

Prediction of Student Graduation Rates using the Artificial Neural Network Backpropagation Method

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Abstract: This student graduation rate research focuses on analyzing academic performance with the main aim of identifying and distinguishing between students who graduate on time and those who graduate late. The application of data mining techniques in this research uses the neural network method, which is expected to offer deeper insight into the factors that influence students' graduation times. In this study, the neural network method was used to classify graduation data from 150 students. The results of this analysis were very encouraging, with 149 students identified as graduating on time and one student graduating late. The level of accuracy achieved in this classification is 98%, which shows the effectiveness of the neural network method in processing and analyzing academic data. These results confirm that neural networks are a powerful and reliable tool for predictive tasks like this. The successful use of neural networks in this study also proves their potential in broader educational applications, particularly in optimizing educational and intervention strategies. By understanding the characteristics of students who graduate on time versus those who graduate late, educators and administrators can design more effective programs to support student success. This is important not only to improve graduation statistics, but also to improve the overall educational experience for students.

Keywords: Accuracy; Backpropagation Neural Network Method; Data Mining; Graduation level; Precision; Recall

INTRODUCTION

Student graduation is an important moment that marks the closing of a chapter in an academic journey and the beginning of a new chapter in professional life or further education. The graduation procession is usually filled with pride and joy, both for the students and the family and friends who have supported them over the years. This ceremony is often celebrated with lively ceremonies, where students wear typical graduation gowns and caps, receiving diplomas as proof of their academic achievements. The moment of graduation is also often used as an opportunity to reflect on the journey that has been passed. Many students experience a variety of challenges, ranging from academic difficulties to personal problems that they have had to overcome to reach this point. Therefore, graduation is not only a celebration of learning outcomes, but also a celebration of resilience and perseverance. Furthermore, graduation is not the end, but a step towards a future full of possibilities. For many graduates, this is a time to start a career, enter an industry they have long been interested in, or continue their education at a higher level. Feelings of enthusiasm and a little uncertainty mixed together, providing new energy in planning the next step. Graduation, with all its traditions and traditions, will always be a symbol of an important achievement and a significant transition point in every student's life.

Every student starting their higher education may enter the university gates with the same hopes and dreams, but their paths to graduation are often different. This research is almost the same as research conducted by (Ridwan, Lubis, & Kustanto, 2020) in that research on student graduation rates is carried out to see the potential and abilities of students in the world of education and this research can be carried out using the neural network method. This difference can be caused by many factors, ranging from educational background, financial support, to mental and physical health. While some students may navigate the educational process smoothly and graduate on time, others may encounter obstacles that hinder or even halt their progress. Universities and colleges strive to provide resources to support students on their academic journey, but not all students can access or utilize these resources in the same way. For example, students who work part-time or full-time may have more limited study time

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compared to those who do not work. Likewise, students who have family responsibilities or health problems may have difficulty keeping up with the pace and demands of an intense study program. One significant problem in student graduation rates is the disparity in graduation rates between students from different economic backgrounds. Statistics show that students from low-income families tend to have lower graduation rates compared to their peers from high-income families. Factors such as limited access to learning materials, lack of academic support at home, and the need to work while studying can affect a student's ability to concentrate and achieve at university. These disparities reflect larger challenges in an education system that often does not provide equal opportunities for all students, regardless of their economic background.

