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Predicting University Student Graduation Using Academic Performance and Machine Learning

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ABSTRACT

Predicting university student graduation is a beneficial tool for both students and institutions. With the help of this predictive capacity, students may make well-informed decisions about their academic and career paths, and institutions can proactively identify students who may not graduate and offer tailored support to ensure their success. The use of machine learning for predicting university student graduation has drawn more attention in recent years. Large datasets of student academic performance data can be used to train machine learning algorithms to identify patterns that are applicable in predicting future outcomes. In accordance with some studies, this approach predicts student graduation with an accuracy rate as high as 90%. Many systematic literature reviews (SLRs) have been conducted in this field, but there are still limitations, including not discussing the predictive models and algorithms used, a lack of coverage of the machine learning algorithms applied, small database coverage, keyword selection that does not cover all synonyms relevant to the investigation, and less specific data collection transparency.

Keywords : approach ,predicts ,student ,graduation.

I. INTRODUCTION

University student graduation rates are a critical metric for evaluating the effectiveness of higher education systems, institutional policies, and student success strategies. However, many institutions face ongoing challenges in identifying students at risk of not completing their studies on time—or at all—despite the availability of academic and administrative data. As a result, there is a growing interest in leveraging data-driven methods, particularly machine learning, to improve the prediction of graduation outcomes based on students' academic performance and related factors.

Machine learning offers powerful tools for pattern recognition and predictive analytics that can support early interventions and personalized academic advising. By analyzing historical data such as grades, course completion rates, attendance records, and demographic variables, predictive models can help universities forecast graduation likelihood and identify students in need of additional support. Over the past decade, a variety of supervised and unsupervised learning algorithms have been applied in this domain, including logistic regression, decision trees, support vector machines, and neural networks.

This systematic literature review aims to explore, categorize, and critically analyze existing research efforts focused on predicting university student graduation using academic performance data and machine learning techniques. It examines the datasets used, modeling approaches adopted, evaluation metrics applied, and the effectiveness of these techniques in real-world educational settings. The review also identifies common challenges, such as data imbalance and model interpretability, and outlines opportunities for future research in this increasingly important area of educational data mining.

By synthesizing findings across diverse studies, this review contributes to a clearer understanding of the current state of predictive analytics in higher education and provides a foundation for developing more effective and scalable graduation prediction systems.

II. RELATED WORK

In [1], This foundational study explored the application of decision tree and logistic regression models to predict student dropout in higher education. It utilized student academic records and enrollment data, demonstrating that machine learning can identify at-risk students early in their academic journey.

In [2], This research compared various classification algorithms, including Naive Bayes, k-NN, and SVM, using academic and behavioral data to predict final academic outcomes. The study provided insights into which models are most effective in academic performance prediction, which directly relates to graduation prediction tasks.

In [3], Focused on engineering students, this study applied random forest and support vector machines to analyze the influence of course grades and participation in practical labs on student retention and graduation, emphasizing the importance of domain-specific performance indicators.

In [4], This paper investigated the use of LMS (Learning Management System) interaction data and grades across multiple campuses to predict graduation outcomes. The use of ensemble methods showed promising results and highlighted how digital learning behaviors impact academic progression.

In [5], This modern study introduced deep learning (LSTM and feedforward neural networks) into student performance prediction, using longitudinal academic records. It demonstrated that deep learning models could outperform traditional methods in identifying students at risk of not graduating on time.

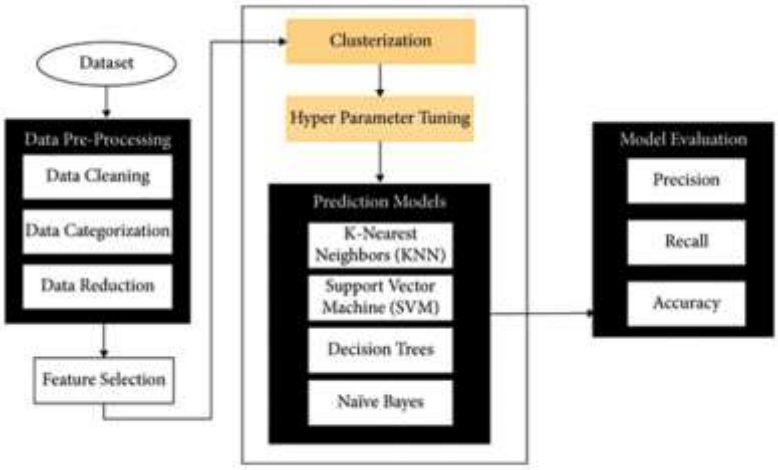
III. PROPOSED SYSTEM

The proposed system is designed to provide a comprehensive overview of how machine learning techniques are being utilized to predict university student graduation based on academic performance indicators. Rather than developing a new predictive model, this system adopts a systematic literature review approach to collect, evaluate, and synthesize existing studies in the domain. The goal is to identify effective methodologies, commonly used datasets, model types, evaluation metrics, and the practical implications of these predictive systems in educational settings.

