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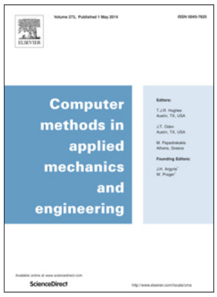

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Variational Multiscale error estimators for solid mechanics adaptive simulations: an Orthogonal Subgrid Scale approach

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Abstract

In this work we present a general error estimator for the finite element solution of solid mechanics problems based on the Variational Multiscale method. The main idea is to consider a rich model for the subgrid scales as an error estimator. The subscales are considered to belong to a space orthogonal to the finite element space (Orthogonal Subgrid Scales) and we take into account their contribution both in the element interiors and on the element boundaries (Subscales on the Element Boundaries). A simple analysis shows that the upper bound for the obtained error estimator is sharper than in other error estimators based on the Variational Multiscale Method. Numerical examples show that the proposed error estimator is an accurate approximation for the energy norm error and can be used both in simple linear constitutive models and in more complex non-linear cases.

1 Introduction

In the general solution of computational solid mechanics problems using finite element approximations, many times one faces situations where it is convenient to focus the computational effort in certain subdomains of interest. This is the case for instance when simulating fracture processes, where very large deformation gradients are concentrated along fracture lines. If the position and orientation of fracture lines are known a priori, a suitably refined computational mesh can be built beforehand.

However, in most engineering cases of interest the location of such failure lines is precisely part of the information that one expects to obtain from a computational simulation. As a consequence, the information required to build such meshes is not known a priori. In this case one faces with the need of either building extremely fine computational meshes capable of appropriately capturing the details of the solution no matter where these appear, or running successive simulations with different computational meshes which are progressively built as more information is available.

Adaptive mesh refinement (AMR) techniques [1, 2, 3] appear precisely to deal with simulations where the refinement requirements are not known a priori. AMR consists in introducing local modifications in the computational mesh in such a way that the computational effort for attaining a certain error level is minimized. Or, equivalently, adaptive strategies allow one to maximize the accuracy of the obtained solution for a given computational cost.

There are two main ingredients which are involved in an AMR simulation: the first one is the actual mesh refinement algorithm, which allows one to increase the accuracy of the