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PREDICTING STUDENT ACADEMIC PERFORMANCE USING GENETIC ALGORITHM

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ABSTRACT

In this research, a user-friendly software tool for predicting the students' performance in course which is based on genetic algorithm technique was developed. The feature selection technique was combined with classification method in order to predict student academic performance for students in tertiary institution. It was discovered that almost all previous feature selection techniques apply local search technique throughout the process, so the best and optimal solution seems difficult and nearly impossible to achieve. Software for predicting the likely performance of a student was developed and tested using genetic algorithm technique. The methodology adopted in this thesis is structured system analysis design methodology (SSADM), the model was implemented using python programming language and MySQL database respectively. The result obtained from the study shows that genetic algorithm can be used by an educator for classifying students and distinguishing students with low achievements or weak students who are likely to have low achievements.

Keyword: Academic Performance, Genetic Algorithm, Prediction, Student and Model

I. INTRODUCTION

This research aims to develop a student academic performance prediction model using a method called Genetic Algorithm (GA). Therefore, GA is applied as a technique of features selection using classification method in order to improve classification accuracy and get the most optimal value of student academic performance prediction. This method was also applied to enable the use of datasets with high dimensional and imbalanced class. Parameters like class attendance, previous grades/academic record, study hours, assignment scores, extracurricular and final grade were applied in this research. The student class attendance will be evaluated in percentage per semester, their total academic performance from the previous semester will be evaluated by over 100, the study hour entails their total study hours per week, total assignment score out of 100, the extracurricular will be a binary 0 and 1 representing yes or no and finally their final grade will be the targeted result after evaluating all the parameters. (Hailikari et al, 2008). The main objective of the admission system is to determine the students who would likely perform well in the next semester and the students who wouldn't. Accurate predictions help students to be aware of how bad or how good their performance in the last academic session was, it will also enable the lecturers and instructors to distinguish between suitable and unsuitable candidates for the next academic program, and identify candidates who would likely do well (Abu, 2012). The results obtained from the prediction of academic performance may be used for classifying students, which enables educational managers to offer them additional support, such as customized assistance and tutoring resources. The results of this prediction can also be used by instructors to specify the most suitable teaching actions for each group of students, and provide them with further assistance tailored to their needs. In addition, the prediction results may help students develop a good understanding of how well or how poorly they would perform, and then develop a suitable learning strategy. Accurate prediction of student achievement is one way to enhance the quality of education and provide better educational services (Kanakana and Olanrewaju, 2011). Different approaches have been applied to predicting student academic performance, including traditional mathematical models and modern data mining techniques. In these approaches, a set of mathematical formulas was used to describe the quantitative relationships between outputs and inputs (*i.e.*, predictor variables). The prediction is accurate if the error between the predicted and actual values is within a small range.

GA is a population-based metaheuristic developed by John Holland in the 1970s. GA uses techniques inspired from nature, more specifically evolution, to find an optimal or near-optimal solution towards a problem. It applies evolution concepts such as reproduction and survival of the fittest to solve a problem. GA belongs to the larger class of evolutionary algorithms. If I were to try and explain GA in a few sentences, I would say that GA is a way to optimize a problem by creating many solutions and updating those solutions in certain ways related to evolution concepts to reach a "good enough" solution or the best solution possible (Selvakumari, 2023). A genetic algorithm (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution, genetic algorithm, in artificial intelligence, a type of evolutionary computer algorithm in which symbols (often called "genes" or "chromosomes") representing possible solutions are "bred." Genetic Algorithms are search algorithm based on mechanics of natural selection and natural genetics. They combine survival of the fittest among string structures with a structured yet randomized information exchange to form a search algorithm with some of the innovative flair of human touch. This "breeding" of symbols typically includes the use of a mechanism analogous to the crossing-over process in genetic. They used the average point scores of grades 12 students as inputs and the first-year college results as output. The research showed that a genetic algorithms-based model is able to predict student performance in the first semester with high accuracy (Nida et al, 2021).
An important contribution from artificial intelligence and the machine-learning area has been the capability to build predictive models of students' academic performance through genetic algorithms (GA), GAs entail the possibility of using all the interactions between predictor variables to achieve a better estimation of the outcome variable (Namoun and Alshanqiti, 2020) and possess the capability of obtaining a prediction even when the independent and dependent variables are related in a nonlinear way. GAs also allows the analysis of vast volumes of information and the construction of predictive models regardless of the statistical distribution of the data (Miranda et al. , 2013). Nevertheless, a lack of conceptual and methodological understanding has prevented an increase in the use of GAs among educational researchers as they have preferred to fit predictive models based on more traditional approaches such as multiple linear regressions.

