Coupled Multiscale Virtual Element methods for analysis of heterogeneous porous media

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ABSTRACT

The solution of coupled problems in porous media such as consolidation and vibro-acoustics often necessitates the use of computationally intensive numerical models. This is driven by the requirement to account for highly heterogeneous material parameters, which require very fine mesh discretizations to be accurately captured.

The Coupling Multiscale Finite Element Method (CMsFEM) [1] is an upscaling technique used to reduce computational costs by appropriately resolving heterogeneities at their corresponding meso scale; solution of the governing equations is then performed at a coarse scale hence decreasing computational costs. Traditional element geometries like quadrilateral (2D) and hexahedral (3D) elements are employed to mesh the coarse and fine scales. However, more complex domains, e.g. the irregular geometry of inclusions in elastomer/ metallic foam bi-materials, require more flexible mesh generation capabilities. The Virtual Element Method (VEM) [2] is a Generalized Finite Element Method extended to accommodate more complicated element geometries and/or higher-order inter-element continuity within its framework. The stiffness matrices are evaluated only through appropriately chosen degrees of freedom and spaces. There is no explicit definition of basis functions.

In this work, we apply the VEM to the CMsFEM for the analysis of heterogeneous poroelastic media to obtain a novel Coupled Multiscale Virtual Element Method (CMsVEM). The resulting computational scheme naturally allows for generalized polygonal and non-convex elements at the fine scale. The accuracy and performance of the method is evaluated through a set of numerical benchmarks using an in-house MATLAB code.

REFERENCES

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