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Parallel Preconditioning in the Analysis of Anisotropic Diffusion Simulation with the Human Brain Diffusion Tensor MRI Data

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We conduct simulations for the 3D unsteady state anisotropic diffusion process in the human brain by discretizing the governing diffusion equation on Cartesian grid and adopting a high performance differential-algebraic equation (DAE) solver, the parallel version of implicit differential-algebraic (IDA) solver, to tackle the resulting large scale system of DAEs. Parallel preconditioning techniques including sparse approximate inverse and banded-block-diagonal preconditioners are used with the GMRES method to accelerate the convergence rate of the iterative solution. We then investigate and compare the efficiency and effectiveness of the two parallel preconditioners. The computational results of the diffusion simulations on a parallel supercomputer show that the sparse approximate inverse preconditioning strategy, which is robust and efficient with good scalability, gives a much better overall performance than the banded-block-diagonal preconditioner.