2. LITERATURE REVIEW

Hashmia et al. (2016), Discovering hidden facts and trends regarding students' performance through the application of data mining techniques in an educational setting is called Educational Data Mining. Parameters including internal marks, sessional marks, and admission score were chosen for this study, and two classification methods Decision Tree and Fuzzy Genetic were used.Decision tree and fuzzy genetic algorithms were used independently to predict students' academic performance in bachelor's and master's degrees for each subject. The results of the decision tree algorithm made more students in risk classes, which led lecturers to decide to provide more care for those students, which helped improve in and nearly 100% of final exam results. The results of the fuzzy genetic algorithm gave more passed students because they took into consideration those who are between risk and safe, to safe state that gives students a mental satisfaction, but the lecturers will take care of them indirectly, so a friendly environment will be created between tutors and students. Additionally, expert students will be recruited by reputable companies that make students' future safety a priority, Early hiring of students by businesses elevates the status of the school and the students [1].

Al Farissi et al. (2019),. In order to forecast students' academic performance, a method based on the Genetic Algorithm (GA) feature selection methodology and classification method is proposed in their study. The Area under the Curve (AUC) performance assessment is utilized to appraise the suggested approach. The experimental results indicate that the proposed strategy performs impressively in predicting the academic achievement of students. In this study, we have experimented with six classifiers that use evolutionary algorithms and feature selection strategies to predict academic achievement of students. The Kaggle repository's public student performance dataset is used in our investigations. The conducted tests were verified by x cross fold validation, and the validation findings were calculated using a confusion matrix. Six classifiers technique is used to address the issue of class imbalance, while a genetic algorithm is used to address the problem of high dimensional datasets. Thus, we deduce that the combination of GA feature selection with the Random Forest classifier method yields a notable enhancement in predicting students' academic achievement. Our study's future research will experiment with various optimization strategies and classification algorithms in an effort to create dependable models with highly accurate predictions[2].

Farissi et al. (2020),. Their research aimed to increase the accuracy of forecasting academic performance of students by proposing Genetic Algorithm based Feature Selection (GAFS) in conjunction with a single classifier selection. The Kaggle dataset is employed in this work, and two phases of experiments, one with a single classifier without GAFS and another with GAFS have been carried out. The trials' results demonstrate that, when compared to other methods already in use, the accuracy of the suggested GAFS for classification performs impressively in forecasting students' academic achievement. In order to improve the performance accuracy for student academic prediction, DT, k-NN, NB, and RF classifiers have been applied with GAFS approaches in this work. The Kaggle repository's dataset, which included student performance, was utilized. In order to increase predictive accuracy, this study was successful in reducing the dimensions of the data set through the application of feature selection approaches. The experimental findings demonstrate remarkable advances in prediction of students' academic performance. Subsequent studies will assess how many suggested optimization strategies stack up against alternative feature selection strategies and ensemble approaches[3].
Ruhi and Bichkar (2022), The outcomes are examined in relation to the size and accuracy of the tree created by the genetic algorithm and J48 (from WEKA).The characteristics that are crucial for predicting the outcomes of first-year engineering

students are also determined. Decision trees are a useful tool for forecasting engineering students' performance. Both evolutionary algorithms and greedy algorithms can be used to induce decision trees. The results show that the range of early prediction accuracy is between 59% and 69%. Predicting exam results for first-year engineering students is heavily influenced by the characteristics that characterize their prior success on various tests. The obtained values are rather satisfactory, despite the low accuracy, since they provide us with a good idea of the exam's outcome ahead of time and can be utilized to provide students with more information. According to the sort of students and academic input, the results make sense[4].

