



Predicting Students' Performance in Final Examination 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

The academic result is the most important thing in a student's career. This result depends on their academic performance and many other factors. Educational data mining can help both students and institutions develop their academic performance. For analysis of their performance, we can use new techniques Deep Learning, Convolution Neural Networks, Data Clustering, Optimization Algorithms, etc. In machine learning. Using Deep Learning, we will predict the student's performance yearly in the form of CGPA and compare that with the real CGPA. A real dataset can boost the prediction performance. We used a real dataset from the Institute of Science, Trade & Technology (ISTT). We used a total of 18 data factors to predict the performance and the data factors are: Class Performance, Test Marks, Class Attendance, Due Time Assignment Submission, Lab Performance, Previous Semester Result, Family Education, Freelancer, Relationship with Faculty, Study Hours, Living Area, Social Media Attraction, Extra-Curricular Activity, Drug Addiction, Financial Support from Family, Political Involvement, Affair & Year Final Result.

Keywords: *Deep neural network; CNN; optimization algorithm; data mining; student's performance.*

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1. INTRODUCTION

Some of the researchers have already worked on this, and after reviewing their articles we found some limitations which are low accuracy, low volume of a dataset compared with us, and not using the latest techniques and predictions factors are few as well. In this study, we have used a deep neural network to have a better model with high-performance accuracy along with 2844 records of 158 students which are absolutely read data. We also used 18 factors to generate better insights compared with others through data which is the highest data factor. After running the model, we achieved an accuracy of 98.33% which is the highest among all the techniques that have been used. Please see Fig. 5 for a visual understanding. "Discovering Knowledge from a large number of Databases is known as Data mining. It extracts secret information from various data sources pertaining to several fields. Different techniques can be engaged in various fields of data mining together with weather forecasting, oil research, medical, business, EDM, marketing, etc" [1].

In our paper, we do Educational Data mining. Everybody knows that Education is the claw of a nation. The Educational institutes and parents both parties are both worried about their results. These results have a big impact on their career life. So, they to know whether their child will do best in their exam or not.

"Actually, Educational Data Mining mention the recipe to figure out exact information from large number of an educational dataset. In our experiment, we collect the data from educational institutions and apply several methods to produce meaningful and significant information" [2]. "Students' academic performance, usually, is measured by year final examination results that are considered to point where the students able to reach in future. In the Comprehensive evaluation method, examination outcome is pardoned by Cumulative Grade Point Average (CGPA)" [3]. "In order to derive knowledge from educational environments Data mining, statistics, and machine learning are applied to EDM. Nowadays it is in need and gathering more care because of the increase in the educational data of eLearning systems, and even developing usual education. Alarmed with sprouting methods for uncovering the distinctive types of data present in scholastic environments, it seeks to extract significant information in order to advance and praise learning processes from vast amounts of raw data" [4]. According to the records of a

traditional database can provide the answer to Problems such as "find the students who failed the examinations", whereas EDM offers answers to additional problems like "predicting the students' performance pointing out the CGPA depending on some various factors such class attendance, test marks, personal facts and so on.

Over and again, many researchers started exploring various data mining techniques to create students' exploration models. It naturalizes the learning method, guesses the dropout rate, helps the grading scheme, etc. These patterns embody several techniques for prediction such as decision tree, regression, classification, clustering, and the like to proceed final output. But, the outcome of those predictions is not yet up to the mark [2]

After looking into all the existing results, we are offering a Data Mining technique to resolve this problem in an additional authentic manner depending on 18 factors of every single student to show how these factors affect their academic performance. Our model will help us to know whether the particular student will do a good result or not. Most educational Institutes follow the CGPA system to measure students' performance. So we are planning to make a model which will predict their next year's result depending on some abstract and their previous semester's results and provide a CGPA. We collect those attributes from the students physically and through an online survey.

After Analysis all the previous attempts and to get more accuracy we used an original dataset from the department of CSE at the Institute of Science, Trade, and Technology (ISTT). Here we take the data of 158 students for result analysis. we make the neural network with two hidden layers which is called a deep neural network. Now we use the Supervised machine learning algorithm CNN to train the deep neural network. We also used one hot encoding to convert our categorical data into numerical data. We refuted our entire dataset into three parts. One part is for training our neural network also we keep one for testing and the last one is for verifying the result and we get a low percentage of error.

