(Machine) Learning to differentiate

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Abstract

Artificial neural networks together with associated computational libraries provide a powerful framework for constructing both classification and regression algorithms. In this paper we use neural networks to design linear and non-linear discrete differential operators. We show that neural network based operators can be used to construct stable discretizations of initial boundary-value problems by ensuring that the operators satisfy a discrete analogue of integration-by-parts known as summation-by-parts. Furthermore we demonstrate the benefits of building the summation-by-parts property into the network by weight restriction, rather than enforcing it through a regularizer. We conclude that, if possible, known structural elements of an operation are best implemented as innate—rather than learned—properties of the network. The strategy developed in this work also opens the door for constructing stable differential operators on general meshes.