PROBABILISTIC FORMULATION OF SCALE-COUPLING AND UNCERTAINTY PROPAGATION IN GF-BASED MULTISCALE MODEL

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In multiscale methods, the scale-coupling condition, which relates the discrete microscale quantity with the continuous macroscale quantity, often introduces certain heuristics regarding information exchange. In hierarchical methods, up-scaling is realized by embedding the microscale mechanics into the macroscale simulation [1]; the macroscale constitutive law is constructed in terms of locally averaged quantities. In concurrent methods, periodic boundary assumption is made in the transition region [1]. The modeling error introduced by such assumptions is hard to quantify and the propagation of uncertainty due to the associated information loss cannot be traced.

In this presentation, recently developed uncertainty quantification (UQ) techniques are used to compliment the Green's function (GF)-based multiscale model in order to study the significance and the propagation of uncertainty due to information loss in up-scaling. The information containing the deterministic, high-frequency fluctuation in the microscale region is passed into the macroscale region through its quasi-static variable with uncertainty. The fluctuation that can be resolved by long wavelengths is represented by the mean of the variable; the information carried with the higher-frequency fluctuation, such as the extreme value and the volatility, is transformed into the probabilistic description of the variable. Thus the significance of the unresolved fluctuation can be evaluated by the uncertainty n the variable. The propagation of this uncertainty can be carried out by solving the macroscale domain problem with the random variable as its parameter.

The usual GF-based multiscale model [2] is first introduced together with recent developments in UQ analysis. The formulation of the new stochastic GF-based multiscale model is presented. To demonstrate the usage, a wave propagation problem is considered within a semi-infinite continuum/semi-infinite crystal coupled system. The significance and the propagation of uncertainty is studied with respect to the angular frequency of vibration source. The result is compared to that of the full-size microscale simulation and the usual GF-based multiscale model. Future research plan and potential application will also be discussed.

References

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