isogeometric Residual Minimization Method (iGRM)

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We focus first on stationary advection-diffusion problems [1]. We present a stabilized isogeometric analysis method that exploits the Kronecker product structure of the computational problem. The trial spaces in our solution scheme are maximum continuity B-splines. To accelerate the solution of the algebraic scheme, we introduce preconditioner for the conjugate gradients method which has a linear cost. We call our method isogeometric Residual Minimization (iGRM) with direction splitting preconditioner. We verify the accuracy and efficiency of the method on the problem with the manufactured solution, the Eriksson-Johnson problem, and a rotating flow problem. We compare our method to the Discontinuous Petrov-Galerkin (DPG) and the Streamline Upwind Petrov-Galerkin (SUPG) stabilization methods.

Next, we focus on non-stationary advection-diffusion problems [2]. We implement an implicit time integration scheme and apply, for each space-direction, a stabilized mixed method based on residual minimization. We show that the resulting system of linear equations has a Kronecker product structure, which results in a linear computational cost of the direct solver, even using implicit time integration schemes together with the stabilized mixed formulation. We test our method on three advection-diffusion computational examples, including model membrane problem, the circular wind problem, and the simulations modeling pollution propagating from a chimney. We compare the numerical accuracy and the order of the time integration scheme, for Backward-Euler, Crank-Nicolson, Peaceman-Rachford, and Strang schemes.

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[1] M. Los, Q.Deng, I. Muga, V.M.Calo, M. Paszynski, Isogeometric Residual Minimization Method (iGRM) with Direction Splitting Preconditoner for Stationary Advection-Diffusion Problems, submitted to Computer Methods in Applied Mechanics and Engineering (2019)

[2] M. Los, J. Munoz-Matute, I. Muga, M. Paszynski, Isogeometric Residual Minimization Method (iGRM) with Direction Splitting for Non-Stationary Advection-Diffusion Problems, Computers and Mathematics with Applications (2019) doi.org/10.1016/j.camwa.2019.06.023