Usage Report for Fiscal Year 2023

Project Title: Numerical simulation of electomagnetic wave propagation in human body and its application

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1. Background and purpose of the project, relationship of the project with other projects

The neuro-stimulation is performed in various scenarios 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 such a system, we need to understand the suitable frequency range, location of the excitations and so on. Since we cannot try out such experiments on humans, we have to perform the numerical simulations with digital human phantom. The human tissues can be 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 conditions, subgridding, subcell method, usage of SSE instruction, OpenMP,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.

2. Specific usage status of the system and calculation method

Calculation method is the finite difference time domain method and its radar application of the time reversal algorithms for localisation and tracking of the targets behind the walls and the cancers in the human body. 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 uncertainty of the complex permittivity of human tissues depending on the patients and tracking of humans behing the wall as well. Furthermore we applied our skills in handling the digital human phantom to the 3-way classification of the medical images of the brain into the Normal condition (healthy brain), Alzheimers' disease and the intermediate stage called MCI.

3. Result

Unfortunately we do not have any publications using Riken's resources so far in this Fiscal year 2023. We are currently producing a maniscript of the work which used Riken's resources.

４． Conclusion

This year was extremely unsuccessful year due to a couple of severe disruptions caused by the University.

５． Schedule and prospect for the future

When we regain the internet access we would like to use Riken’s facility. As our work is moving toward the use of GPU for machine learning computation we would like to know the charging system for GPU cluster in the new system.

６． If no job was executed, specify the reason.

In June 2022, we lost internet access from our University's computers to external networks. During April- December 2022, our department had to relocate to a new building, which was still under construction and subject to certain restrictive regulations. Despite the efforts of our IT service, we made limited progress in resolving our networking issues in the new facility.

Additionally, in June 2023, our University experienced a cyber attack, causing our IT service to become even more cautious about internet connections. At this point, we are uncertain how long it will take to fully restore our external network access. Prior to the move to the new building, we had access to some of Riken's computational resources, although they were used sparingly in spring,2022

Fiscal Year 2023 List of Publications Resulting from the Use of the supercomputer