Therefore, the author intends to conduct in-depth research on student graduation rates. The main aim of this research is to identify factors that influence students in achieving graduation, whether on time or late. As was done in the research (Suniantara, Suwardika, & Soraya, 2020) that research on student graduation rates can be carried out using neural network methods. This research will be divided into two main classification categories: on-time graduation and late graduation. These two categories will help in understanding the dynamics and challenges faced by students during their study period. On research (Safitri, Hilabi, & Nurapriani, 2023) Graduating on time is the dream of all students, but you need to know that not all students can do that. Therefore, it is carefully studied so that we can get students who can graduate on time. In order to dig deeper and produce accurate findings, this research will use a classification model in data mining. The technique chosen to analyze the data is the backpropagation method in artificial neural networks. The backpropagation method is a popular approach in machine learning, which is effective in dealing with complex and large classification problems. Artificial neural networks, with their high adaptability, will be processed to recognize patterns and correlations between various variables that influence students' graduation times. This research will involve collecting data from various sources, including student academic records, surveys assessing various aspects of student life, and other relevant supporting data. This data will then be processed and analyzed using a backpropagation artificial neural network model. The goal is to develop a predictive model that can accurately classify students based on their estimated time to graduation. Thus, it is hoped that this research can provide useful insights for educational institutions in implementing more effective strategies and interventions to help students achieve graduation on time or identify the causes of delays in graduation.

LITERATURE REVIEW

Data mining is the process of analyzing large sets of data to discover patterns, trends, and previously unknown information, which can help in decision making (Aji & Devi, 2023) (Bustomi, Nugraha, Juliane, & Rahayu, 2023). This technique is widely used in a variety of industries, including finance, healthcare, retail, and telecommunications, to gain insights that can increase efficiency, identify new market opportunities, or improve marketing strategies (Saputra, Hindarto, & Haryono, 2023) (Abas et al., 2023). Data mining combines methods from statistics, machine learning, and databases to extract useful information from large and complex data sets (Sinaga, Marpaung, Tarigan, & Tania, 2023). Through the use of special algorithms, data mining can identify patterns and relationships in data that are not easily seen by human observation alone. With the ability to process and analyze very large volumes of data, data mining has become an important instrument in data-oriented business strategies. Data mining is also used in research (Hasibuan, Sihombing, & Nasution, 2023) where classification using the neural network method has an accuracy of 100%. The accuracy results obtained provide very good results.

Backpropagation Neural Network is one type of artificial neural network architecture that is most widely used in machine learning (Lestari, Mawengkang, & Situmorang, 2023) (Hindarto, 2023) (Karo Karo et al., 2023). This method is a standard technique for training multilayer neural networks, mainly used for supervised learning tasks (Samanta & Rout, 2016) (Nurdin, Sartini, Sumarna, Maulana, & Riyanto, 2023). Backpropagation allows a network to adjust its weights through an iterative process by calculating the gradient of the loss function with respect to each weight in the network, which effectively informs how large changes should be made to the weights to reduce errors in the output (Isthigosah, Sunyoto, & Hidayat, 2023) (Dharma, Sitorus, & Hatigoran, 2023).

This method operates in two main phases: forward pass and backward pass phases. In the forward pass phase, input is provided through the network to produce output (Anwar, Jalinus, & Abdullah, 2023). Then, in the backward pass phase, the output is compared with the actual target to calculate the error. This error is then propagated back through the network, from the output layer to the input layer, to systematically update the weights, reducing errors in the next iteration (Suherman, Hindarto, Makmur, & Santoso, 2023). Backpropagation is at the heart of many modern machine learning applications, from speech recognition to natural language processing and image analysis, because of its ability to efficiently refine and enhance models. As in research conducted (Sari, Yanris, & Hasibuan, 2023) the neural network method can be used to classify public interest in Pertamina fuel.

METHOD

To conduct this research, the method that will be used in this research is the Neural Network method. In order for this research to be carried out, there are several stages that will be carried out, namely as follows.

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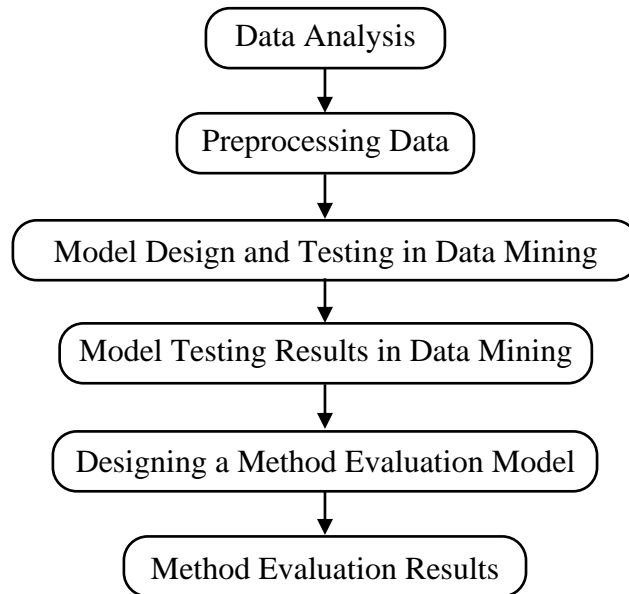