Rohani et al. (2020), Their study introduces an innovative method, named G-SA, for predicting students' academic performance in courses that can be utilized to stop students from failing. Combining genetic and simulated annealing methods yields the benefits of both. This is the G-SA algorithm. Crossover and mutation operators create stronger neighbors, which eventually result in superior solutions, by depending on the best global solution in the suggested method. The suggested method, which has been able to eliminate local optima in addition to accelerating convergence, also balances the powers of exploration and exploitation thanks to the combination of the two algorithms. The suggested technique enhances accuracy performance from 1.09% to 24.39% when compared to alternative metaheuristic comparison methods and from 0.29% to 6.57% when compared to well-known conventional classification methods, according to experimental data from the implementation of the G-SA algorithm[5].

Salvi et al. (2018), In order to estimate a student's final period grade, this paper suggests a novel method that makes use of easily attainable and interpretable characteristics of typical study behavior as well as historical academic record information about the student.An innovative strategy for forecasting student performance in academic courses has been put forth in this research. The suggested method processes the universal data, in contrast to simple clustering regression analysis, which considers a portion of the exact sample data. When managing a large number of student academic records which are regularly and continually distributed, this has an intuitive appeal. By adding an offset value to the predictive model, the work utilizes characteristics associated with observed student study behavior. Compared to the previous techniques, the offset value mechanism-backed embedded fuzzy clustering methodology produces superior outcomes. The method combines the usage of intuitive qualities from an academic course with typical study habits of students by using fuzzy representation. This helps make the predicted results more readily interpretable, while involving simple computation[6].

Ellysa et al. (2022),. Their analysis concludes that, in order to provide chances and answers to a variety of issues facing academic institutions, including the mitigation of student dropout, student academic prediction was crucial. Academic prediction for students can generally be accomplished with the majority of data mining tools. Based on the review results, we recommend using Random Forest, Neural Network, Decision Tree, and Naïve Bayes approaches to forecast student performance because of their high accuracy. Moreover, we discover that academic elements are commonly applied in sectors related to EDM. There is currently little research on predicting student success using personal traits like psychological and social/behavioral traits. Therefore, further research into it is necessary in order to lower the dropout rate as well[7].

Yousuf and Nur (2022), Predicting student academic performance is linked to developing the best educational policies in higher education, which significantly impact economic and financial development. It also helps pupils evaluate and enhance their performance. An extensive analysis of relevant research on the academic performance of students is presented in this study. Several techniques have been reviewed, such as Support Vector Machine (SVM), Naïve Bayes (NB), Logistic Regression (LR), Decision Trees (DT), Extreme Learning Machine (ELM), Artificial Neural Network ANN, k-Nearest Neighbors (kNN), and ensemble methods such as Bagging, Random Forest (RF), and Adaptive Boosting (AB). Furthermore, many classifiers have been utilized to compare and utilize student factors. As a result, the results verified that neural networks were the most effective classifiers, and that academic assessment played a significant role in predicting students' academic success. Academic performance in the future was found to be strongly predicted by elements related to students' past and current academic performance assessments. Finally, but just as importantly, the work's objective is to support and assist future researchers in identifying the variables and creating a legitimate model that can reliably and simply predict students' academic achievement. Furthermore, it will enable educators to identify students who require further support in the classroom, enabling more thorough and precise forecasting of student performance results[8].

Eyman and Dilek (2020), Since student achievement is frequently used as a performance indicator for educational institutions, it is essential to their operations. The success of at-risk pupils can be significantly increased by early identification and preventive actions. Machine learning methods have been widely applied lately to make predictions. Although there are many success stories in the literature, instructors who are familiar with "computer science," or more accurately, "artificial intelligence," are the primary audience for these tactics. Choosing which student traits to emphasize, how to define success for students, and which machine learning method is best for a given situation are just a few of the decisions involved in applying data mining techniques effectively and efficiently[9].

3. MATERIALS AND METHOD

PROPOSED SYSTEM MODEL ARCHITECTURE

The machine learning model is trained using a genetic algorithm. The training dataset includes a mix of good and bad performance data to avoid bias. The genetic algorithm helps in evolving the model over generations to find the best coefficients

for prediction. The model is saved as best_model.pkl and loaded by the Django application for making predictions. The following steps are carried to create and test the model Prediction of Students Academic Performance Using Genetic Algorithm

