# High performance computing techniques for fluid flow simulation

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## Abstract

Vortex method is one of the most efficient mesh less methods in fluid flow simulation. Vortex methods have remarkable advancements in the past decade, but still face numerous challenges, especially high computation cost for 3D vortex method where a large number of particles calculate simultaneously. It is evident from previous studies, that a large number of vortex elements are required for accurate vortex method calculation. In recent studies, a million of particles have been calculated by using parallel computations with the use of hundreds of parallel processors. At the end, it has been demonstrates that, with the present computational resources, vortex method at practical Reynolds numbers are not feasible.

The advent of fast algorithms such as fast multipole method made it possible to achieve a scaling of O(N), and with the help of the rapid development in computational hardware such as a special-purpose computer; MDGRAPE-3, a calculation involving million of vortex elements became possible. The vortex method was recognized as a discretization method rather than an attempt to model vortex dynamics, because the computational power that was necessary to prove these claims became available. Consequently, it was still difficult for vortex methods to be considered as an alternative to conventional methods in computational fluid dynamics.

In the present study, the calculation of vortex method has been accelerated with the simultaneous use of the FMM and MDGRAPE-3 for N=107. This number is not sufficient for accurate vortex method calculation that can be used in real engineering applications. The present results indicate that for the calculation of significant high Reynolds number, the vortex method requires impractically large N, which is possible by using the proposed acceleration method with the use of high-performance supercomputer. To the best of my knowledge, this is the first time that one MDGRAPE-3 board has been successfully used for vortex method calculation other than molecular dynamics (MD) calculation.

My research objective is to develop and test advanced computational methods to support flow simulation and modeling in a number of “targeted challenges” identified in the areas of computational technology and science where I expect to make an impact. The goal is to create a simulation and modeling environment that can be used effectively to investigate challenging technological issues and complex, real-world problems in mechanical engineering and computational fluid mechanics.