1044	26	25.51	1094	42	41.69	2044	24	23.50	2094	27	26.38
1045	28	29.01	1095	45	44.30	2045	24	23.80	2095	33	32.50
1046	32	32.92	1096	37	32.58	2046	26	27.10	2096	40	42.65
1047	31	31.84	1097	35	35.69	2047	28	29.60	2097	50	48.90
1048	27	30.39	1098	35	34.36	2048	32	33.70	2098	32	35.30
1049	28	23.92	1099	36	36.89	2049	31	30.10	2099	42	39.78
1050	48	46.42	2001	28	27.94	2050	27	26.30	3001	24	23.69

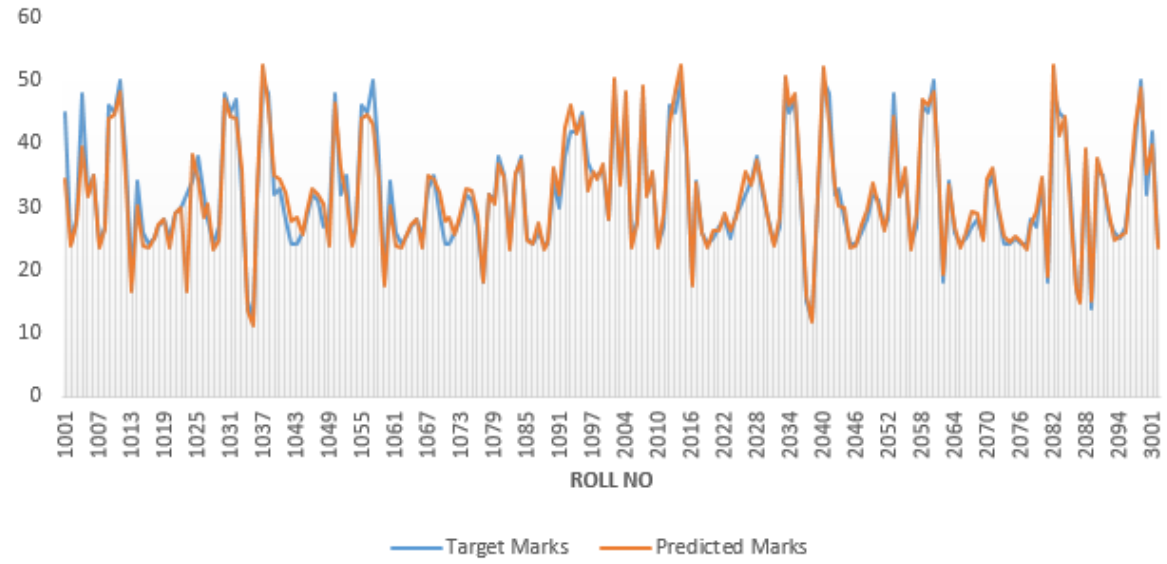

Fig. 5. Comparison graph target marks and predicted marks

It is another measure of how well the neural network has fit the data is the regression plot that is shown in Fig. 4.(b). Plot regression fit line or surface that minimizes the imbalance between predicted marks and target marks. The conforming regression plots represented the network outputs concerning targets for training, validation, and test sets. For a perfect fit line, the data should fall along a 45-degree line, where the network outputs are equal to the targets.

In this study, the fit line is reasonably good for all datasets. Here, the regression is plotted across all samples, and R-value is (0.906446). The regression plot represents the actual network outputs plotted in terms of the connected target values. If the network has been obtained to fit the data well, the linear fit to this output-target relationship should almost split the bottom-left and top-right corners of the plot regression.

4.3 Compare the Performance Actual Marks and Predicted Marks

Table 2 illustrates the prediction student marks of our proposed method. The proposed method was run 200 times with different academic student data.

In Fig. 5 displays the comparative result according to table values as target marks and predicted marks. We have observed that our proposed deep neural network (DNN) achieves predicted marks nearly target marks [21].

In the above graph, the prediction is represented by the deep yellow line, and the target line trend is illustrated by the blue line. The closeness of these two lines represents how expert our proposed deep neural network model is. In Fig. 5 we have seen that the student marks that our proposed model predicts which is nearly target marks in all points [22].

5. CONCLUSION

The student academic performance prediction in polytechnic education in Bangladesh is an argument. In advance, polytechnic student performance prediction can help Polytechnic Institute to take steps timely, as planning for proper conduct to improve students' academic success rates. In this paper, we have proposed a novel deep neural network (DNN) model to predict student academic performance for improving their achievement. From the experiment, we have seen that the student marks that our proposed model predicts are close to the observed marks in all points. This study can bring many advantages and effects to technical education like Polytechnic Institute in Bangladesh.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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