


Chapter 6

Self-Evolving Neuromorphic Systems for Predictive Learning Interventions

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ABSTRACT

This research presents a novel framework for learning analysis based on self-evolving neuromorphic systems that is capable of real-time prediction and intervention in the learning process. By combining impulse neural networks and evolutionary algorithms, the proposed model was able to significantly increase the accuracy of prediction and personalization of interventions. Simulation results showed that this approach has a more stable performance in detecting cognitive disorders and adjusting intervention compared to static models. This system can be used as a basis for the development of future intelligent educational tools.

1- INTRODUCTION

In the era of digital transformation, educational systems are increasingly faced with big data, complex learner behaviors, and the growing need for personalization. Learning analytics, as an interdisciplinary branch in this field, attempts to extract effective patterns in the learning process by utilizing behavioral, cognitive, and contextual data and transform them into targeted and effective interventions. However, while conventional learning analytics tools are mainly designed based on traditional

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machine learning algorithms and statistical methods, they face challenges such as real-time processing, high consumption of computational resources, and inability to adapt structurally to dynamic data (Herodotou et al., 2020).

In the meantime, approaches based on neuromorphic computing, inspired by the structure of the human brain, provide unique capacities for processing educational data at a deep, fast, and low-energy level. Neuromorphic architectures, especially spiking neural networks (SNNs), unlike conventional artificial networks, are able to operate on temporal events and transient patterns and exploit local learning rules such as STDP (Cogliano et al., 2022). These features not only enable real-time and adaptive analysis, but also make them an attractive option for designing educational intervention systems with real-time performance and high sensitivity to changes in learner behavior.

Given the inherent complexities of learner behavior, including cognitive changes, motivational fluctuations, and multifaceted interactions with content and other users, an effective learning analytics system must be able to dynamically adapt to environmental and individual changes. This requires designing systems that are not only able to predict critical moments in the learning process, but also able to optimize their internal structure in response to new data. The concept of “self-correcting learning” in this context enables the design of such systems; systems that become more effective in predicting and intervening over time by continuously learning from past experiences and continuously modifying their decision-making path (Aliahmadi & Nozari, 2023).

The integration of these two approaches—neuromorphic computing and self-correcting learning—opens a new path in the design of intelligent educational systems. In this path, any interaction-based data from the learner (e.g., response time, level of hesitation, type of error, or interruption patterns) is considered as input to a neuromorphic model that evolves over time. Instead of following static patterns, such a system can continuously and instantaneously align its structure with observed behaviors and provide targeted, personalized, and precise interventions. These interventions can include recommending new content, issuing warnings to the teacher, or suggesting pauses and revisions to the learner; All of them rely on mechanisms inspired by the human brain (Nozari, Ghahremani-Nahr, & Szmelter-Jarosz, 2024).

A key advantage of this approach is the ability to deploy at the edge of the network, where data is processed on local devices such as tablets, wearables, or even augmented reality glasses. This not only helps to increase the speed of analysis and response, but also greatly alleviates privacy concerns. In addition, architectures based on memristors and bio-inspired units significantly reduce the power consumption of these types of systems, which is a critical advantage in long-term applications or resource-constrained environments (Nozari, Szmelter-Jarosz, & Ghahremani-Nahr, 2021).

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