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Linear Operator Learning Using GreenONets and a Multi-Level Neural Network Approach

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The solution of boundary-value problems using deep learning approaches, such as physics-informed neural networks [Raissi et al., JCP, 2019] or deep operator networks [Lu et al., NMI, 2021], has been extensively investigated in recent years. However, achieving high accuracy in the approximations obtained from these methods often remains a significant challenge. A multi-level neural network approach was proposed in [Aldirany et al., CMAME, 2024] that allows one to iteratively reduce the errors, sometimes within machine precision, when approximating a solution using PINNs. In this work, we extend the multi-level approach to approximate linear operators using Green operator networks (GreenONets) as described in [Aldirany et al., CMA, 2024]. Starting with an initial approximation of the operator, we correct the solution by considering a different Green operator network involving higher frequencies. The method enables one to iteratively reduce the high-frequency component of the residuals. Numerical examples will be presented to demonstrate the efficiency of the proposed multi-level approach.