Immersed Boundary Method and Fluid-Structure Interaction Problems Involving Membrane Bodies

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ABSTRACT

Interaction between a flow and a thin membrane can be seen in many circumstances in the real world. From a structural point of view, the thin structure that surrounds a blood cell, a sail wing, the skin of a parachute, an airbag, can all be modelled as a membrane. Solving the fluid-structure interaction problem involving such thin membranes in an internal and/or external flow presents a scientific challenge with a different set of requirements compared to other fluid-structure interaction problems. Because membranes react rapidly to any change in the applied loads, a tighter coupling is required between the fluid and structural solver. Unlike bulky structures, membranes can easily deform into complex geometries and undergo large deformations. Immersed boundary methods [1] are quite popular for dealing with complex geometries undergoing large deformations. However, additional challenges exist in discretising the computational domain of the flow field, accurately imposing velocity boundary conditions, satisfying continuity, and interpolating variables between the fluid and structural solvers. The paper will apply a novel immersed boundary method based on domain decomposition [2] to sail wing geometries that are used in Airborne Wind Energy. The method uses adaptive mesh refinement and optimisation to regenerate the flow mesh and align the elements along the boundary layer. While solving for the flow field, velocity boundary condition is strongly imposed to avoid any flow through the membrane and pressure Poisson's equation is solved in a decomposed sub-domain to ensure mass conservation. Interpolation schemes to exchange variables between the immersed body and the simplified model used in the structural solver will be described.

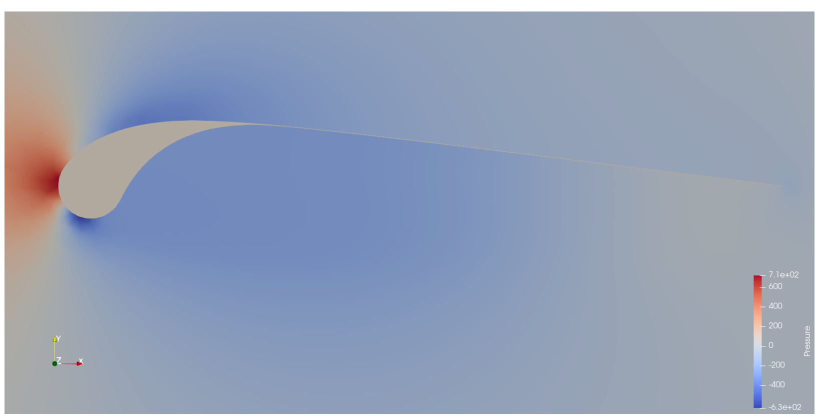

Figure 1: Pressure Poisson's equation is solved in a sub-domain of the computational field to avoid connectivity between suction side and pressure side.

REFERENCES

[1] Mittal, R. and Iaccarino, G. Immersed boundary methods. *Annual Review of Fluid Mechanics* (2005) **37**:239–261.

[2] Krishnan, N., Viré, A., Schmehl, R. and van Bussel, G., An immersed boundary method based on domain decomposition. **under preparation**