The main contribution of this paper is that we offer a new technique founded on a Supervised Deep Neural Network which figures out the information from students' data. The empirical results display that academic performance exceedingly depends on some factors both from academic and personal life.

The residual sections of the paper are embodied here. Related work with our experiment on predicting students' performance describes in section II. In section III, we bring in our proposed solution including some sub-sections. Section IV is responsible for the narration of the dataset. Section V is for the Implementation of our offered technique. We started our Result in section VI & our future work is visible in the last section means VII.

2. RELATED WORKS

Fahim, Sajal and Jalal et al. [2], propose "a neural network which helps to guess student's yearly accomplishment using neural network in the form of Cumulative Grade Point Average (CGPA) and compare that with original CGPA". Kyndt et al. [5] used "a neural network to predict the academic performance of the first year bachelor degree student, based on students' inspiration, way of learning, working memory retention and attention".

Ioannis E. Livieris, et al. [6] in their study predicted "the performance of students in Mathematics using an Artificial Neural Network (ANN) classifier. They found that the modified spectral Perry trained artificial neural network performs better classification compared to other classifiers in this context".

S. Kotsiantis, et al. [7] investigated "in distance learning using machine learning techniques for dropout prediction of students. Their study made an important contribution as it was a pioneer and helped to carve the path for educational data mining".

San Pedro et al. [8] analyzed "a web-based tutoring method on 3747 school students for mathematics course and try to guess whether a student will be present college (5 years later). The authors trained the students to be effective in middle school mathematics as weighted by the tutoring method are more likely to enroll 5 years additional in college. On the other side, the students who proved chaotic, and inadvertency in the method have a minor chance of college inscription. For the prediction, they used logistic regression classifier".

Vihavainen et al. [9] Worked with "some data from Computer Science students programming course of Helsinki University and tested to calculate whether a Student will pass or fail introductory mathematics course".

Bhardwaj and Pal [10] guess "students' performance and found out living place has a high impact on student's year final outcome. They use all the information from the Department of Computer Applications students at Purvanchal University".

Al-Radaideh, et al. [11] predict "the final grade of students who taken the C++ course in Yarmouk University, Jordan. There are three various classification techniques namely, ID3, Naive Bayes, C4.5 and the are used. The outcome reported that the Decision Tree model had better guesses than other models". Nguyen and Peter [12] guess "the performance of the students and likened the proficiency of two classifiers as Bayesian networks and Decision Tree using the WEKA tool. They engaged two several groups of students of the postgraduate and undergraduate levels. The performance of the Decision Tree was more correct around 3-12% compared to Bayesian networks. This experiment was beneficial for pointing the weak students for commanding and choosing good students for scholarship".

S. Anupama and Vijayalakshmi [13] Hope "the performance of final exam of MCA students in accordance with their internal marks. This time they used a Decision tree algorithm. They liken the predicted results and original results which points out, that there was a meaningful uplift in results as the prediction support a lot to place good and weak both types of students to confirm good marks. They also likened their model with an algorithm named Decision tree & show that the developed system or method or model is better in terms of proficiency and time taken to make the decision tree".

Smith et al. [14] "Bring forward in sight school safety pardon by student academic representation, attendance, and post-secondary aspirations".

Baris Cetin [15] "Bring in to learning and age in guessing college students' academic acquisition. Improved higher order orthogonal iteration algorithm for student rending prediction".

Yadav [3] S. K. Yadav, S. Pal, and B. Bharadwaj "Data mining applications: A comparative study for predicting student's performance," arXiv preprint arXiv:1202.4815, 2012 [4] Scheuer et al., Educational data mining. In Encyclopedia of the sciences of learning pp. 1075–1079, Springer, 2012.

There are so many researchers had already done their experiments on this topic. In our paper, we mention a model which is highly effective comparing the existing ones.

Albreiki [16] Modern approaches, strategies, and applications from educational data mining are essential in improving the learning environment. By examining and analyzing educational data using machine learning and data mining approaches, the most recent research offers useful tools for evaluating the learning environment of students. The environment in which modern academic institutions function is extremely complex and competitive. Universities frequently encounter difficulties with performance evaluation, high-quality instruction, performance assessment methods, and future activities. Plans for student intervention must be put into place at these colleges to address issues that students face while pursuing their education. This systematic review examines the pertinent EDM literature from 2009 to 2021 that relates to identifying at-risk pupils and dropouts among students.