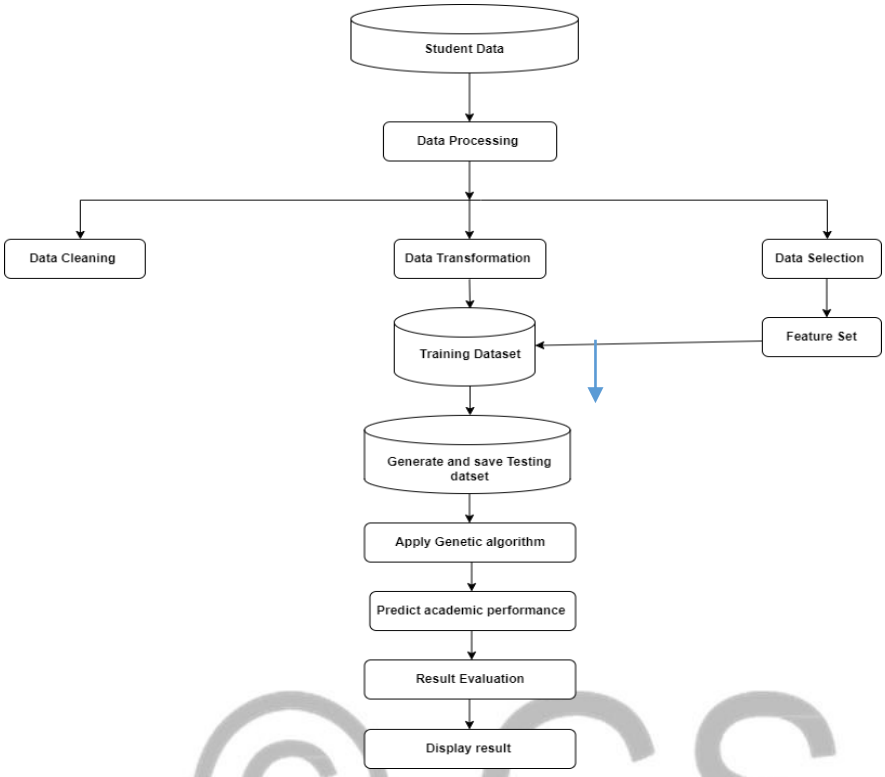

Figure 1: The architectural diagram of the proposed system prediction model

Figure 1 shows the architectural diagram of the proposed system prediction model. Genetic algorithms are now widely applied in science and engineering as adaptive algorithms for solving practical problems. The general acceptance is that GA is particularly suited to multidimensional global search problems where the search space potentially contains multiple local minima. Unlike other search methods, correlation between the search variables is not generally a problem. Genetic algorithm works modeling the parameters of a problem as real strings. The following figure depicts the various components of GA model. The proposed system consists of starting edge from the student analyzing data and ending edge by finding the most important parameter that is found by undergoing several processes as follows

1. Analyzing the performance information in educational systems that are quantifiable such as attendance, internal assessment marks, study hours, previous semester marks, extracurricular, general proficiency, papers that are considered important in that course.
2. On collecting those parameters, the equation construction that containing all those parameter values with weight values are designe
3. After designing the equation, the real-coded genetic algorithm is applied.
4. The operations such as mutation and cross over are carried out.
5. The best parameter is identified, once analyzing all the parameters through real genetic algorithm. The quantitative factors that are considered into the analysis of students' performance are given below:

1. Attendance: Percentage of classes attended.
2. Previous Grade: Grades from previous assessments.
3. Study Hours: Average hours spent studying per week.
4. Assignment Score: Average scores of assignments.
5. Extracurricular: Participation in extracurricular activities (binary: 0 or 1).
6. Final Grade: obtained from the equation as the result Here GA tool that is developed for predicting student performance requires the quantitative attributes of student (i.e.) measurable variables like study hours, previous grades, attendance, daily test marks etc. are listed below.

FINDING THE BEST PARAMETER USING GA

Most Important Parameter Using GA This analysis is concerned with finding most important attribute that affects the performance of student. As the fore mentioned properties of GA are highly advantageous, GA is designed using Crossover and Mutation process. For this experiment we have selected the quantitative factors among the student in college/school. The genetic algorithm (GA) uses a real value as a parameter of the offspring in populations without performing coding and encoding process before calculates the fitness values of individuals. The performance analysis for GA model is given by the following equation.

