A ResNet-based isosurface learning method for dimensionality reduction in high-dimensional function approximation

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Abstract

We developed a ResNet-based iso-surface learning method for dimensionality reduction in high-dimensional function approximation. Existing linear methods, including sliced inverse regression, active subspace methods, reduce the dimensionality by imposing a ridge function structure and learning an affine/linear transformation; and our contribution is to extend such transformation to the nonlinear regime. Specifically, we defined a nonlinear transformation using one type of reversible ResNets, and trained the ResNets to approximately parameterize the target function's iso-surfaces in low-dimensional parameter spaces, so as to greatly increase the anisotropy of the transformed function. A new loss function was designed for training the ResNets, such that the trained transformation can approximately capture the nonlinearity of the iso-surface. The effectiveness of our approach is demonstrated by applying it to three two-dimensional functions for illustrating the nonlinearity of the transformation, as well as to several twenty-dimensional functions for showing the improved approximation accuracy with the use of the nonlinear transformation.