HIerarchical MODel (HI-MOD) reduction: towards haemodynamics applications

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A hierarchical model (Hi-Mod) reduction provides surrogate models suited to describe phenomena with a dominant dynamics, even though locally featuring relevant transverse components. Istances of such phenomena are the blood flow in arteries, the hydrodynamics in river networks, the gasdynamics in an internal combustion engine.

The driving idea of a Hi-Mod reduction is represented by a different discretization of the dominant and of the transverse dynamics, in the spirit of a separation of variables. In particular, according to the original formulation [1, 2], the mainstream is tackled by affine finite elements, while a modal approximation solves the transverse directions. This approach leads to solve along the principal direction a "psicologically" one-dimensional model, with coefficients automatically including the effect of the transverse dynamics. Moreover, the number of modes can be locally tuned along the mainstream, according to the meaningfulness of the transverse information [3]. The rationale is that relatively few modes are enough to capture the transverse dynamics of interest with an overall reduction of computational costs.

In this presentation, we focus on the most recent advances in the Hi-Mod setting. The reference application is the computational haemodynamics. This goal has led us to apply the Hi-Mod reduction to 3D cylindrical geometries, in case with a curvilinear supporting fiber, by assuming the Stokes equations as first reference model.

Another interesting issue is represented by the generalization of the Hi-Mod procedure to a parameter dependent setting, with a view to an estimation of the parameters involved in the haemodynamics models.

References

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