Performance Value(PV) =
*{*0.1(Attendance) + 0.15(Previous Grade) + 0.25(Study Hours) + 0.10(Assignment Score) + 0.20(Extracurricular) + 0.2(Final Grade)*}*

The working of real genetic algorithm in performance analysis is as follows.

a. [Start] Generate random population of attributes as chromosomes
b. [Fitness] Evaluate the fitness f(x) of each chromosome x in the population
c. [New population] Create a new population of attributes by repeating following steps until the new population is complete
i. [Selection] Select two parent chromosomes from a population according to their fitness (which satisfies the fitness function)
ii. [Crossover] with a crossover probability Pc crossover the parents to form a new offspring (children). For real values, linear crossover is performed. ax+(1-a)y, where a is priority value in the equation and x, y are real values
iii. [Mutation] with a mutation probability Pm mutate new offspring at each locus (position in chromosome), For real value mutation, add any random value as x + N(0,0.1)
iv [Accepting] Place new offspring in a new population
d. [Replace] Use new generated population for a further run of algorithm.
e. [Test] if the end conditions are satisfied, stop, and returns the best parameter in current population
f. [loop] go to step b.

Initially a population of chromosomes, each of which represents a potential solution to the problem at hand, is generated randomly and each of them is evaluated by finding its fitness. The next generation of same size is created by selecting more fit individuals from this population and by applying genetic operators like crossover and mutation to them. Mutation is an operator which creates a new individual by making a random change in the old one, whereas crossover creates new individuals by combining parts from multiple individuals. Classic mutation randomly alters a single gene, while crossover exchanges genetic material between two or more parents. This completes one generation and after repeating this procedure for a number of generations, due to selective pressure the algorithm converges and it yields a better solution.

DATASET DESCRIPTION

The dataset contains the following features:

1. Attendance: Percentage of classes attended.
2. Previous Grade: Grades from previous assessments.
3. Study Hours: Average hours spent studying per week.
4. Assignment Score: Average scores of assignments.
5. Extracurricular: Participation in extracurricular activities (binary: 0 or 1).
6. Final Grade: The final grade predicted based on the features.

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9. Study Hours: Average hours spent studying per week.
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12. Final Grade: obtained from the equation as the result Here GA tool that is developed for predicting student performance requires the quantitative attributes of student (i.e.) measurable variables like study hours, previous grades, attendance, daily test marks etc. are listed below.

Table 1. Possible range of values for all derived variables

Variable	***Description***	***Possible range of values***
Attendance	Percentage of classes attended.	0-100
Previous Grade	Grades from previous assessments.	0-30
Study Hours	Average hours spent studying per week.	0-25
Assignment Score	Average scores of assignments.	0-50
Extracurricular	Participation in extracurricular activities	Binary: 0 or 1
Final Grade	Final Grade obtained from the equation as the	0-100

	result	

Now the equation used to analyze and categorize the performance of the student consists of the input parameters such as attendance, internal assessments, Assignment score, General proficiency, study hours, extracurricular as mentioned above. The parameter which shows more variation in the evaluation of the performance using the algorithm, it is chosen as the optimum parameter. On finding the result for each student, we can generally find the most optimizing parameter for the student management and thereby taking necessary steps for improving the overall performance of the students.

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PERFORMANCE EVALUATION METRICS

The following performance metrics were used to determine whether the model is accurate or not;

Mean Absolute Error (MAE): Mean Absolute Error (MAE) is one of the most common performance metrics. It is used to calculate the prediction error of the model. The MAE measures the average magnitude of the errors in a set of predictions. MAE is given by the following Equation (1):

$MAE = 1/N * N \sum_{i=1}^{N} |yi - \hat{} yi|$

where yi represents the actual value, ˆ yi represents the predicted value of yi, and N represents the number of instances.

Mean Absolute Percentage Error (MAPE): The MAPE is calculated as follow. $MAPE = 100 * (MAE/yi)$

where MAE represents the value of MAE and yi represents the actual value.

4. IMPLEMENTATION AND RESULT.

Home Interface: This is the first page where the user lands. In this page there is a "choose file" function and an Upload button where the user can upload the selected file to the system. This page also contains a little description of what the built system it's all about and the purpose of the system too.

