A ϕ-FEM approach for time-dependent domains with unfitted meshes

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In this work, we propose an unfitted finite element scheme to approximate the solution of the heat equation on moving domains. We use the φ-FEM paradigm in which the computational domain is described implicitly by a level-set function φ. This function is incorporated into the variational formulation in order to ensure the boundary conditions, which allows the use of unfitted meshes in space. Such a strategy avoids the need for remeshing at each time step and makes it possible to handle complex geometrical evolutions. We introduce a fully discrete scheme that combines the φ-FEM spatial discretization with a standard discontinuous finite element method in time. Under suitable mesh regularity assumptions, we establish a priori error estimates in classical norms. Finally, we present several numerical experiments that confirm the theoretical convergence results and illustrate the robustness and accuracy of the proposed method.

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