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Tensor Empirical Interpolation Method for multivariate functions

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Several problems of practical interest in physical, chemical, biological or mathematical applications naturally lead to multivariate approximation problems. Such problems are often composed of multiple simpler systems and models. Therefore, in order to better understand the behavior and properties of multidimensional models, tensor-based modeling is a natural choice in these cases. We thus derive a Tensor Empirical Interpolation Method (TEIM) for multivariate functions. This method relies on the classical Empirical Interpolation Method (EIM) where the greedy procedure is used to compute the interpolation points and the basis functions "direction-by-direction". The algorithm returns interpolation functions that directly fulfill the Lagrange property. The TEIM provides an approximate representation of a given function f in separate form. As any tensor decomposition procedure, the TEIM leads to a computational complexity for highly multivariate functions. We then propose two strategies to reduce the complexity due to the use of the TEIM. The first one is the mixed EIM-SVD tensor decomposition. It consists in applying the Singular Value Decomposition (SVD) with low-rank truncation to the separate form of f resulting from the TEIM decomposition. As a second strategy, we develop an interpolation method by sparse collocation point set. This method is also based on EIM greedy procedure and it returns basis functions that satisfy the Lagrange property. Error estimates of the developed TEIM, the truncated SVD decomposition and the sparse collocation interpolation are derived. To validate the performance of the proposed algorithms, several numerical experiments are proposed. The three different algorithms are applied to a regular and a non-regular functions and then the TEIM is applied to a five variables regular function. Numerical experiments confirm that each of the three methods has a very good behavior in terms of stability and accuracy.

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