Kim [17] The authors present a new deep learning-based system called GritNet that builds on the bidirectional long short-term memory and reframes the student performance prediction problem as a sequential event prediction problem (BLSTM). The GritNet consistently outperforms the conventional logistic-regression-based method, according to our results from graduation predictions made for actual Udacity students. However, improvements are especially noticeable in the first few weeks, when making accurate predictions is the most difficult.

Wang [18] The Sequence-based Performance Classifier (SPC), which comprises a sequence encoder and a traditional data mining classifier, is a two-stage classification framework that the authors suggest for treating the performance prediction issue as a short-term sequence prediction problem. More specifically, they first present an attention-based hybrid recurrent neural network (HRNN) to encode students' campus behaviors by assigning a higher weight to the ones that are related to the students' last action in order to more thoroughly identify the sequential features from the data. The conventional Support Vector Machine (SVM) technique is then further combined with these newly learned features to conduct student performance prediction, leading to the development of our SPC model. We carry out in-

depth tests using the actual student card dataset. The trial outcomes show the superiority of their suggested approach.

3. METHODOLOGY

Fig. 1 shows the entire system overview. It describes the overall idea of how we made our model and how the performance will predict. First of all, we went to an educational institute and collect the data from students. After collecting the data, for the most part, is that we need to clean our data which means preprocessing the data, in this case, we use one-hot encoding to preprocess the data and convert categorical data into a numerical value. After preprocessing the data then we design a machine learning-based neural network which is a supervised neural network to help to train the data & figure out the essential information from the data. In this experiment we predict the student's final year result in CGPA. We also used the CNN algorithm to train our neural network. In our model, we predict students' performance and then attempt to find out the accuracy percentage comparing the original one. Every single part of our proposed system is described below in the subsections.

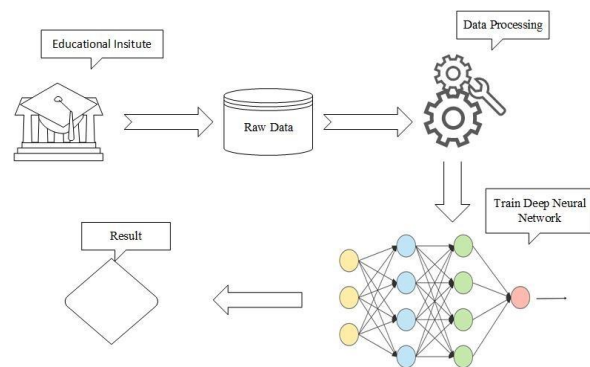


Fig. 1. System overview

3.1 Data Collection

Data collection is the methodical way to collect and standardize information from different origins to get a fulfilled and accurate image of an area of interest. Data collection enables a person, organization, or institution to answer relevant queries, assess results, and make predictions about coming possibilities and trends. In our system, first, we collect students' relevant data for predicting the student's yearly performance. Here we use 158 students' data for our research purpose which is taken from the department of

Computer Science & Engineering (CSE) of the Institute of Science Trade & Technology (ISTT). We collect these data from the students of ISTT via an online survey using Google docs and physically from the students. In this survey, we consider 18 factors where 17 are our input factors and the last one is our output factor. We consider it as not only academic data but also some other personal information like Living area, Family Education, Political involvement, Drug addiction, Social media interaction, Affairs, and so on. For every student we received values, so the total number of records is 2844. Students who participated in this survey are all from the computer science & engineering department and their level of study is Undergrad.

3.2 Data Pre-Processing

After collecting the data, we preprocess the data. Now we have to do a filter to remove some unnecessary data. First of all, we convert all the categorical data into a numerical value using one hot encoding. Then we divided the 18 factors into two parts. One part is the input part which uses 17 factors among these 18 factors and the remaining one factor is called target value. Fig. 2 shows the steps of data pre-processing.

