CASE STUDY | AMRITA UNIVERSITY

AMRITA UNIVERSITY ACCELERATES THE PREDICTION OF NEUROLOGICAL DISORDERS USING GPUs.

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Amrita University accelerates the prediction of neurological disorders using GPUs

Spread across three states and catering to 18,000 students, Amrita Vishwa Vidyapeetham is one of India's leading research universities. Its School of Biotechnology brings together a wide range of medical and scientific disciplines to develop innovative approaches for the diagnosis, treatment and prevention of diseases.

Amrita University's Computational Neuroscience Lab, part of the School of Biotechnology, has been using the NVIDIA Tesla Accelerated Computing Platform to design prediction models for neurological disorders and to better understand neural circuit function. This work will ultimately help pioneer treatments for brain disorders and dysfunctions, as well as support developments in engineering and robotics.

CHALLENGE

The Computational Neuroscience Lab team, led by Dr. Shyam Diwakar, is seeking to gain a greater understanding into brain disorders, such as ataxia and Alzheimer's disease, that disrupt the lives of millions of people globally each year. Currently, over 44 million people suffer from the devastating effects of Alzheimer's. As the global population ages, Dr. Diwakar's work to understand and manage these conditions will become increasingly important.

At the heart of this challenge is the human brain's vast complexity. Science is only beginning to scratch the surface of how its tens of billions of neurons work together at the molecular level. By looking specifically at one of the most interesting structures in the brain, the cerebellum, Dr. Diwakar and his team are seeking to provide insight into these complex workings. Only by understanding what causes the brain's functions and dysfunctions can researchers hope to develop treatments for crippling conditions like Alzheimer's.

To get to the root of cerebellar disorders, Dr. Diwakar's team is studying the cerebellum's cellular and network components that make up the "granular layer." The size and complexity of this layer have previously rendered it a "black box," since its neurons are among the smallest and most numerous found in the human body.

Recent findings indicate that a better understanding of cerebellar disorders lies in the molecular mechanisms that code for various properties in individual cells, circuits and entire organs. To analyse these mechanisms, the Amrita team created large-scale computational models of neurons and synapses. To perform information theoretic analysis of how the granular layer responds to sensory and tactile inputs, a large amount of data from simulations involving thousands of neurons is required.

Performing the computationally intensive mathematical calculations associated with these complex neural circuit model computations and data analysis tools required a solution with ultra-high performance computing capabilities.

SOLUTION

Dr. Diwakar's team uses NEURON, an open-source C++ based application for simulating neuron and circuit models based on ordinary differential equations. Data analysis was performed using GPU-accelerated applications developed in C and MATLAB at Amrita.

Simulating these models on NVIDIA Tesla GPU accelerators, the team achieved results 30 times faster compared to conventional CPU-based systems. This performance increase enabled the team to simulate larger-scale neuron circuit models and develop new data-analysis tools for that purpose.

"Larger scale models help mimic and reconstruct brain function and dysfunction," Dr. Diwakar explained. "With GPU acceleration, these implementations provide a precise elaborations of processes underlying brain dynamics."

IMPACT

The most significant outcome of Dr. Diwakar's research to date is greater visibility into and understanding of timing in brain processes and the role of single neurons in the neural network, providing new insight into brain operation and disorder.

An example application of this research is in understanding physiological and pharmacological behaviour to predict the impact of drugs on brain dysfunctions.

"Our primary goal to seek mechanisms through which some of these conditions can be managed," said Dr. Diwakar.

Thanks to the GPU-accelerated research at Amrita University, the development of new understandings and perspectives are increasing the prediction and treatment of these debilitating neurological conditions that affect millions around the world.

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