Enhanced Student Academic Performance Prediction with Interpretable and Optimized AI Approach

Proposal

In recent years, the education sector has witnessed a significant transformation towards digital learning platforms and online assessments. This creates a demand for intelligent systems to evaluate the student's academic performances for improving educational outcomes and personalized learning. This study proposed a novel interpretable and optimized Artificial Intelligence (AI) framework for predicting the student's academic performances accurately. The proposed strategy combines the efficiency of nature-inspired optimizer and hybrid deep learning algorithm for precise performance prediction. The developed work commences with the collection of student academic data and it was preprocessed to make it appropriate for subsequent predictive analysis. Consequently, a Sculptor Optimization Algorithm-based feature selector was designed to identify the most influential academic, demographic and behavioral factors. This feature selection not only boosts the prediction accuracy but also increases the system's interpretability, making it explainable for educators to understand the reason behind prediction. Finally, the prediction algorithm was developed by incorporating Squid Game Optimizer (SGO) into Deep Belief assisted Bidirectional Long Short Term Memory (DBaBiLSTM) model for assessing the student's academic performances. The SGO fine-tunes the hyperparameters of the designed hybrid AI model, leading to improved training speed and enhanced adaptability, while the DBaBiLSTM model was trained using the selected features and understands the patterns, hierarchical relations influencing student's performances. Thus, the combination of meta-heuristic optimizer and AI model predicts the academic performance of the students in educational institution precisely. The presented framework was modeled and executed in Python and validated using the publicly available academic student database. The experimental results demonstrated that the designed model achieved higher accuracy, less mean square error, greater correlation coefficient, and less computational time. Furthermore, a comparative assessment was performed with conventional predictive algorithms and it highlighted that the proposed strategy achieved better performances than others.

This study proposes an Enhanced Student Academic Performance Prediction (ESAPP) model, integrating Explainable AI (XAI) techniques with an optimized deep learning framework to enhance both accuracy and interpretability. The model utilizes feature selection through Evolutionary Optimization Algorithms to identify the most influential academic, demographic, and behavioral factors. A hybrid deep learning architecture, combining Long Short-Term Memory (LSTM) networks for temporal data processing and Graph Neural Networks (GNNs)

for relational data analysis, is employed to improve prediction robustness. To ensure transparency, SHAP (Shapley Additive Explanations) and LIME (Local Interpretable Model-Agnostic Explanations) are incorporated, enabling educators to interpret model decisions effectively.

Given the increasing complexity of student learning behaviors and the impact of online and hybrid education systems, our approach is timely and essential. Extensive experiments on real-world educational datasets demonstrate that the ESAPP model outperforms traditional machine learning and deep learning methods in terms of prediction accuracy, F1-score, and computational efficiency. This research underscores the importance of integrating interpretable and optimized AI models in education, paving the way for more transparent and effective student performance analysis and intervention strategies.

Keywords: Artificial Intelligence, Meta-heuristic Optimization, Deep Learning, Student Performance Prediction