

SURROGATE COMPUTATIONAL HOMOGENIZATION FOR INELASTIC COMPOSITES AND ROOM FOR QUANTUM ACCELERATION STRATEGIES

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ABSTRACT

We have recently proposed a class of data-centric methods for computational homogenization (CH) using radial basis function (RBF) interpolation, which substitutes for the microscopic analysis for inelastic composites at small-strain and finite-strain [1,2,3]. This approach, which is referred to as RBF-based surrogate CM, has been applied to elastoplastic composite materials at small strain [1] and finite strain [2], and viscoelastic composite materials [3] to demonstrate the capability in overcoming the difficulty of conventional multiscale analysis methods. However, the computational cost of the process of obtaining the weights of RBFs by solving linear equations with the kernel matrix as coefficients is high, and this approach has been applied only to two-dimensional (2D) problems. To address the problem that comes from the sheer volume of data, in this study, various measures can be taken to extend the RBF-based surrogate CH to 3D problems from a practical perspective. For example, a limited number of combinations of the six components of macroscopic strain are randomly selected on the hypersphere to perform numerical material tests to generate a set of macroscopic stresses and macroscopic strain histories. After that, the procedure should be the same as the one we have developed so far. The present study particularly focusses on a partitioned RBF interpolation with the help of decision-tree-based partitioning of the data space. Optimizing the partitioning of the hyperspace, consisting of macrostrain and history-dependent variables in the input data, allows for low-cost and efficient RBF interpolation approximation. Several numerical examples are presented to demonstrate the promise and performance of the proposed method. The RBF-based surrogate model thus created can be applied to several engineering problems. For example, its convenience can be used for topology optimization, and we will also briefly discuss its potential for combination with quantum algorithms for nonlinear multiscale analysis.

REFERENCES

- [1] Yamanaka, Y., Matsubara, S., Hirayama, N., Moriguchi, S., Terada, K., *Comput. Methods Appl. Mech. Engrg.* 415, 116282, 2023
- [2] Nakamura, A., Yamanaka, Y., Nomura, R., Moriguchi, S., Terada, K., *Comput. Methods Appl. Mech. Engrg.* 436, , 117708, 2025
- [3] Yamanaka, Y., Hirayama, N., Terada, K., *Internat. J. Numer. Meths. Engrg.* 126, 2025, e70008