Project Title:

Numerical simulation of electromagnetic wave propagation in human body

Name: Fumie Costen
**Laboratory: Bio-research Infrastructure Construction Team,
RIKEN-HYU Collaboration Research Center, Corporate & International Relations Division,
RIKEN Advanced Science Institute, RIKEN Wako Institute**

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 used RICC system this whole year. Calculation method is the finite difference time domain method. Since the finite difference time domain method is the memory and CPU hungry method, we are developing new algorithms and new computational methods. Regarding the new algorithms, we are currently working on the subcell methods in order to reduce the total FDTD cell number without significant reduction in accuracy and also the efficient boundary condition as well as implicit schemes and filtered FDTD schemes. Regarding the computational method, we use OpenMP, MPI and GPU for the speed up.

Result and perspective for the future

We have published an international journal paper using the RICC system. The journal is the most prestigeous in this research field. We are planning to produce more journal papers in the next year (Apr/2013-Mar/2014).

Conclusion

This year was very productive and we deeply appreciate your help. However, in many occasions, we were not able to run jobs due to the restriction of the CPU time per job. We would like to get your help on this aspect in the next year.

Schedule and prospect for the future

Next year we are going to continue working on the same topic, applying OpenMP, MPI and GPU. The usage of the GPU will be increased as one of our target is to publish journal papers on GPU+ FDTD.

Fiscal Year 2012 List of Publications Resulting from the Use of RICC

[Publication]

M. Abalenkovs, F. Costen, J.-P. B´renger, R. Himeno, H. Yokota and M. Fujii, "Huygens Subgridding for 3D Frequency-Dependent Finite-Difference Time-Domain Method", IEEE Transactions on Antennas and Propagation, vol. 60, No.9, pp.4336–4344, DOI 10.1109/TAP.2012.2207039, 2012

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Therefore I felt there was no need to put an acknowledgement.