PARALLEL MESH GENERATION FOR CFD SIMULATIONS OF COMPLEX REAL-WORLD AERODYNAMIC PROBLEMS

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Abstract

The primary focus of this project is to design and implement a parallel framework for an unstructured mesh generator based on the advancing front method (AFM). In particular, we target large-scale Computational Fluid Dynamics (CFD) simulations of complex problems.

There are two popular approaches in the literature for parallel mesh generation: (1) those that target shared memory [1] and (2) techniques that employ distributed memory architectures [2, 3]. In the present work, we focus on the distributed memory architecture because of scalability in terms of the problem size. For a complete survey of parallel mesh generation methods, the reader is referred to [4].

The objective of the current work is to modify and implement the parallel framework presented in [2] in conjunction with the unstructured grid generator VGRID [5]. The main contribution is implementation of new techniques to alleviate the known problems of previous works [4]. In particular, we investigate two approaches: (1) improve the quality of the partition faces before generating the volume grid and (2) terminate the volume grid by local remeshing when necessary.

In the first approach, we apply a Laplacian smoothing to the partition interfaces, i.e., the triangular faces shared between adjacent partitions. In our experience, this operation removes artifacts at the interfaces and improves the quality of the boundary mesh. In turn, the improved quality of faces facilitates the sequential advancing-front process for generating tetrahedral volume grids.

In the second approach, we locally remesh voids or "pockets" near the interfaces that VGRID may fail to close. A post-processing utility code called POSTGRID (a component of VGRID) is employed to perform the remeshing step. POSTGRID first removes one or more layers of cells to further open the pockets and then attempts to close them by the AFM. This approach is simple and highly effective and scalable in terminating the volume grid generation process.

In the final paper, we will present a performance evaluation of the method along with detailed data from the parallel mesh generator as well as the computational results from CFD solutions for several aerospace applications. The present approach is based on the discrete domain decomposition for partitioning. This method is utilized in the first phase of the project as a preliminary development step. The future work is geared towards continuous domain decomposition based on an Octree data structure, which is more suited for generating unstructured grids for Navier-Stokes computations.

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