数据科学与深度学习
博士生与青年学者论坛

Neural Sparse Approximation for Functional Learning



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Abstract: Learning nonlinear functionals defined on infinite-dimensional function spaces is a fundamental problem in approximation theory and operator learning. Traditional approaches often rely on linear feature representations which may suffer from the curse of dimensionality. In this talk, we present a sparse-aware neural approximation framework that exploits the feature extraction capabilities of convolutional neural networks (CNNs). We first establish a theoretical connection between CNNs and sparse coding, providing stability guarantees and exponential convergence rates for sparse feature recovery. Building on these results, we develop an encoder–decoder architecture in which a CNN extracts sparse representations from finitely sampled input functions, while a deep neural network approximates the target nonlinear functional. Our analysis establishes approximation error bounds governed by the sparsity of the extracted features rather than the full dimension of the underlying dictionary. We further show that random sampling is sufficient for stable sparse recovery under suitable conditions. For function classes with rapidly decaying coefficients or mixed smoothness, the resulting approximation rates substantially overcome the curse of dimensionality.

个人简介:冯寒，香港城市大学副教授。2011年本科毕业于北京师范大学应用数学专业，2016年于加拿大阿尔伯塔大学获数学博士学位，随后赴美国俄勒冈大学从事博士后研究。2018年加入香港城市大学。主要研究方向为深度神经网络的数学理论，重点关注深度神经网络的逼近理论、卷积神经网络的特征提取与分类误差分析等。相关研究成果发表于 IEEE Transactions on Neural Networks and Learning Systems、Neural Networks、Analysis and Applications、SIAM Journal on Imaging Sciences、Neural Computation 以及 AAAI 等国际期刊和会议。