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Exploration into Bio Inspired Computing Based on Spintronic Energy Efficiency Principles and Neuromorphic Speed Pathways

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Abstract : Neuromorphic computing, inspired by the intricate operations of biological neural networks, offers a revolutionary approach to overcoming the limitations of traditional computing architectures. This research proposes the integration of spintronics with neuromorphic systems, aiming to enhance computational performance, scalability, and energy efficiency. Traditional computing systems, based on the Von Neumann architecture, struggle with scalability and efficiency due to the segregation of memory and processing functions. In contrast, the human brain exemplifies high efficiency and adaptability, processing vast amounts of information with minimal energy consumption. This project explores the use of spintronics, which utilizes the electron's spin rather than its charge, to create more energy-efficient computing systems. Spintronic devices, such as magnetic tunnel junctions (MTJs) manipulated through spin-transfer torque (STT) and spin-orbit torque (SOT), offer a promising pathway to reducing power consumption and enhancing the speed of data processing. The integration of these devices within a neuromorphic framework aims to replicate the efficiency and adaptability of biological systems. The research is structured into three phases: an exhaustive literature review to build a theoretical foundation, laboratory experiments to test and optimize the theoretical models, and iterative refinements based on experimental results to finalize the system. The initial phase focuses on understanding the current state of neuromorphic and spintronic technologies. The second phase involves practical experimentation with spintronic devices and the development of neuromorphic systems that mimic synaptic plasticity and other biological processes. The final phase focuses on refining the systems based on feedback from the testing phase and preparing the findings for publication. The expected contributions of this research are twofold. Firstly, it aims to significantly reduce the energy consumption of computational systems while maintaining or increasing processing speed, addressing a critical need in the field of computing. Secondly, it seeks to enhance the learning capabilities of neuromorphic systems, allowing them to adapt more dynamically to changing environmental inputs, thus better mimicking the human brain's functionality. The integration of spintronics with neuromorphic computing could revolutionize how computational systems are designed, making them more efficient, faster, and more adaptable. This research aligns with the ongoing pursuit of energy-efficient and scalable computing solutions, marking a significant step forward in the field of computational technology.

Keywords : material science, biological engineering, mechanical engineering, neuromorphic computing, spintronics, energy efficiency, computational scalability, synaptic plasticity.
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