OPERATOR APPROXIMATION FOR FAST WAVEFIELD COMPUTATION

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ABSTRACT

Significant attention is shifting towards the capability of neural networks to approximate operators i.e. maps between spaces of functions. Many mathematical models of geophysical processes can be expressed in operator notation as $g(m) = d$. Approximate neural operators could learn mappings from arbitrary m to the associated d. An accurate network of this type could significantly increase the computational speed of many geophysical workflows. In this paper, we focus on the recently proposed Fourier Neural operator and its application to the acoustic frequency domain wave equation (Helmholtz equation). The goal of this work is to obtain solutions u to the Helmholtz equation for arbitrary wavespeed models c. We investigate three methods of generating training data for this network: intravolume, extravolume, and generation by sine basis functions. For each generated dataset, we solve the Helmholtz equation and learn the mapping from c to u in a data driven manner. We achieve relative errors of 0.067, 0.4238, and 0.2028 for each training data set respectively. This motivates large scale training in future work.

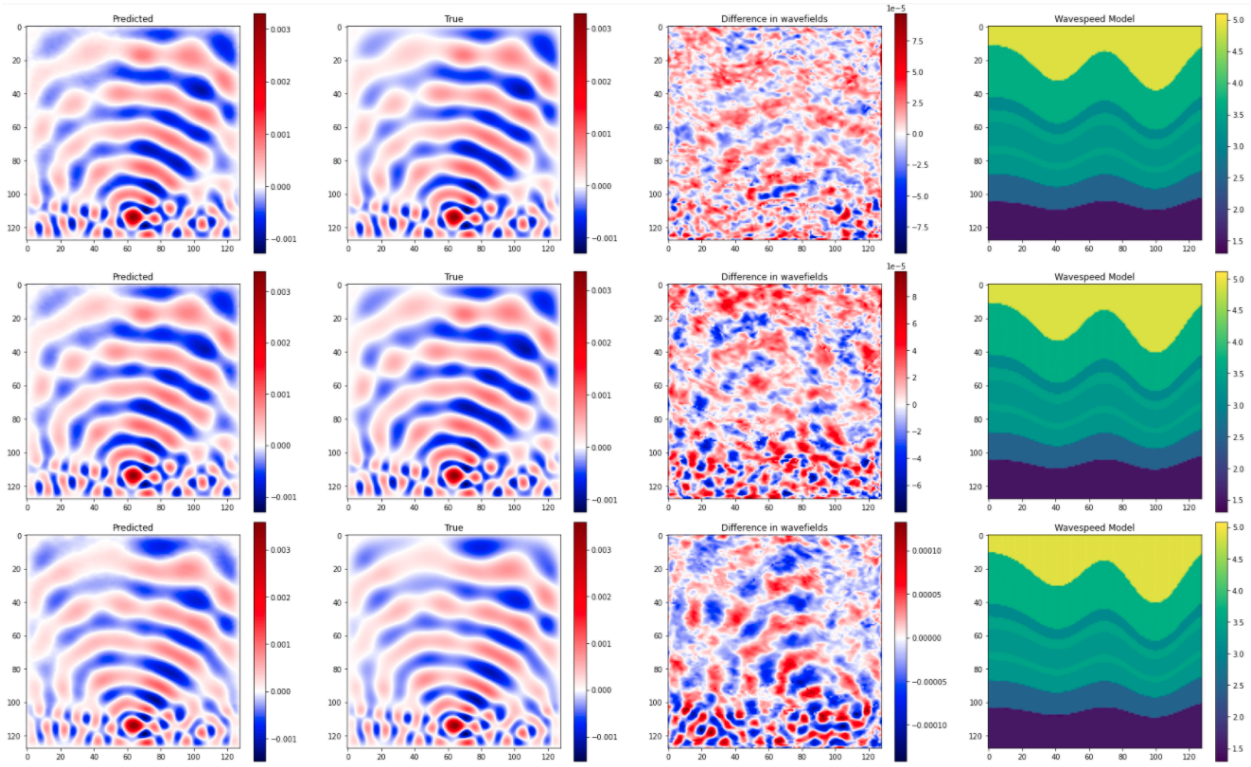

Figure 1. Results from training the Fourier Neural Operator network on 20Hz wavefields from intravolume wavespeed models. Column 1: Predicted Wavefield. Column 2: True wavefield as computed by the finite element method. Column 3: Difference between the true and predicted wavefield. Column 4: Wavespeed model.