Surrogate-based acceleration of the coupling of black-box solvers

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\textbf{ABSTRACT}

Fluid-structure interaction (FSI) problems have become widespread in many engineering disciplines, but their solution is still computationally demanding, especially in the case of an incompressible fluid with high added mass. To overcome this challenge, a partitioned approach with two black-box solvers can use a coupling algorithm like IQN-ILS \cite{Degroote2009} or IQN-MVJ \cite{Lindner2015}.

These coupling methods apply quasi-Newton iterations to obtain convergence in every time step, where the Jacobian is a low order approximation based on previous solver evaluations. As such the solvers are treated as a black-box. For many problems however, additional information can be straightforwardly obtained. The source of the prior knowledge is denoted by the general term surrogate model. Examples include solving the problem with coarse grids, reducing the dimensionality of the problem, using results from an analytical calculation and using the solver evaluations from previous time steps. All these surrogates provide an approximation of the intended result, while being considerably cheaper than the original problem.

In this work, the \textit{quasi-Newton method with approximation of the inverse Jacobian from a least-squares model and surrogate model} (IQNI-LS-SM) is presented. The algorithm uses a surrogate model both as predictor for the first iteration and as initial Jacobian, to complement the Jacobian construction from a least-squares model as in the IQN-ILS method. The aim is to reduce the required number of quasi-Newton iterations. Furthermore, it is shown how existing methods fit in this general framework. For example, by using the previous time step as surrogate model for the current one, IQNI-MVJ is obtained.

The performance of IQNI-LS-SM with several surrogate models is evaluated on the propagation of a pressure pulse through an elastic tube, as well as on the steady case of an inflated elastic tube.

\textbf{REFERENCES}
