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THE AGGREGATED UNFITTED FINITE ELEMENT METHOD FOR ELLIPTIC PROBLEMS

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ABSTRACT. Unfitted finite element techniques are valuable tools in different applications where the generation of body-fitted meshes is difficult. However, these techniques are prone to severe ill conditioning problems that obstruct the efficient use of iterative Krylov methods and, in consequence, hinders the practical usage of unfitted methods for realistic large scale applications. In this work, we present a technique that addresses such conditioning problems by constructing enhanced finite element spaces based on a cell aggregation technique. The presented method, called *aggregated unfitted finite element method*, is easy to implement, and can be used, in contrast to previous works, in Galerkin approximations of coercive problems with conforming Lagrangian finite element spaces. The mathematical analysis of the method states that the condition number of the resulting linear system matrix scales as in standard finite elements for body-fitted meshes, without being affected by small cut cells, and that the method leads to the optimal finite element convergence order. These theoretical results are confirmed with 2D and 3D numerical experiments.

Keywords: unfitted finite elements; embedded boundary methods; ill-conditioning.

CONTENTS

1. INTRODUCTION

Unfitted FE techniques are specially appealing when the generation of *body-fitted* meshes is difficult. They are helpful in a number of contexts including multi-phase and multi-physics applications with moving interfaces (e.g., fracture mechanics, fluid-structure interaction [1], or free surface flows), or in situations in which one wants to avoid the generation of body-fitted meshes to simplify as far as possible the pre-processing steps (e.g., shape or topology optimization frameworks, medical simulations based on CT-scan

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