Parallel Unstructured Mesh Generation for Large-Scale Aerodynamics Simulations

Jianjun CHEN*, Yao ZHENG, Jianjing ZHENG, and Dawei ZHAO

Center for Engineering and Scientific Computation,
and School of Aeronautics and Astronautics,
Zhejiang University, P. R. China

*Corresponding author: chenjj@zju.edu.cn

Thanks to the rapid advance of High Performance Computing (HPC) technologies, the powerful parallel machines are now more and more cost-effective. Many aerodynamics simulation codes have been parallelised for many years in the academic and industry communities. Hundreds or thousands of computational cores are employed in the daily industry simulations. However, as one of the major performance bottlenecks of complex aerodynamic simulations, the mesh generation step is usually executed sequentially in these simulations. Although parallel mesh generation has attracted the attentions of many researchers for almost twenty years, the robust codes that can fully parallelise the mesh generation process of complex aerodynamic simulations are still worthy of further investigation to attain a comparable maturity with the parallel simulation codes.

Unstructured meshes are now being vastly applied in aerodynamics simulations. Surface mesh generation, volume mesh generation, and volume mesh improvement are three major steps involved in the preparation of an unstructured mesh model. First of all, we will discuss the parallelisation techniques of the three steps, respectively. Several domain decomposition schemes involved in these techniques are highlighted. The domain decomposition problem regarding the parallelisation of a simulation code is essentially a graph partitioning problem, and can now be solved with vastly available open-sourced tools such as Metis or ParMetis. However, the domain decomposition problem investigated in this study will be more complicated, which involves some specific geometrical and load-balancing issues that have not been fully resolved so far. Meanwhile, great efforts are required to improve the performance of the parallel meshers and improvers in terms of efficiency, reliability and element quality.

Finally, the parallel meshers and the parallel improver will be combined. As a result, a fully parallel preprocessing pipeline is formed, and its effectiveness and efficiency will be demonstrated by the large-scale aerodynamics simulations configured with complex geometries.

Keywords: Mesh generation, Parallel algorithm, Aerodynamics, Domain decomposition