



Neural Network Radiative Transfer for Imaging Spectroscopy

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Abstract. Visible/Shortwave InfraRed imaging spectroscopy provides valuable remote measurements of Earth's surface and atmospheric properties. These measurements generally rely on inversions of computationally-intensive Radiative Transfer Models (RTMs). RTMs' computational expense makes them difficult to use with high volume imaging spectrometers, and forces approximations such as lookup table interpolation and surface/atmosphere decoupling. These compromises limit the accuracy and flexibility of the remote retrieval; dramatic speed improvements in radiative transfer models could significantly improve the utility and interpretability of remote spectroscopy for Earth science. This study demonstrates that nonparametric function approximation with neural networks can replicate radiative transfer calculations over a relevant range of surface/atmosphere parameters. Incorporating physical knowledge into the network structure provides improved interpretability and model efficiency. We evaluate the approach in atmospheric correction of data from the PRISM airborne imaging spectrometer, and demonstrate accurate emulation of radiative transfer calculations which run several orders of magnitude faster than first-principles models. These results are particularly amenable to iterative spectrum fitting approaches, providing analytical benefits including statistically rigorous treatment of uncertainty and the potential to recover information on spectrally-broad signals.

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1 Introduction

Remote Visible / ShortWave InfraRed (V/SWIR) imaging spectroscopy, also known as hyperspectral imaging, is a powerful approach to map the composition, health, and biodiversity of Earth's ecosystems (ESAS, 2018). Remote sensing of the solar-reflected spectrum from 380-2500nm reveals physics and chemistry of many processes in Earth's surface/atmosphere system (Schaeppman et al., 2009), including: terrestrial plant health and traits (Asner et al., 2017; Ustin et al., 2004); biodiversity (Jetz et al., 2016); the condition and composition of aquatic, benthic, and near-shore ecosystems (Fichot et al., 2015; Hochberg, 2011); geology (Swayze et al., 2014); and trace greenhouse gases (Frankenberg et al., 2016). While Earth scientists aim to measure these geophysical variables, remote sensors can only measure the incident light at the sensor. Inferring geophysical

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