RBF-based Interpolation and Its Application in the Flow-structure Interaction

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ABSTRACT

The study on viscous-dominated flow-structure interaction (FSI) now trends towards to be popular by using the modern CFD and CSD technique, that concerns in a board range of applications for ship and ocean engineering. For example, CFD and FEA are coupled to predict the dynamic behaviour of a flexible barge in regular head waves, including the hydroelasticity of a large container ship and the deformation of a thin flat plate in air flows. The particular phenomenon of interest in this paper involves scattered data interpolation on the interface between the solid and liquid by introduction of the radial basis function (RBF) technology. Additionally, the RBF-based interpolation is optimized and improved according to the region decomposition technology and the error estimate of the RBF, which helps to effectively solve the large full-rank matrix connected with the RBF-based interpolation. In this way, a new data-independent RBF interpolation point selection method is developed.

Three typical cases are given by using the global RBF interpolation, the compactly supported RBF interpolation and the partitioned RBF-based interpolation, in which we analyse the bending deformation of the flat plate under the impact of airflow, which is the representative of the FSI problems. By comparison, our developed partitioned RBF-based interpolation shows the global efficiency and accuracy. In particular, the relationship between the error estimate of the RBF and the filling distance of the interpolation domain is well verified. Probably, it provides a new simple approach for data exchange in FSI.

KEY WORDS: the partitioned RBF-based interpolation; domain decomposition; the error estimate of the RBF; data-independent RBF interpolation point; the FSI.

INTRODUCTION

Destructive problems have arisen in many flow-structure interaction phenomena, such as fatigue failure of propellers, failure of elbow erosion, damage to high-rise buildings by strong winds and bridge deformation due to sea waves. These problems seriously threaten product life and building safety. These problems now are widely solved numerically using the partitioned coupling method due to its efficiency. In the partitioned coupling solution, independent fluid and structural modules can be used respectively. It was verified (Su, 2010; Zhang, 2017) that, fluid-solid modules can help to take advantage of the existing CFD and CSD study within this frame, which usually show different spatial-temporal discrete methods. Thus, it is necessary to develop a high-precision and efficient interface transfer algorithm on the interface between the flow field and the structure field.

Theoretically, the FSI data translated methods based on the partition coupling technology are roughly divided into two categories according to the interface fitting method: the interpolation methods based on boundary fitting methods and the interpolation methods based on non-boundary fitting methods. Figure 1 illustrates the boundary fitting methods’ grid configuration, in which the nodes on each grid in FSI analysis could be mapped to the corresponding grid elements. For example, displacement on the solid interface could be mapped to the fluid coupling surface. In the same way, pressure on the fluid interface could be mapped to the solid coupling surface. Based on the interpolation method of boundary fitting method mentioned above, a coupling interface information transfer method needs to be established, which can be divided into local interpolation method and global

![Fig. 1 Schematic of the boundary-fitting coupling interface](image)

1944