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Numerical approximation of mixed dimensional partial differential equations

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Numerical approximation of mixed dimensional partial differential equations

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Abstract

In this thesis, we explore numerical approximation of elliptic partial differential equations posed on domains with a high number of interfaces running through. The finite element method is a well-studied numerical method to solve partial differential equations, but requires alterations to handle interfaces. This can result in either unfitted or fitted methods. In this thesis, our focus lies on fitted methods.

From finite element methods, one obtains large linear systems that need to be solved, either directly or via an iterative method. We discuss an iterative method, which converges faster when using a preconditioner on the linear system. The preconditioner that we utilise is based on domain decomposition.

In Paper I, we consider this kind of partial differential equation posed on a domain with interfaces, and show existence and uniqueness of a solution. We state and prove a regularity result in two dimensions. Further, we propose a fitted finite element approximation and derive error estimates to show convergence. We also present a preconditioner based on domain decomposition that we use together with an iterative method, and analyse the convergence. Finally, we perform numerical experiments that confirm the theoretical findings.

Keywords: Finite element method, mixed dimensional partial differential equation, a priori error analysis, subspace decomposition, preconditioner.