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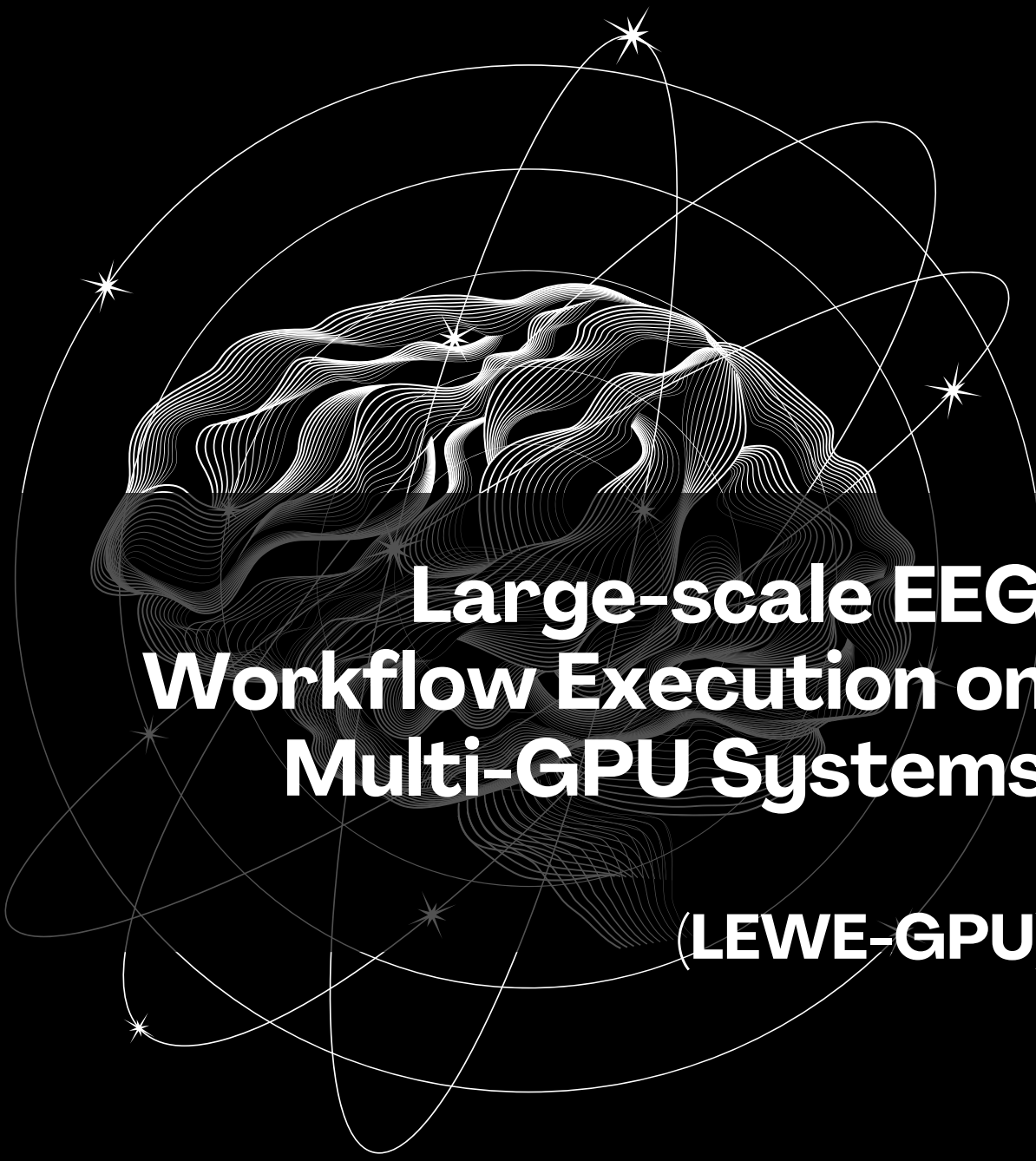