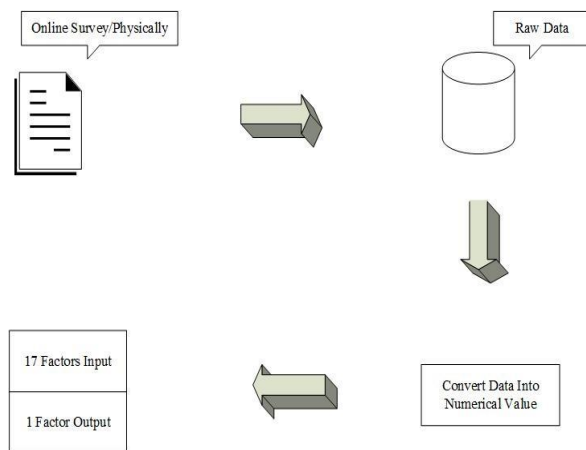


Fig. 2. Data pre-processing

3.3 Deep Convolutional Neural Network

“In living years, in the circumstances of the research area, the neural network has been drawing rising intentness. A neural network has solved some of the riddles posed and made some development for future predictions. The first thing is to get the prediction we build a deep neural network. Alter that we train the deep

neural network with our preprocessed Data” [1]. We used a supervised neural network and train the neural network using CNN. “Supervised learning is one of the Machine learning methods which is used to perform a function from designated training data. In the supervised learning method, two kinds of data are provided which are known as inputs and outputs. After providing the data, the system procedures the inputs and analogies its decision outputs against the required outputs. After this procedure, systems sometimes find some errors. These errors are once again propagating to the system. Then the System synthesizes the weights which control the network. This method occurred repeatedly as the weights are frequently tweaked. The dataset we used in our system for the training purpose is known as the training set. In the training cycle of the neural network, an identical dataset is actioned repeatedly as the connection weights are always tasted. Sometimes training process continues for some days. This process is getting paused only when the system comprehensions some statistically aimed outcomes or expected accuracy. However, some networks never learn and the reason behind this is, the input data does not carry specific information. That is why we cannot find the expected output. Networks cannot manipulate necessary learning if there are less data. There should be sufficient data so that some data can be caught backward as a testing phase. This network consists of many layered including a couple of nodes in each & every layer are efficient of deporting information” [1].

4. DESCRIPTION OF DATASET

4.1 Class Performance

One of the significant factors to measure students’ performance in class performance. In Our experimental analysis, we consider three divisions of class performance. If the students’ level of class performance is not meet the expectations then we call it poor, if it is kind of satisfactory then average & if it meets the expectation level then we call it good.

4.2 Test Marks

Class test marks are one of the important elements to predict the students’ performance. Generally, those students get the highest mark in their class test having a high possibility to do good in the final year examination. We take the

class test marks and divided them into three parts which are poor, average, and good. If the mark is below forty percent, then it's poor. If the mark is between forty & eighty percent, then it's average and if the mark is above eighty percent then it's good.

4.3 Class Attendance

Another vital importance is Class attendance for student performance analysis. Those who attend classes regularly have a high chance to understand the teacher's lectures comparing those who do not attend classes. We consider the class attendance mark 100%. If students' mark is less than 40% will count as poor, between 50 to 70% will count as average, and above 80% will count as good.

4.4 Due time Assignment Submission

We take assignment one of our factors for students' performance analysis. Most teachers give the assignment to students to check how much they understand the lecture sometimes teachers want to know how they apply their knowledge. We divided it into two categories. If the assignment mark is below 50 percent, then it is poor and if the mark is above 50 percent then it is good.

4.5 Lab Performance

One of the vital factors is lab performance for student performance analysis. Teachers can understand using this lab performance how much students get to understand the theoretical things. We consider three categories for lab performance first one is poor, the second one is average and the last one is good.

4.6 Previous Semester Result

This is also an important factor. Students who get good results in the previous semester will inspire to make good results in the future. Contrariwise those who do not get good results may fall into depression or be disappointed. We consider this one for our experiment analysis.

4.7 Family Education

One of the universal truths is we all started our learning from our family. Educated parents are always wanted that their children also be

educated people hence they always try to inspire them. That's why family education is one important factor for predicting students' performance. We divided this into three categories which are poor, average, and good.

4.8 Freelancer

Some students started freelancing when they are a student. In this case, they point to being able to give proper time to their study which will affect their performance. We divided it into two categories they are Yes or No.

4.9 Relationship with Faculty

We consider this one of our factors. Students who have a good relationship with faculty have a chance to get career counseling from their faculty and those who haven't missed this opportunity. We divided it into three categories which are poor, average, and good.

