A fast method for the calculation of computational fluid dynamics problems

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Abstract

The recent progress of computational fluid dynamics (CFD) is quite challenging especially the numerical analysis of high Reynolds number flows. The vortex methods have been developed and applied for analysis of complicated, unsteady and vortical flows related with problems in a wide range of industries, because of its simple algorithm based on physics of flow.

The calculation cost of vortex methods are relatively high compared to other conventional CFD methods for the case of high Reynolds number flows in complex geometry. The main advantage of this method is that it can be easily applied to flows with complex geometry because of its grid-free characteristic.

There are two ways to reduce calculation cost of this method. One is to use fast algorithms such as the tree code or the fast multipole method (FMM). The other way is to execute with MDGRAPE-3, which is a special-purpose computer, designed for force calculations between point-charge or point-mass particles. It's performance is 100~1000 times higher than general-purpose computers of the same cost.

The present study discusses some numerical techniques on the simultaneous use of the FMM and MDGRAPE-3 to make the impractically expensive calculation feasible without the loss of numerical accuracy.

The scaling of MDGRAPE-3 calculations is of $O(N^2)$, the use of the FMM brings them both down to O(N) where N is the number of interacting particles.