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Deep Learning Approaches to Student Stress Detection and Academic Risk Prediction

S. Jenitta Sofia, V. Madhumitha
RAAK ARTS AND SCIENCE COLLEGE, VELALAR
COLLEGE OF ENGINEERING AND TECHNOLOGY

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[1]S. Jenitta Sofia, Assistant. Professor, Department of Business Administration, Raak Arts and Science College, Perambai, Villupuram, Tamil Nadu, India. jenisofia27@gmail.com

[2]V. Madhumitha, Assistant Professor, Department of CSE (Artificial Intelligence and Machine Learning), Velalar College of Engineering and Technology, Erode, Tamil Nadu, India. vmadhumitha2024@gmail.com

Abstract

Rising levels of academic pressure and psychological strain among students present a significant challenge for modern educational institutions, where demanding coursework, competitive learning environments, and increasing reliance on digital learning platforms contribute to elevated stress levels that influence learning engagement, academic performance, and program completion rates. Early identification of stress indicators and academic risk factors therefore represents a critical component in the development of intelligent educational support systems capable of improving student well-being and academic success. Rapid advancements in artificial intelligence and educational data analytics provide new opportunities for analyzing complex behavioral and academic patterns generated through learning management systems, wearable sensing technologies, academic records, and digital interaction logs. Deep learning techniques offer powerful capabilities for processing large-scale and heterogeneous educational datasets through automatic feature learning and hierarchical pattern recognition. Convolutional neural networks enable analysis of visual and emotional cues derived from facial expressions and classroom monitoring systems, while recurrent neural architectures capture temporal relationships embedded within sequential behavioral interactions and physiological signals associated with stress responses. Hybrid and multimodal deep learning frameworks further enhance predictive capability through integration of behavioral, physiological, and academic indicators within unified analytical models designed for continuous student monitoring. This chapter presents a comprehensive examination of deep learning approaches applied to student stress detection and academic risk prediction within modern educational ecosystems, including analysis of key data sources, multimodal neural architectures, predictive analytics frameworks, and intelligent monitoring systems designed for early identification of at-risk learners. Critical challenges associated with data privacy, dataset availability, model interpretability, and scalability within educational environments receive detailed consideration, along with emerging research directions focused on explainable artificial intelligence and real-time learning analytics. Analytical insights highlight the growing potential of deep learning–driven predictive systems in enabling proactive intervention strategies, personalized academic support mechanisms, and intelligent student monitoring infrastructures that strengthen educational resilience and retention outcomes across higher education institutions.

Keywords: Student Stress Detection, Deep Learning, Educational Data Mining, Academic Risk Prediction, Multimodal Learning Analytics, Student Dropout Prevention.

Introduction

Rapid transformation of educational environments through digital technologies has created new challenges related to student well-being and academic sustainability. Academic institutions experience increasing concern regarding the psychological pressure experienced by students across various levels of education [1]. Intensive academic workloads, frequent evaluations, competitive learning environments, and uncertainty related to career prospects contribute to elevated levels of stress within student populations. Persistent exposure to such conditions influences concentration, memory retention, and decision-making abilities during learning activities [2]. Declining engagement, reduced motivation toward academic tasks, and emotional fatigue frequently emerge as consequences of unmanaged academic stress [3]. Educational systems therefore require effective analytical approaches capable of identifying early signals of psychological strain and academic difficulty. Early recognition of stress conditions enables timely intervention strategies that support students before academic performance begins to deteriorate [4]. Development of intelligent monitoring frameworks within educational systems represents a critical step toward maintaining healthy learning environments and improving student outcomes. Integration of advanced analytical technologies into educational infrastructures enables continuous observation of behavioral patterns, learning engagement, and emotional responses associated with academic activities [5].

Growth of digital learning platforms and online educational systems has generated large volumes of data reflecting student behavior within academic environments. Learning management systems record detailed interaction logs including resource access patterns, participation in discussion forums, time spent on learning materials, assignment submission behavior, and assessment outcomes [6]. Such digital traces provide valuable evidence regarding student engagement, study habits, and learning progression across academic periods. Behavioral variations observed within these datasets frequently correspond with psychological conditions experienced during academic activities [7]. Reduced participation in online learning modules, irregular study patterns, and inconsistent completion of coursework often reflect cognitive overload or emotional exhaustion [8]. Educational data analytics provides mechanisms for transforming these large-scale datasets into meaningful insights regarding student learning behavior [9]. Analytical frameworks capable of extracting patterns from educational interaction data enable detection of behavioral signals associated with stress and academic disengagement. Continuous monitoring of learning activities through data-driven approaches contributes to the development of proactive academic support systems designed to maintain consistent learning engagement [10].