
NICK DEXTER, Simon Fraser University

Improving efficiency of deep learning approaches for scientific machine learning

Sparse reconstruction techniques from compressed sensing have been successfully applied to many application areas, including signal processing, inverse problems in imaging, and approximation of solutions to parameterized partial differential equations (PDE). Such approaches are capable of exploiting the sparsity of the signal to achieve highly accurate approximations with minimal sample complexity. For problems whose solutions possess a great deal of structure, their recovery properties can be further enhanced through a combination of carefully selected weighting or structured sampling schemes. Recently connections between compressed sensing and deep learning have been explored, and the existence of deep neural network (DNN) architectures which achieve the same sample complexity and accuracy as compressed sensing on function approximation problems has been established. In this work, we further explore these connections and sparse neural network approximation in the context of high-dimensional parameterized PDE problems. We provide a full error analysis for such problems, explicitly accounting for the errors of best approximation (describing DNN expressibility), spatial discretization of the PDE, and the algorithm used in solving the underlying optimization problem. We complement our theoretical contributions with detailed numerical experiments, demonstrating the potential for sparse neural network approximation in scientific machine learning contexts.