4.10 Study Hours

The main factor for students' performance analysis. Students who study surely they have can gain knowledge daily even if they have the scope to learn a lot of modern things. We divide this Study hour into two categories excluding their class time hours. Those students who study less than 3 hours every week are in the average group & those who study more than 10 hours every week are in the good group.

4.11 Living Area

To do students' performance analysis, we also give a little bit of concentration on the students living areas. Nowadays students who are living in town are a little bit more concerned than remote areas students. Contrariwise, students, who explore their higher education from his/her home and live with their parents they get extra care usually. Regarding this issue, we divided this factor into two categories. Students who are staying in the Mess/hall are in one group and others who are living at home are in a different group.

4.12 Social Media Interaction

Nowadays, most students are involved in social media. Sometimes they do it at exceeds level which will be very harmful to their study and future career. The students consume most of

their time on social media like Facebook, Twitter, WhatsApp, IMO, LinkedIn and so on they don't get sufficient time to study. That's why we consider it a factor in student performance analysis. Students who consume over 30 minutes & less than 2 hours per day on social media are in the average group and the rest of the students who consume more than 2 hours in a single day are in Exceed category.

4.13 Extra-Curricular Activity

Extra-Curricular activities are very important for every student. It helps to refresh and increase the importance for every student. It helps to refresh and increase the power of thought as well as leadership and management skills. In this research paper, we consider students who are connected with extracurricular activities or different clubs in their university are in the "yes" category, and those who are not connected are in the "no" category.

4.14 Drug Addiction

Drug addiction is very harmful to both our mental and physical health. Students who take drugs cannot concentrate on their studies. They are also involved in different kinds of violence in our society. Students who are addicted to drugs are in the yes group and not drug-addicted students are in the no group.

4.15 Financial Support from Family

Those who get financial support from their families get enough time for study, and those who do not have to manage their expenses by doing jobs that will most of the time, they can't study well. We consider students who get financial support from their families to be in the "yes" category and those who are not in the "no" category.

4.16 Political Involvement

One of the things that are harmful is those who are involved in politics. It detracts our students from their studies. We consider students who are involved in the "yes" category and those who are not in the "no" category.

4.17 Affair

An affair is a relationship between boys and girls. Recent research shows that sometimes affairs

can affect a student's academic performance. If a student (boy or girl) is engaged with another student, then they have passed a lot of time doing hangouts. That's why they don't get proper time for study. So, the students engaged in affairs are in the yes category, and those who are not involved in affairs are in the no category.

4.18 Year Final Result

All the conversations we have had till now are input factors. We measure students' performance based on these factors, which is called the year's final result. This one is our target factor and we have already stored the final year CGPA of the student. After doing the prediction, we get the predicted result, which will be compared to the real results and will find the accuracy percentage. The overall view of these eighteen factors, including value, is given in Table 1.

Table 1. Data Set

Factors	Value	Factors	Value
Class Performance	Poor / Average / Good	Study Hours	Average / Good
Test Marks	Poor / Average / Good	Living Area	Hostel / Mess / Home
Class Attendance	Poor / Average / Good	Social Media Interaction	Average / Exceed
Due Time assignment Submission	Poor / Good	Extra-curricular Activity	Yes/No
Lab Performance	Poor / Average / Good	Drug Addiction	Yes/No
Previous Semester Result	SGPA	Financial Support from Family	Yes/No
Family Education	Poor / Average / Good	Political Involvement	Yes/No
Freelancer	Yes/No	Affair	Yes/No
Relationship with faculty	Poor / Average / Good	Year Final Result	CGPA

5. IMPLEMENTATION

In the implementation part of our system, first, we need to import all the libraries named Pandas, numpy, matplotlib.pyplot, and sklearn. Then we import the necessary modules, i.e., train_test_split, mean_squared_error & sqrt. We also import the ML library Keras. After that, we take the dataset which we have preprocessed earlier and use it in the Jupyter Notebook. Then we create a deep neural network with two hidden layers. Now we train our deep neural network and a training algorithm can be added so that the network can be trained. In order to train, we use the CNN algorithm. In our exploratory analysis, we divided the dataset into three parts. The first section is the training dataset, which contains

98% of the data. The second part is the testing dataset, where we use only 1%. And most importantly, another 1% of the data is used to validate the predicted results. After taking all these steps, the train function is used to train the network. After running the neural network, we expect a result that will be positive in terms of accuracy. The following Fig. 3 shows the implementation procedure.

