Preface

When I come into contact with more people from industrial departments, the computation fluids dynamics (CFD) technique is found to be a standard tool in the engineering applications to my surprise. In the small-scale department such as air-conditioning/refrigerator manufactures, the CFD software begins to guide the design process. In the nuclear power plant, all kinds of CFD softwares are used to predict every possible accident. The aerospace department also searches for more reliable CFD methods to replace their expensive experiments. But how far should we trust these CFD data? The question is not easy to answer. The real flows are depicted using the Navier–Stokes equations which are strongly nonlinear. The flows contain large to very small scales which seem impossible to capture at the same time. Turbulence models are necessary to adopt to model these small-scale structures' behaviors. More advanced turbulent models such as large eddy simulation require high-order accurate numerical schemes. Some people predict that LES could be applied on engineering flows in 40 years with the current upgrade speed of computers. With high-order schemes, this period might be shorter. Besides, the configurations are always complex for engineering cases, thus unstructured grids are more flexible in the domain decompositions. Combining both these requirements, the high-order methods on unstructured grids seem a better choice to consider these problems. First of all, high-order schemes can capture the small-scale structures in high resolutions. Secondly, unstructured methods can work on complex geometries. Whereas these unstructured high-order methods are difficult to construct, this thesis tries to give some efficient implementations to make the high-order unstructured methods work robustly. I also believe that high-order accuracy is not only the trend for numerical methods, but also the requirement for other scientific investigation tools.

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