Fig 1. Tahapan Penelitian pada Data Mining

From the stages above, the author will explain each stage that was carried out in this research. The explanation is as follows.

- Data Analysis : The data analysis stage will later be used to select and determine the data that will be used as a dataset and there are 2 datasets used, namely training data and testing data.
- Preprocessing Data : The data preprocessing stage will later be used to select data and compile the data in a form and format appropriate to the research to be conducted.
- Model Design and Testing in Data Mining : This stage will later be used to design a model that will be used to classify data in data mining.
- Model Testing Results in Data Mining : This stage will provide classification results using a previously designed model.
- Designing a Method Evaluation Model : This stage is also a design, but the design stage is to evaluate the method to determine the effectiveness of the method used.
- Method Evaluation Results : This stage is the result of an evaluation that has been carried out using a previously designed model. The model is also designed to carry out evaluations.

RESULT

Data Analysis

Data analysis is the process of determining the data attributes that will be used to become a dataset. There are 2 datasets that will be used, namely training data and testing data. The attributes used in this research are the student's full name, GPA from semester 1 to semester 6. For the data used, 167 data were obtained. Then the data was divided into 2 datasets, namely 17 data for training and 150 data for testing. Not all of the data that will be displayed in this research, the author only displays some data as data samples so that the data used in this research can be seen and understood.

Data Training

Training data is data used to assist the model in classifying data. With the training data, it will later be used to help the testing data be classified using the methods in this research.

Table 1. Research Training Data

Full Name	Gender	Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Category
Akbar Nurfaizi	Man	3.45	3.58	3.65	3.74	3.75	3.78	On time
Ardiansyah putra	Man	3.58	3.65	3.68	3.7	3.75	3.7	On time

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Arya Wiriansyah	Man	3.58	3.65	3.68	3.7	3.68	3.72	On time
Danang Aidil	Man	3.58	3.62	3.68	3.7	3.75	3.72	On time
Dendy Putra Aulia	Man	2.75	2.55	3.1	3.13	2.83	2.65	Late
Erdiansyah	Man	3.2	3.45	3.58	3.65	3.67	3.7	On time
Jul Afrendi	Man	3.48	3.55	3.67	3.68	3.7	3.68	On time
Julfan Efendi	Man	3.58	3.65	3.6	3.68	3.7	3.72	On time
Muhammad Julham	Man	2.34	3.58	3.54	3.68	2.54	3.75	Late
Nuranda Aji	Man	2.54	3.48	2.45	3.64	2.54	3.72	Late

Table Above is a training data table that will be used to assist the model in classifying data in data mining.

Data Testing

Testing data is data that will be classified in data mining. Testing data or what can also be called research sample data is data used to test and evaluate methods.

Table 2. Data Testing

Full Name	Gender	Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
Ade Eka Febriyanti	Woman	3,8	3,67	3,64	3,67	3,69	3,69
Ade Maya Sari	Woman	3,75	3,8	3,75	3,85	3,75	3,8
Adek Santika	Woman	3,42	3,5	3,61	3,54	3,32	3,45
Adinda puspita	Woman	3,74	3,65	3,8	3,7	3,77	3,67
Aditya Ruli	Man	3,3	3,43	3,23	3,45	3,54	3,65
Agus Susanto	Man	3,56	3,67	3,56	3,45	3,54	3,45
Aldimas Adi Anang	Man	3,56	3,6	3,45	3,54	3,6	3,55
Alpen	Man	3	3,2	2,98	3,4	3,68	3,6
Alwidah Yani	Woman	2,67	2,56	2,56	2,75	264	2,9
Andika Juanda	Man	3,58	3,6	3,68	3,65	3,68	3,75
Andy Ali Rahman	Man	3,45	3,56	3,45	3,56	3,45	3,56

The table above is a sample data table that will be classified in data mining. The data above is data for students and female students who have entered their final semester. But the author will only use the GPA scores from semesters 1 – 6.

