# Simulations of Fluid and Rigid Bodies Interaction for Biomechanics Problems


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## ABSTRACT

Computer simulations are able to determine the response of a human anatomy system in different possible scenarios with the great advantage of not being restricted to any ethical implication. They have then a great potential to become a very important tool for a better understanding of human diseases and their corresponding treatments.

Simulations have to provide very accurate results in order to become a reliable tool for decision making in medical treatment or diagnosis. Nevertheless, anatomical human systems commonly involve the interaction of different physics and very complex geometries.

Our work is focused on the simulations of rigid bodies inside laminar and transitional flows where many biomechanics applications can be considered to validate our code, e.g., the behavior of two Bileaflet mechanical heart valves and the focusing of bio-bodies in microchannels.

Accurate results on the solution of biomechanical problems require a number of algorithms that process efficiently a big quantity of data in order to solve the complex human anatomical system. Thus, arriving at a powerful code entails the integration of different algorithmic solutions written to efficiently run in thousands of processors.

The fluid is discretized using a non body-conforming mesh and described in an Eulerian frame of reference. Boundaries of the bodies are embedded in this mesh and geometrically tracked by means of moving polyhedral surface meshes. The force that the fluid exerts on a body is determined from the residual of the momentum equations. Conversely, the velocity of the body is imposed as a boundary condition in the fluid using a high order kriging interpolation [1].

The physics of the fluid is described by the incompressible Navier-Stokes equations. They are stabilized using a variational multiscale finite element method and solved using a fractional step like scheme at the algebraic level. Parallelization is carried out using a master-worker strategy and implemented inside the Alya System [2].

To account for the fact that fluid nodes can become solid nodes and vice versa due to the rigid body movement, we have adopted the FMALE approach [1], which is based on the idea of a virtual movement of the fluid mesh at each time step.

The motion of the rigid bodies is described by the Newton-Euler equations and the contact between them is solved using impulses in order to avoid interpenetrations. Despite all the subdomains simulate the interaction of all bodies and redundant work is done, the implementation is done in such way that each subdomain solves these interactions as fast as possible.


## REFERENCES


[1] C. Samaniego, G. Houzeaux, E. Samaniego, M. Vázquez, Parallel embedded boundary methods for fluid and rigid-body interaction, *Computer Methods in Applied Mechanics and Engineering* (2015) **290**:387-419.

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