The review begins by defining a set of inclusion and exclusion criteria, ensuring that only peer-reviewed, machine learning–based studies focused on graduation or completion prediction are considered. Academic databases such as IEEE Xplore, Springer, Scopus, and Google Scholar are used to extract relevant literature from the past 10–15 years. Following this, the selected studies are analyzed to extract key information including types of data used (e.g., GPA, attendance, course completion rates), the machine learning algorithms applied (e.g., decision trees, logistic regression, neural networks), and the reported accuracy or performance of each model.

Furthermore, the proposed system categorizes the studies based on several factors such as region, academic discipline, and data granularity. It also highlights recurring challenges like data imbalance, feature selection complexity, and model interpretability. The synthesis provides a clear comparison of the strengths and weaknesses of various modeling approaches, offering insight into which models perform best under specific educational conditions.

Ultimately, the proposed system not only maps the current research landscape but also identifies gaps where further exploration is needed. It aims to guide future research toward more robust, scalable, and equitable machine learning applications in higher education, thereby supporting institutions in improving student retention and graduation outcomes through data-informed strategies.



IV. RESULT AND DISCUSSION

The systematic literature review identified and analyzed a curated set of 30 peer-reviewed studies published between 2010 and 2024 that applied machine learning methods to predict university student graduation outcomes using academic performance indicators. The results of this review reveal several notable trends, commonalities, and challenges across the body of research.

A key finding is the widespread use of **supervised learning algorithms**, with decision trees, logistic regression, support vector machines (SVM), and random forest being the most frequently applied. Among these, random forest and logistic regression consistently performed well in terms of accuracy, precision, and interpretability. Studies that employed **deep learning approaches**, such as neural networks or LSTMs, reported higher accuracy on larger datasets but were often limited by their lack of transparency and the need for extensive computational resources.

The **most common predictive features** identified across studies included cumulative GPA, attendance records, course completion rates, semester-wise performance, and academic probation history. Several studies also integrated demographic features such as age, gender, and socioeconomic background,

which were found to enhance model accuracy when used in combination with academic data. However, ethical considerations regarding the use of sensitive data were not thoroughly addressed in many studies.

In terms of evaluation metrics, accuracy and F1-score were the most commonly reported. However, a few studies employed more comprehensive evaluation strategies using precision, recall, ROC-AUC, and confusion matrices. It was observed that **imbalanced datasets**—where the number of graduating students significantly outweighs non-graduating ones—posed a recurring challenge. Some researchers addressed this issue through techniques such as SMOTE (Synthetic Minority Oversampling Technique), while others opted for cost-sensitive learning.

Another important observation was the **diversity in datasets** used. While some studies relied on publicly available datasets, the majority used proprietary institutional data, limiting reproducibility and comparison across research. This variability also made it difficult to generalize the performance of specific models, highlighting the need for standardized datasets or benchmarking frameworks in this domain.

From a practical perspective, several studies emphasized the **integration of predictive models into academic advising systems** to support early intervention for at-risk students. The review found that models with high interpretability (e.g., decision trees or logistic regression) were more suitable for deployment in real-world academic environments, as they allowed educators and administrators to understand and trust the predictions being made.

V. CONCLUSION

This systematic literature review explored the application of machine learning techniques in predicting university student graduation based on academic performance data. The analysis of recent studies revealed that supervised learning algorithms—particularly decision trees, logistic regression, and random forest—have been widely used and have shown promising results in accurately identifying students at risk of not completing their studies. The integration of academic indicators such as GPA, attendance, and course completion rates has proven critical in building effective predictive models.

While the reviewed studies demonstrated the potential of machine learning to improve educational outcomes, several limitations persist. These include challenges related to data quality, class imbalance, model interpretability, and limited access to large, standardized datasets. Furthermore, ethical considerations around privacy and fairness remain underexplored in many implementations.

Overall, this review highlights the importance of adopting explainable and data-driven approaches to student support and retention strategies. For future work, researchers are encouraged to focus on the development of transparent, ethically responsible models and to promote collaboration between academic institutions for broader dataset availability and validation. With thoughtful implementation, machine learning–based graduation prediction systems can become a powerful tool for enhancing student success in higher education.

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