Preprocessing Data

At the data preprocessing stage, the data that has been obtained must first be selected for its suitability for use. This is because sometimes there is still data that cannot be classified later. Therefore, a preprocessing stage is needed so that the data can be used properly. Then, after obtaining data that is good and suitable for use, the data will then be arranged in a good format so that the data classification process can run well.

Model Design and Testing in Data Mining

At this stage, the model design process will be carried out so that it can later be used to classify student graduation rate data. At this stage the model will be tested to obtain data classification results.

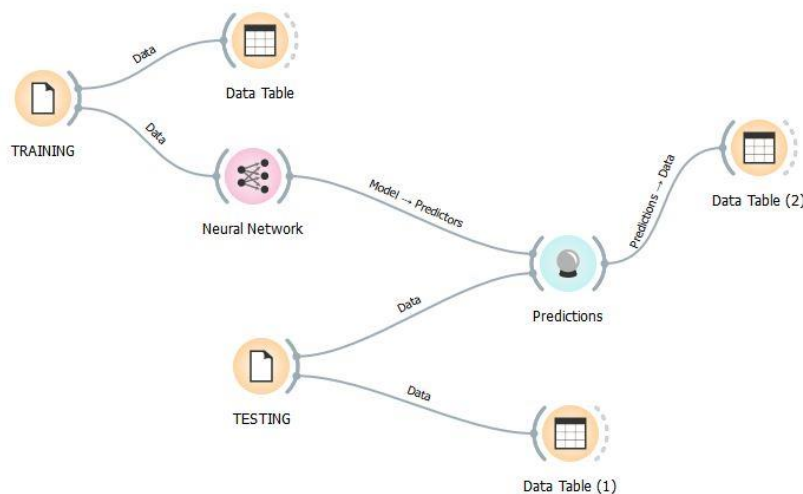


Fig 2. Model Design and Testing in Data Mining

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In the image above is a model design that has been carried out in data mining using the Neural Network method. The application used to help design the data is the orange application. So the training data becomes training data that will classify the testing data with the help of the neural network method. Testing data will be tested using the neural network method with the help of a previously designed model.

Model Testing Results in Data Mining

At this stage, it is the result of data classification using the neural network method with the help of a model that has been designed and with the help of training data. The classification results are as follows.

Table 3. Results of Data Classification with Models in Data Mining

Full Name	Gender	Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Category
Ade Eka Febriyanti	Woman	3,8	3,67	3,64	3,67	3,69	3,69	On time
Ade Maya Sari	Woman	3.75	3.8	3.75	3.85	3.75	3.8	On time
Adek Santika	Woman	3.42	3.5	3.61	3.54	3.32	3.45	On time
Adinda puspita	Woman	3.74	3.65	3.8	3.7	3.77	3.67	On time
Aditya Ruli	Man	3.3	3.43	3.23	3.45	3.54	3.65	On time
Agus Susanto	Man	3.56	3.67	3.56	3.45	3.54	3.45	On time
Aldimas Adi Anang	Man	3.56	3.6	3.45	3.54	3.6	3.55	On time
Alpen	Man	3	3.2	2.98	3.4	3.68	3.6	On time
Alwidah Yani	Woman	2.67	2.56	2.56	2.75	2.64	2.9	Late
Andika Juanda	Man	3.58	3.6	3.68	3.65	3.68	3.75	On time
Andy Ali Rahman	Man	3.45	3.56	3.45	3.56	3.45	3.56	On time

In the table above are the results of data classification testing in data mining using the neural network method. The classification results obtained from the 150 sample data used showed that there were 149 student data that graduated on time and 1 student data that was late to graduate from college. These results have been obtained using data mining models and neural network methods.

