Development of Student's Performance Evaluation System Using Artificial Intelligence

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Abstract

This project involves predicting students' scores using machine learning models and providing academic suggestions based on predicted results. Two primary models were tested: a Deep Neural Network (DNN) and an XGBoost regression model. The project aimed to leverage historical student data to forecast comprehensive exam scores and identify areas needing improvement.

Introduction

The ability to predict academic performance and identify areas for improvement can significantly enhance educational support systems. This project explores the application of machine learning models to predict student scores in the course "Mechanical Oscillations and Waves" offered by BITS Pilani. By analyzing tutorial tests, mid-semester exams, and comprehensive assessments, the project aims to not only forecast scores but also suggest targeted study resources. The DNN model was implemented initially but due to high mean absolute error (MAE) and mean squared error (MSE) the model had to be rejected. To obtain better loss on MSE and MAE a XGBoost model was implemened, this model produced significantly better results as compared to the DNN model.

Literature Review

Literature Review
The application of Artificial Intelligence (AI) in education, specifically for performance assessment and student support, has garnered increasing interest among researchers and practitioners. This review synthesizes findings from recent literature on AI-supported decision-making in educational contexts, examining methodologies, systems, and outcomes associated with these advancements.

Performance Assessment Methodology for AI supported decision making in production management
Burggräf et al. (2020) discuss the role of AI in enhancing decision-making in production management. Though their focus is on industrial applications, the methodologies outlined—such as performance assessment via AI—have parallels in educational settings where performance metrics are similarly critical. They highlight AI's ability to process complex datasets to improve decision accuracy, a feature equally beneficial for educational performance analysis (Burggräf et al., 2020).

Artificial Intelligence for Student Assessment: A Systematic Review
Calatayud, Espinosa, and Vila (2021) provide a systematic review of AI tools used for student assessment. They emphasize the growing integration of AI in educational

practices, noting that AI significantly enhances the accuracy and efficiency of assessments. Their review underscores the potential for AI to personalize learning experiences and adaptively support student needs, pointing towards a future where educational tools are increasingly responsive and tailored to individual performance metrics (Calatayud et al., 2021).

AI for Education 4.0
Chen et al. (2020) explore the concept of Education 4.0, which integrates AI to analyze student performance comprehensively. Their work demonstrates how AI can facilitate a holistic view of student data, enabling predictive analytics and proactive interventions. This approach aligns with the broader goals of personalized learning environments that adapt to the pace and style of each student, promoting an inclusive and effective educational framework (Chen et al., 2020).

The IEEE paper on "Education 4.0 - Artificial Intelligence Assisted Higher Education" further investigates AI's role in early recognition systems within higher education. It illustrates how machine learning models can predict student success with significant accuracy, thus supporting timely interventions (IEEE, 2018). Such systems exemplify the proactive capabilities of AI in educational settings, aiming to reduce dropout rates and enhance student engagement through targeted support.

Tools for Subjective Assessment
The development of tools like TESA (Tool for Evaluating Subjective Answers using AI) as discussed in IEEE publications, showcases the application of AI in evaluating open-ended responses. TESA represents a shift towards more nuanced AI applications capable of interpreting and assessing complex student inputs, which are traditionally challenging for automated systems. This innovation marks a significant step forward in automating the assessment of creative and analytical skills (IEEE, 2021).

Smart Computing in Engineering Education
Verma, Sood, and Kalra (2017) discuss a smart computing framework designed to evaluate student performance in engineering education. Their model leverages sensor data and student interaction metrics to predict academic outcomes, providing a multifaceted approach to student assessment. This research highlights the potential of integrating various data points to enhance predictive accuracy and tailor educational strategies to student behaviors and preferences (Verma et al., 2017).

Assignment Problem

The task was to predict the scores of students in a comprehensive examination based on their performance in earlier assessments and tutorial tests. Additionally, the project sought to automatically suggest study materials and topics for students underperforming relative to a calculated threshold.

The dataset that the model was trained and tested on is the scores obtained by students in Mechanics, Oscillations and Waves. The second dataset used for the model for different kind of data is the score of Fluid Mechanics both the datasets are present in the given link: https://drive.google.com/drive/folders/1hzS-ltFsJfRoEt0OCQuf3HMYpf7-kijl

Implementation

The project was implemented in Python using jupyter notebooks for data processing, model training and data plotting using many libraries such as:

Pandas, NumPy, scikit-learn, Matplotlib, XGBoost and TensorFlow.

The dataset used was obtained using the previous year and current year scores of students in the subject Mechanics, Oscillations and Waves. This dataset was later enhanced with engineered features such as average tutorial scores and total pre-comprehensive scores. The data was then scaled using StandardScaler to normalize feature scales, this was done so that the gradient doesn't move too fast and randomly i.e. to prevent noisy gradients. This was done to tackle the issue of data with high variance and non-linear nature.

To train a XGBoost (eXtreme Gradient Boosting) model XGBoost library was used which is an open source machine library used for efficient implementation of gradient boost algorithm, this is an ensemble learning technique used for building strong predictive models by combining multiple decision trees in a sequential manner.

Results and Analysis

The DNN model used in the project posed several problems as the testing phase began, some of the problems were:

- Exploding gradients resulting in the result – NaN (Not a Number).
- High loss and metric value i.e. Mean Squared Error and Mean Absolute Error due to the non-linear nature of data.

To overcome these problems several methods were used:

- To prevent overfitting dropout and early stopping were used, dropout deactivates neurons in the network randomly which helps in better generalization, early stopping tracks the metric on the validation/test set over each training epoch. If the metric fails to improve for a certain number of consecutive epochs i.e.

patience (here set to 10) the model parameters with best performance are retained.

- The exploding gradient problem was fixed using data processing, feature engineering, data scaling and batch normalization layers in the DNN

The DNN model, despite several layers and dropout regularization, failed to achieve satisfactory performance, indicated by high mean absolute errors and mean squared errors. Whereas the XGBoost model provided better predictive accuracy and stability, as evidenced by lower error metrics.

Moreover, the suggestions function, based on thresholding predicted scores, was able to generate actionable academic advice.

Future Work

Future research could explore the integration of more complex feature engineering, such as temporal analysis of student performance trends. Additionally, experimenting with ensemble methods and more advanced neural network architectures like RNNs or Transformers might yield improvements in predictive accuracy.

Conclusions

These studies collectively illustrate the diverse applications of AI in education, from automated assessments and performance predictions to personalized learning enhancements. Each study contributes to understanding how AI can be implemented effectively within educational frameworks to support decision-making processes, improve assessment methodologies, and foster student success. However, challenges such as data privacy (this can be implemented using federated learning), the need for model transparency, and the risk of over-reliance on automated systems are critical considerations that future research needs to address to optimize AI's role in education.

References

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