Compact quasi Newton coupling algorithm for high performance biomechanical applications

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ABSTRACT

In this work, a high performance version of the interface quasi Newton algorithm (IQN)[1], is presented. This coupling scheme is used to couple staggered fluid-structure interaction (FSI) solvers. Despite its numerical complexity, this algorithm allows to tackle two of the main problems in computational biomechanics: added mass instability[2] and n-field coupling[3].

The cost of solving complex highly detailed geometries of biological systems, like the heartbeat, may ascend to a few million elements. To solve this computational intensive coupled physics problems, an efficient and parallel code is mandatory. The presented novel approach allows to solve such problems in large high performance computing systems.

The components of the IQN algorithm are dismembered and fused to obtain a reduced version, minimizing memory consumption and operations, called *compact* interface quasi Newton.

A scalability test is done showing a similar behaviour to the much simpler Aitken coupling scheme, fact that shows a refined design of the proposed algorithm. Two 3D numerical examples are shown, first a simple academical test with two fluid subdomains and one solid domain with human-like bulk properties. The second numerical example is a fully coupled fluid-electromechanical simulation of the heartbeat.

In conclusion, the designed algorithm is able to tackle both, the added mass and the n-field coupling with ease, and shows good application to biomechanical applications.

REFERENCES

- J. Degroote, K. J. Bathe, and J. Vierendeels, "Performance of a new partitioned procedure versus a monolithic procedure in fluid-structure interaction," *Computers and Structures*, vol. 87, no. 11-12, pp. 793–801, 2009.
- [2] C. Förster, W. A. Wall, and E. Ramm, "Artificial added mass instabilities in sequential staggered coupling of nonlinear structures and incompressible viscous flows," *Computer Methods* in Applied Mechanics and Engineering, vol. 196, no. 7, pp. 1278–1293, 2007.
- [3] M. Mehl, B. Uekermann, H. Bijl, D. Blom, B. Gatzhammer, and A. Van Zuijlen, "Parallel coupling numerics for partitioned fluid-structure interaction simulations," *Computers and Mathematics with Applications*, vol. 71, no. 4, pp. 869–891, 2016.