Designing a Method Evaluation Model

This design stage is the design stage to be used as an evaluation model for neural network methods. This evaluation was carried out to determine the effectiveness of the method in classifying data. The aim is also to determine the accuracy of the method used.

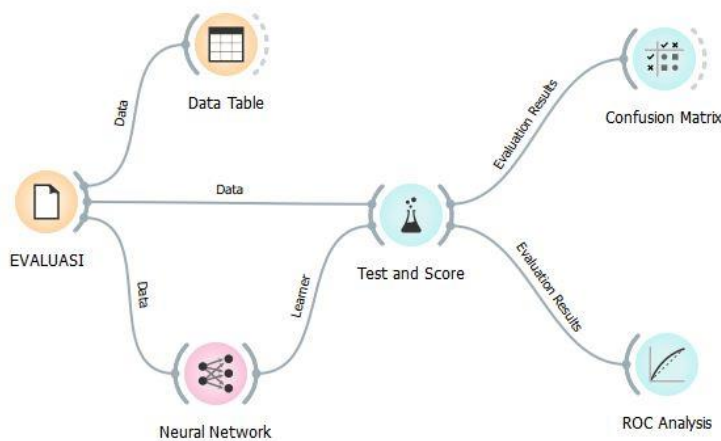


Fig 3. Design of Method Evaluation Model

The image above is used to carry out evaluations which will result in accuracy, precision and recall results from the method used. The widgets that will be used in this evaluation are the test and score widget and the confusion matrix widget. Later the author will also use the ROC Analysis widget which will be used to provide graphs of the evaluation results.

Method Evaluation Results

These results will explain and present each method evaluation result using a previously designed model. The results are as follows.

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Test Results and Scores

Test and score results are evaluation results obtained from the test and score widget which will provide accuracy, precision and recall results.

Table 1. Result of Test and Score

Model	AUC	CA	F1	Precision	Recall
Neural Network	0.987	0.971	0.970	0.970	0.971

The test results and scores obtained can be seen in the table above for the accuracy results of the neural network method obtained, namely 0.987 (98%), for CA results obtained at 0.971 (97%), for F1 results, namely 0.970 (97%), for Precision results are 0.970 (97%), recall results are 0.971 (97%). The results obtained can be concluded that the neural network method can be used to classify student graduation rate data.

Confusion Matrix Results

The results of the confusion matrix are the results obtained from predictions and actual results in the matrix used. Later, the results obtained are also the same as the test and score widget, namely accuracy, precision and recall. However, in this widget, the accuracy, precision and recall results are obtained by manual calculation using the formula for accuracy, precision and recall.

Table 2. Confusion Matrix Results in the Neural Network Method

		Predicted		Σ
		Interest	Not Interested	
Actual	Interest	146	2	148
	Not Interested	1	1	2
Σ		147	3	150

For the results, there are True Positive (TP) results which are 126 data, for True Negative (TN) results which are 9 data, for False Positive (FP) results which are 1 and for False Negative (FN) results which are 3 data. For these results, it is not possible to directly measure the accuracy value, the data above must be calculated first using the formula in the confusion matrix, which is as follows.

Accuracy = $\frac{146+1}{146+1+2+1} + 100\%$ Then the Accuracy value = 98%

Presi = $\frac{146}{146+2} + 100\%$ Then the Precision value = 98%

Recall = $\frac{146}{146+1} + 100\%$ Then the Recall value = 99%

ROC Analysis Results

The ROC Analysis results are graphic results that explain the evaluation graph of the method used, namely the neural network method.

