RICC Usage Report for Fiscal Year 2011

Project Title:

Numerical simulation of electromagnetic wave propagation in human body

Name: Fumie Costen
Laboratory at RIKEN: Bio-research Infrastructure Construction Team,
Advanced Technology Support Division, RIKEN Advanced Science Institute,
RIKEN Wako Institute

Description of the project

Background and research context

The neuro-stimulation is performed in various scenario and cases for a wide range of the illness treatment. One of the examples include the deep brain stimulation. Illness related to the brain such as Parkinson's disease, depression, Altzheimers' illness can be treated by the deep brain stimulation. However, the treatment is severely invasive. In our research group, we are trying to develop a system which can stimulate a part of the brain non-invasively. This may be realized by sending the electomagnetic signals from multiple locations on the skull and focusing the energy inside the brain. However, in order to develop a system, we need to understand the suitable frequency range, location of the excitations and so on. Since we cannot try out such an experiment on humans, we have to perform the numerical simulations with digital human phantom. The human tissues are very small and in order to obtain an appropriate accuracy, we need to have a very fine mesh for modelling human. One of the most appropriate numerical methods for this type of problems is the finite difference time domain method. It is the time domain solution of the Maxwell's equations. However, given the small spatial sampling, the stability condition forces the time step to be unreasonably small. In the end, the explicit FDTD method can take quite long time. On the other hand, implicit schemes can take a larger temporal step. We are working on the improvement of the speed and accuracy of the FDTD method from many aspects such as boundary condition, usage of SSE instruction, MPI and GPU acceleration. Since we have to handle a human in a very small spatial resolution, we need a big computational facility for activities such as algorithm development, accuracy assessment and real numerical experiments for clinicians.

Specific usage status of the system and calculation method.

We have just started using RICC system a couple of weeks ago. Calculation method is the finite difference time domain method. We are currently familiarizing ourselves to RICC system. So we did not perform big calculation. However, in the very near future (i.e. in a couple of weeks time) we would like to start the calculation of the electromagnetic wave propagation in the head and the torso.

Result and perspective for the future

We did not perform any meaningful calculation so far. Some results would be ready within one month with the availablity of RICC system. We are going to perform the calculation using the explicit FDTD method on avery big shared memory architecture and at the same time we calculate the LOD-FDTD method which is one of the implicit methods for the FDTD algorithm. We are going to check the scalability of the LOD-FDTD method and accuracy when the spatial sampling is increased far beyond the CFL stability condition. Then we can produce a journal paper. After that we are going to move our activity to the GPU cluster. We are going to implement the LOD-FDTD method on the GPU cluster.

The usage situation for the extention of our account

As mentioned earlier in this report, we have just started using the RICC system. So we have never run the practical simulations. However we have an immediate plan for the future work and it would involve about 7 days calculation per job in the large memory capacity server and we need to run the similar amount of the total CPU time on Massively Parallel Cluster.

Our concern is the run time limit per job.