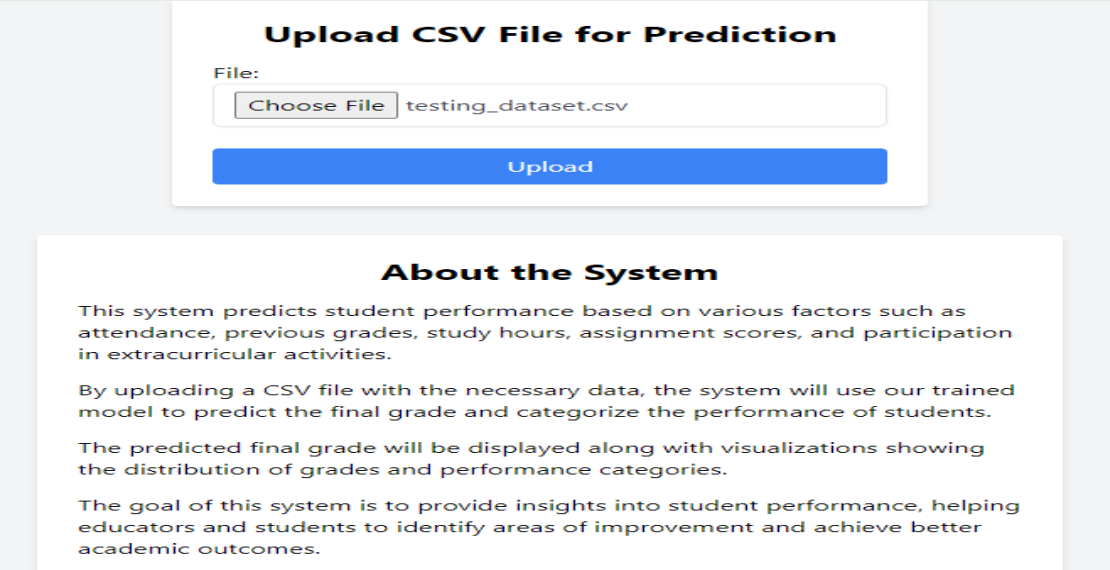


Fig 2: Homepage Interface

Fig 3. Result Data frame Interface

Student Performance Category Interface: This page shows the representation of the students' performance category page. It is a bar chart showing the total number of students in accordance to their performance, inclusive of the "doing well" and "Needs improvement" students.

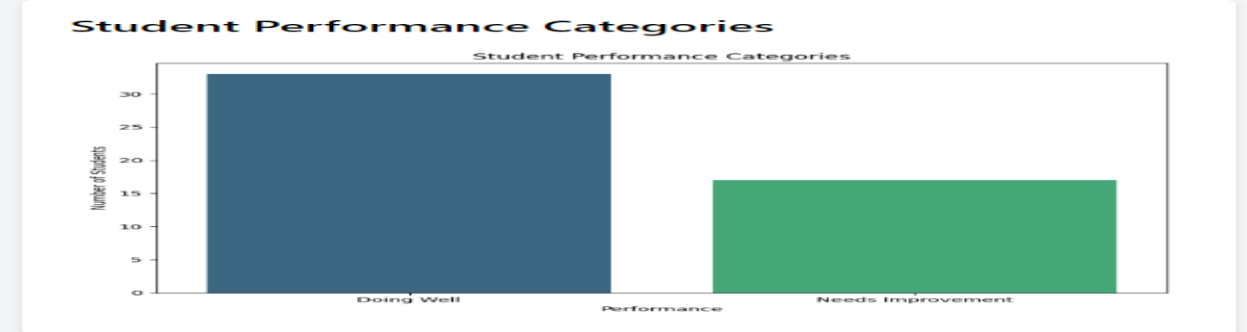
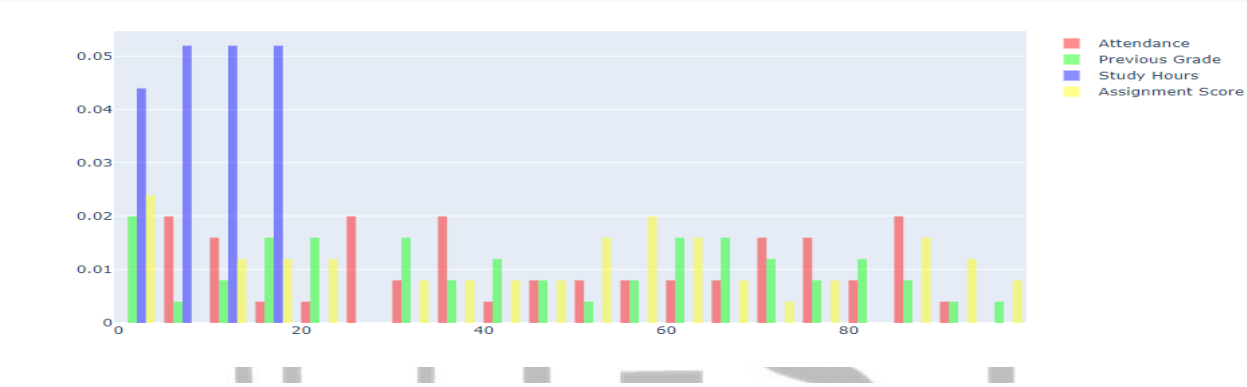


