MULTISCALE WAVELET-BASED HOMOGENIZATION OF HETEROGENEOUS MEDIA

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In some physical problems we wish to resolve both coarse and fine scale solutions, or to obtain reliable solution at a specific length scale. For example, the understanding of how microstructure evolution and microscale defects affect the continuum behavior of materials requires sufficiently detail information at various scales. Standard homogenization of highly heterogeneous media often filters out the fine scale information, and as a consequence, it produces acceptable results only for certain type of periodic structures.

In this work, a wavelet-based multiscale homogenization is introduced for highly heterogeneous materials where the standard asymptotic technique can't be effectively applied. A set of scaling and wavelet functions based on the linear hat function and its corresponding wavelet transformation are constructed. The advantages of this wavelet transformation constructed by hat function compared to that formulated using Haar function are identified. One of the advantages of using scaling functions and wavelets based on linear hat function over Haar functions is due to the fact that it can be utilized as shape functions in the wavelet Galerkin method with integration by parts to yield a symmetric system. However, due to the translations of scaling functions, the dependency of shape functions in this method renders a singular stiffness matrix if the integration by parts is invoked to assemble the stiffness matrix. This problem is resolved by means of an eigenvalue shifting technique. The resulting modified wavelet Galerkin method is applied to wavelet-based multiscale homogenization. This wavelet based multiscale homogenization allows a hierarchical filtering of the high scale components of the solution, and thus provides an effective framework for the multiscale selection of the most essential scales of the solution.