Development of a Polygon Wall Boundary Model Considering Corner of Wall and Its Numerical Application to FSI

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ABSTRACT

Fluid–Structure Interaction (FSI) simulation is useful in a wide range of engineering fields. Especially, the partitioned FSI analysis methods combining a mesh free particle method and a Finite Element Method (FEM) are in the spotlight. For coupling fluid analysis by particle method and structure analysis by FEM, transfer of physical variables between fluid domain and structure domain, namely, wall boundary model for particle method is important. Explicit Represented Polygon (ERP) wall boundary model [1] is suitable for FSI because of its mechanical and geometrical consistency. However, the original ERP model has an issue on calculation accuracy near corners of wall since wall is assumed to be completely plane. Therefore, it cannot be applied to semi-implicit particle method due to the local error near corners.

In this research, we develop an improved ERP wall boundary model by considering the corners and introduce the improved ERP model to stabilized Incompressible Smoothed Particle Hydrodynamics (ISPH) method [2]. To consider corners, we extend a definition of reflecting operation for surface polygon in the original ERP model to corners. Besides, volume of a wall domain expressed for a corner is modified using approximate polynomial based on geometric property of corner such as angle. Finally, we apply the ISPH method with the improved ERP model to partitioned FSI analysis method.

As verification and validation, we solve hydrostatic pressure problems and a dam break problem using the stabilized ISPH code with the improved ERP model. Results of the hydrostatic pressure problem show that the improved ERP model can obtain more smoothed and correct distribution of pressure than the previous one. And according to results of the dam break problem, it is confirmed that the solution obtained by the improved ERP model is in better agreement with the experimental result [3] than the previous ERP model. Also, we conduct some FSI simulations, for example, a dam break problem with an elastic obstacle and so on.

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