Fig 4. Student Performance Category Interface

A program testing represents the logical elements of a system for a program to run satisfactorily, it must compile and test data correctly and tie in properly with other programs. In testing this system, I will use the trained model to predict student performance based on a given test dataset. This is carried out using the following steps;



- **Visualize the Predictions, First, we need to ensure the predictions are loaded and then create the visualization. Below is the distribution of the predicted final grade.**

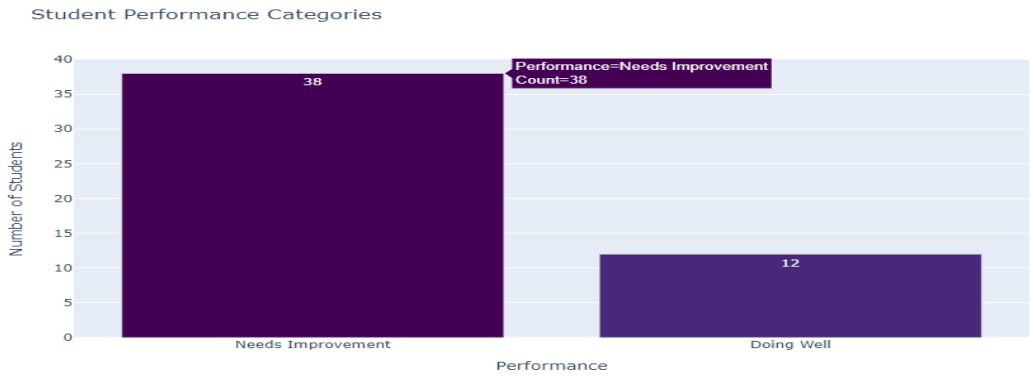
The results section includes:

- Predicted Final Grades: The predicted final grades for top 5 students in the test dataset.

	Attendance	Previous_Grade	Study_Hours	Assignment_Score	Extracurricular
0	80	78	19	57	0
1	60	88	14	4	0
2	85	70	9	32	1
3	92	89	4	42	1
4	25	71	2	18	1

	Predicted_Final_Grade	Performance
0	72.191561	Doing Well
1	53.093421	Needs Improvement
2	59.648373	Needs Improvement
3	64.438430	Doing Well
4	37.860209	Needs Improvement

- Performance Categorization: Students are categorized into 'Doing Well' or 'Needs Improvement' based on their predicted grades.



5. CONCLUSION

The capacity to very accurately classify expected student performance, which is also what tests attempt to do, without the performance sampling issues of traditional testing, and using a much broader spectrum of all factors influencing a student methodology. In fact, it also represents a more valid approach to educational assessment due to its overall accuracy and the breadth of the constructs considered to classify the expected performance. Traditional assessments are not sufficient for more complex assessments or for assessment systems that intend to serve multiple direct and indirect purposes, in complex educational situations. In this respect, this new approach allows for the conceptualization and development of new modes of assessment which could facilitate breaking away from traditional forms of testing while at the same time improving the quality of the assessment process.

Finally, the use of GA together with other methods as linear regression analyses and Kohonen networks could contribute to the study of the specific patterns of those variables which influence the learning process for each level of performance. In fact, a major observation resulting from the data in this study is that variables contribute to the prediction in relatively small proportions, and it is the joint effect of many contributing variables that could cause significant changes in performance. In other words, there is no "magic rather the accumulation of effects from all these various sources that produces significant changes in outcomes. These results provide an insight into learning questions from a different perspective and one that has important implications for educational policy and education at large.

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