Numerical modeling of 2D complex movement patterns to FSI problems using Smoothed Particle Hydrodynamics

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Abstract: Understanding dynamic behaviors of natural locomotion, such as aquatic animal swimming and aerial animal flight, is very important for researchers and engineers who wish to develop robotics with good locomotion capability. Aquatic and aerial locomotion generally have high efficiency, high maneuverability and low noise with which no man-made robotics can compare. However, modeling and reproducing natural locomotion using mesh-based numerical schemes, such as finite element method (FEM), finite volume method (FVM) and finite difference method (FDM), are extremely challenged due to the highly mixed patterns including translation, rotation, flexible motion and etc.

This paper presents a study based on weakly compressible smoothed particles hydrodynamics (WCSPH) method, aiming at an available numerical modeling of two-dimensional (2D) complex movement patterns to fluid-solid interaction (FSI) problems. The SPH scheme is first briefly recalled and discussed through its formulations. Then a new technic based on dynamic boundary condition and designed to mimic the arbitrary shapes with complex movement patterns is introduced. Two distinct test cases, including wedge water entry and angularly reciprocating plate, are presented in order to validate this method. It has been found that there is a general agreement between the simulation results and experimental data. Moreover, two novel cases inspired by basilisk lizard locomotion [1] and anguilliform swimming are conducted to show the capacity of the computational model developed here for modeling the complex movement patterns.

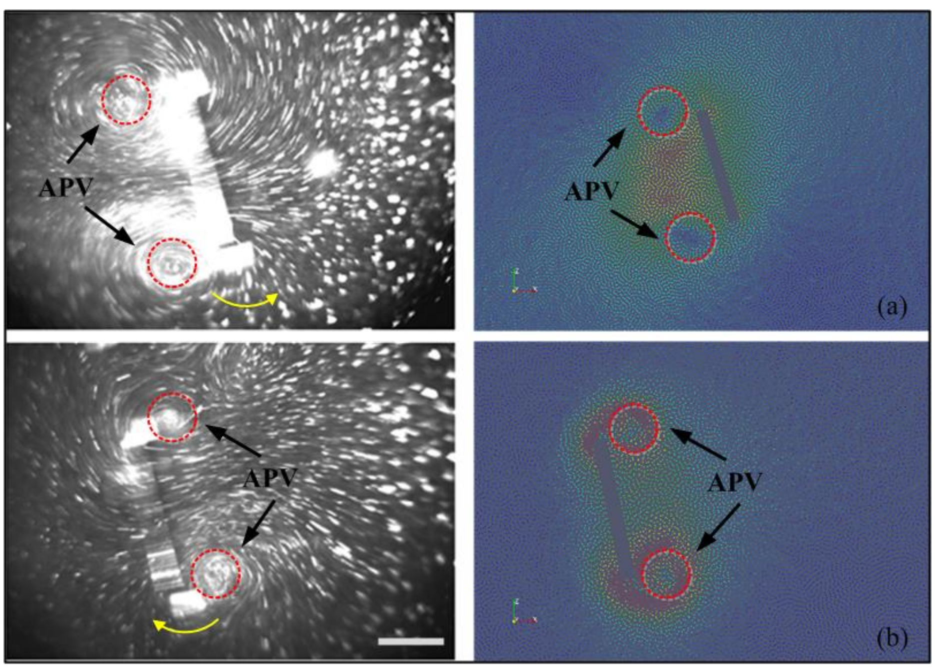

Figure 1: Comparison of flow structure around the angularly reciprocating plate between experimental image by Lee [2] (left) and SPH (right). (a) APV at $\theta = 10°$; (b) APV at $\theta = 5°$. The round arrow indicates the instantaneous direction of flat-plate rotation.

References

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[2] Jeongsu Lee, Yong-Jai Park, Useok Jeong, Kyu-Jin Cho, and Ho-Young Kim. Wake and thrust of an angularly reciprocating plate. *Journal of Fluid Mechanics*, 720:545–557, 2013.