Large-scale EEG Workflow Execution on Multi-GPU Systems

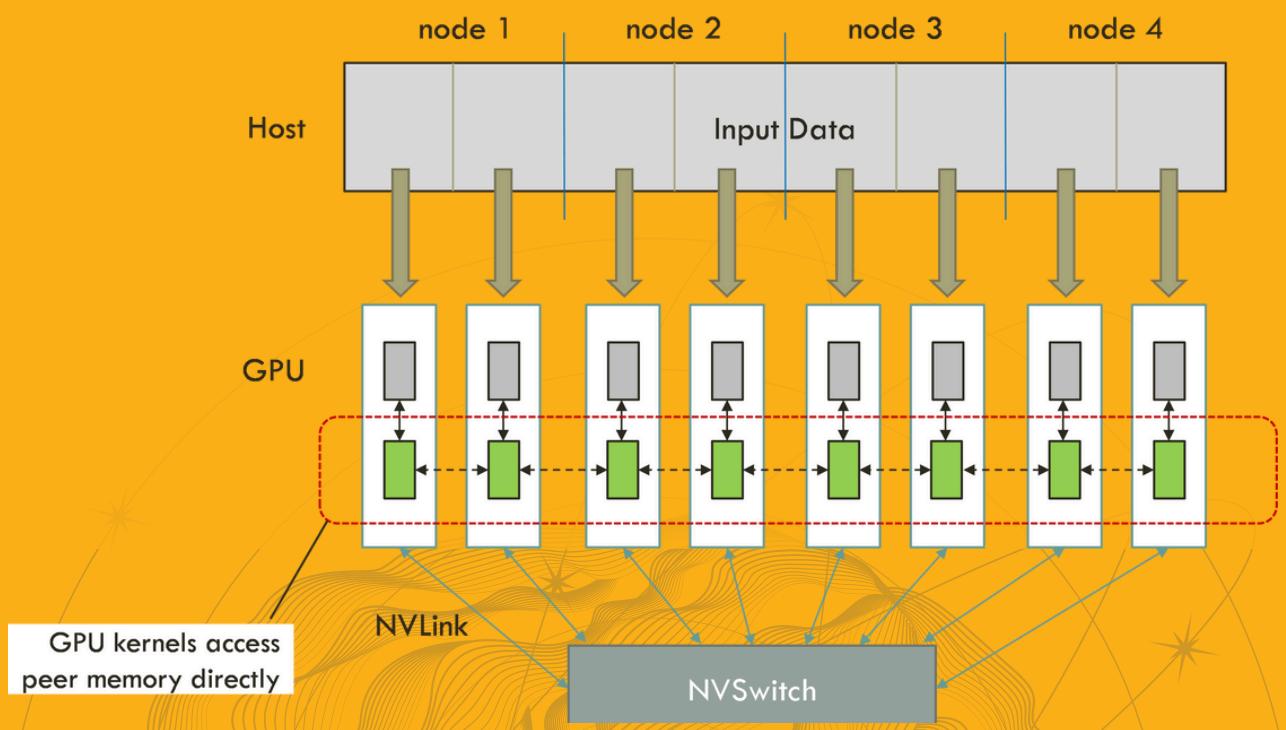
(LEWE-GPU)

An Open Call Success Story

Bioelectrical imaging, such as Electroencephalography (EEG) has the advantage over other brain imaging modalities in that it provides very high temporal resolution which allows us to track the dynamic changes in brain activity with millisecond accuracy. This helps in uncovering the sequence of activations and the interconnections among different brain areas in the time course of various task executions. Unfortunately, state-of-the-art EEG signal processing is a highly compute and data-intensive task, traditional CPU-based data processing pipelines can run for several hours.

Thanks to the SLICES-SC project, we were able to access a 16-GPU HGX-2 compute system in the IMEC GPULab facility for several months which allowed us to develop a multi-GPU (“graphics card”) accelerated EEG pre-processing pipeline that drastically reduces the execution time of large-scale EEG workflows.

This involved developing a set of parallel algorithms for fundamental EEG signal and data processing methods, such as signal filtering, Fourier and Wavelet transforms, current source density estimation, Independent Component Analysis, Empirical Mode Decomposition and various statistical measures and tests. We also performed extensive system performance benchmarking to characterise I/O and memory performance, GPU kernel execution scalability, and the performance of fundamental matrix operations and our individual EEG processing operations. This system enabled us to design highly optimised parallel implementations and test their correctness and execution speed.



Besides obtaining remote, transnational access to the system, we could visit the GPULab facilities in Gent, receive training and support, and perform experiments on-site.

This project helped us to achieve our research goals at a time when we could not have access to similar high-performance computing systems. The architecture of the computer allowed us to experiment with high-performance interconnection systems, understand their behaviour and performance impact, and design algorithms that minimise communication overheads during execution. The results of this work have been published in two scientific journals and three conference papers.

We believe that our developments will enable researchers to conduct future large-scale EEG studies with increased statistical power without sacrificing temporal and/or spatial resolution.

The expected direct impact of our work is that EEG processing times will be reduced from hours to minutes, largely increasing research productivity. In addition, various types of analyses on large subject EEG datasets, e.g. the Healthy Brain Network (Child Mind Institute, New York) database that contains measurements from more than 3000 children, will easily become feasible. These fast algorithms can also lay the foundation of new clinical methods or online processing systems that can be used in future patient diagnostic or monitoring applications.

Meet the Team

The research focus of the Bioelectrical Brain Imaging Laboratory of the University of Pannonia (Veszprem, Hungary) is the study of the bioelectrical phenomena of the human brain, and the research and development of novel signal and data processing/analysis methods that may extract more details and/or more accurate information from EEG (electroencephalography) measurement data. Our group is especially interested in the study of brain oscillations, novel methods of EEG signal decompositions, calculation and analysis of dynamic brain connectivity networks, the execution time course of various cognitive tasks as well as in the brain reorganisation after stroke. An important part of this work is the design and development of new computational algorithms and their efficient parallel implementation that help in executing the often very time-consuming analysis processes in a very short time. We use very powerful supercomputers for this task.
The current members of the group are Prof Zoltan Nagy, Dr Zoltan Juhasz, Ms Iffah Syafiqah Suhaili, and Mr Zeyu Wang. Every year, several BSc and MSc students participate in various sub-projects of our group in the form of mini-projects or degree thesis work.

Zoltan Juhasz, Iffah Syafiqah Suhaili and Zeyu Wang participated in the SLICES-SC project.

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