GCAS

GULF COAST ACADEMIC SUPERCOMPUTING

PARALLEL GRANGER CAUSALITY FOR LARGE-SCALE TIME SERIES CAUSALITY ANALYSIS

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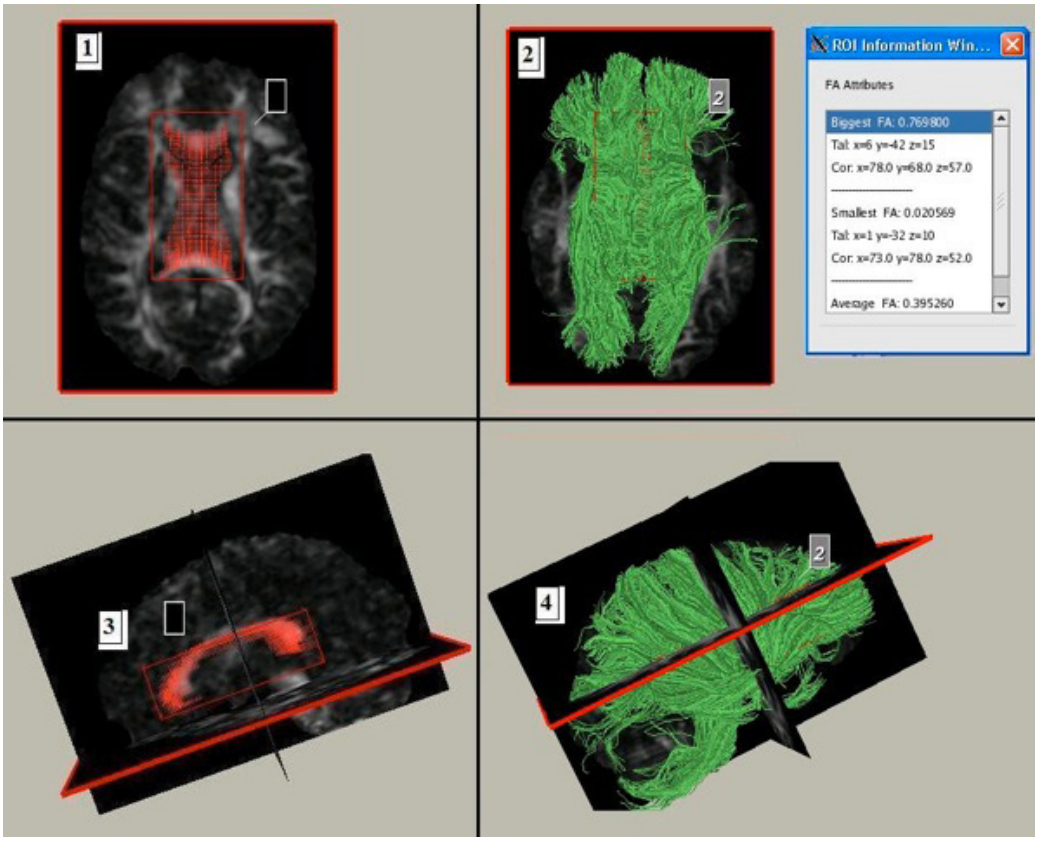

Large scale time series processing is required in many modern signal processing applications, such as functional brain connectivity analysis. Today's brain mapping machines are capable of acquiring neurophysiological electroencephalographic (EEG) signals from hundreds of locations on the scalp with sub-millisecond resolution, thus resulting in enormous amounts of data. In general, to obtain a functional brain connectivity network, the scalp recording locations are considered as nodes on a graph, and the direction of information flow across the various the brain regions is studied using Granger causality methods. The most accurate methods rely on the solution of a large system of multivariate autoregressive models representing the interaction of all nodes simultaneously. Therefore, these methods are very computationally intensive and memory outages prohibit the use of standalone computers when a large number of simultaneously interacting brain locations is considered.

We have ported a naively written version of Granger causality algorithm to one which is scalable to a user-selectable number of processes using OpenMP-style programming. At the same time, Granger causality lends itself to Single Instruction Multiple Data (SIMD)-style parallelization. We have used vendor-optimized LAPACK and parallel ScaLAPACK libraries to exploit these multithreading opportunities in performing linear algebra operations, such as matrix-vector multiplications, matrix inversion, and least squares estimation. Using our multithreaded C and Fortran code, we have been able to estimate Granger causality measures in EEG recordings from up to 256 scalp locations. We have tested the program on the myrinet Atlantis Itanium cluster at the Texas Learning and Computation Center.

We are currently developing an MPI version of the Granger causality algorithm that uses a master-worker paradigm. This will allow us to exploit SIMD-style parallelism in addition to multithreading and can result in considerable overall speedup of the Granger connectivity algorithm.

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