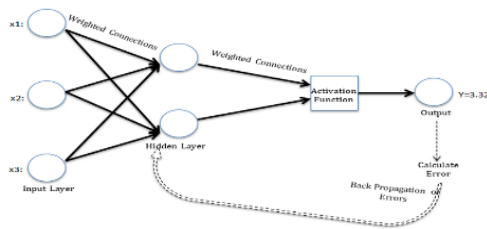


Fig. 3. Deep Neural Network Architecture

6. RESULTS AND DISCUSSION

After running the deep neural network, we have the predicted result in our hand. Fig. 4 shows the original and predicted result.

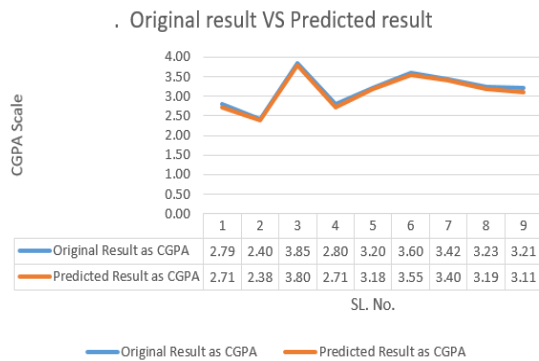


Fig. 4. Original result VS Predicted result

In our experiment, we used nine students' predictions. In Table 2, we show these students' real results and predicted results. Based on these results, we find the accuracy percentage. In Table 2 we show the highest is 99.42% when a student's original result is 3.42 and we get the lowest accuracy of 96.79% when the original result is 2.8. After observing these results, we can say that our system is better because for both cases, we got an accuracy that is very close to the original results.

Table 2. Result comparison

SL. No.	Orginal Result as CGPA	Predicted Result as CGPA	Accuracy
1	2.79	2.714	97.28%
2	2.4	2.38	99.17%
3	3.85	3.8	98.70%
4	2.8	2.71	96.79%
5	3.2	3.18	99.38%
6	3.6	3.55	98.61%
7	3.42	3.4	99.42%
8	3.23	3.19	98.76%
9	3.21	3.11	96.88%

In Table 3, it showed the comparison of accuracy percentage among different techniques. Here we can see four techniques and the lowest accuracy belongs to the artificial neural network, which is 77.8%, and the highest accuracy belongs to the deep neural network, which is 98.33%. For neural networks, the accuracy is 90% and for recurrent neural networks, the accuracy is 85.4%. So, according to the above analysis, our model deep neural network is the one with the highest accuracy. So we can say that our model is best for predicting students' performance.

Table 3. Comparison of accuracy among different techniques

Techniques	Accuracy Percentage
Artificial Neural Network	93.00%
Recurrent Neural Network	85.40%
Deep Neural Network	98.33%
Naive Bayes Simple	89.40%
Decision Tree	74.00%
Data Clustering	74.00%

Fig. 5 shows the accuracy comparison among all the techniques that have been used to perform the performance prediction.

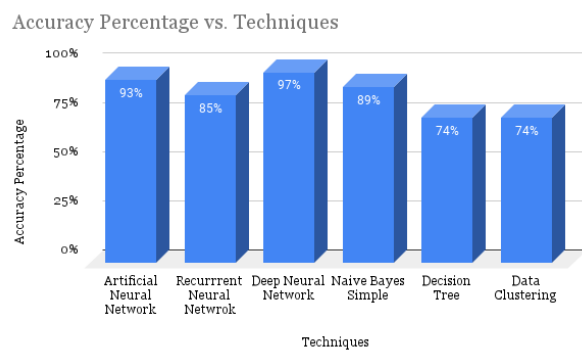


Fig. 5. Accuracy percentage among different techniques

7. CONCLUSION AND FUTURE WORK

As per this study, we can see that our model achieved 97% accuracy which is the best compared with all other techniques. We believe our model will significantly help the educational institution to have a better overview of the students' performance. We will attempt to incorporate a sizable amount of data from various sorts of institutions into our model in the near future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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