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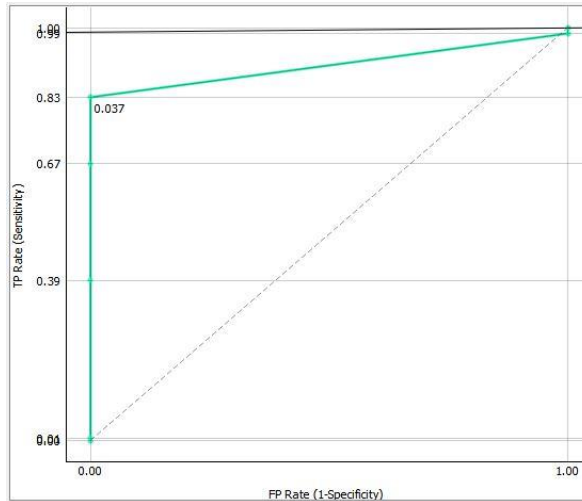


Fig 4. ROC Analysis Results for Students Who Graduated on Time

The results above are graphic results of students who were able to kneel on time. It can be seen in the line graph in the image above.

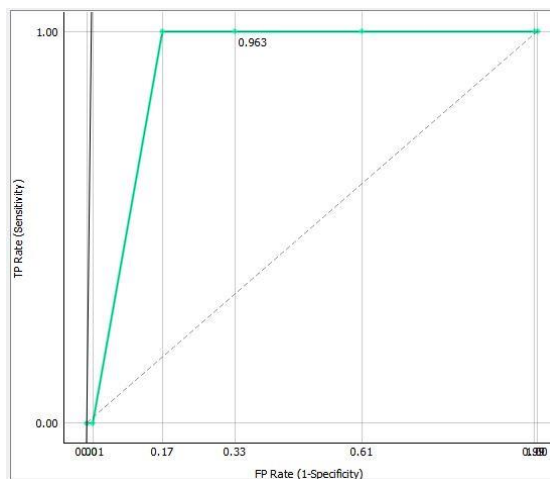


Fig 5. ROC Analysis Results for Students Who Graduated Late

The results above are graphic results obtained for students who graduated late. The graph of students graduating late is greater than the graph of students graduating on time. This is what the neural network method provides.

DISCUSSIONS

This research uses the neural network method in data mining analysis to predict student graduation rates. The main objective of this research is to identify the most accurate and efficient model in predicting graduation outcomes based on a data set that has been collected over several academic years. The neural network method was chosen because of its broad capabilities in handling and analyzing large data with complex variables. In this research, two widgets are used to test and measure the performance of the prediction model: the Confusion Matrix widget and the Test and Score widget. Through the use of the Confusion Matrix widget, the model managed to achieve a very high level of accuracy, namely 98%, with 98% precision and 99% recall. This high level of accuracy shows that the model is very effective in correctly predicting student graduation.

Meanwhile, the Test and Score widget also shows very satisfactory results with an accuracy of 98%, precision of 97% and recall of 97%. These results confirm the reliability of the developed neural network model in classifying data with a very low error rate. A comparison between the results obtained from both widgets shows almost perfect agreement, with only about 1% to 2% difference between the two measurement metrics. This indicates that the model consistency in various test scenarios is very high, providing evidence that the approach used in this research is very robust and reliable in practical applications. With almost identical levels of accuracy, precision and recall from both widgets, it can be concluded that the neural network model developed is a very effective tool for predicting student graduation rates.

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CONCLUSION

Research on the graduation rates of students who graduate on time versus those who graduate late produces findings that provide important insight into the effectiveness of academic programs. From the resulting data, the majority of students, namely 149, graduated on time, while only one student graduated late. These results indicate that the support and educational programs provided to students are likely to be effective. This conclusion is strengthened by the high level of accuracy of the prediction model used, which is analyzed via the Test Score and Confusion Matrix widgets. The success of this model indicates its potential as a tool for evaluating and improving study programs. Universities can leverage this model to identify students at risk of graduating late and immediately provide appropriate interventions, such as more intensive academic advising or additional learning resources. The results of this research not only confirm the effectiveness of data mining methods in higher education, but also provide guidance for increasing on-time graduation rates and minimizing the number of students who graduate late.

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