Emulation of Transient Electrodynamic Physics via Deep Neural Networks

Oameed Noakoasteen, Shu Wang, and Zhen Peng
Electrical and Computer Engineering Department, University of New Mexico
Albuquerque, NM 87131-0001, USA
e-mail: oameednkn@unm.edu; shuwang12@unm.edu; pengz@unm.edu

Machine learning with big data has been recognized as one of the key driving forces for the fourth Industrial Revolution. The research objective of this work is to investigate new computational methodologies that utilize large databases obtained from simulations and measurements in order to develop predictive physical models. New fundamental knowledge will be generated by answering the following questions: (1) Is it possible to obtain predictive models from the available simulation and measurement data? (2) What are the domain-specific machine learning algorithms required to convert various datasets to modeling knowledge? (3) Once the modeling knowledge has been learned, how to seamlessly incorporate it into a data-driven predictive environment?

In the presentation, we will present our recent progress on the emulation of transient electrodynamic physics using artificial neural network (ANN). We demonstrate that ANN surrogates can be developed, by training on finite number of simulation samples, to augment traditional time domain solvers and to reduce computational costs (in terms of time and memory). The typical transient solvers discretize the computational domain in both space (as a regular grid) and time in which electromagnetic quantities of interest (E, H) are updated at each time step according to time-evolution formulas. It is worth noting that the outputs of time domain method can be considered as a series of data sets. We leverage the deep neural network to process series of data. The specific neural network being considered for this study is a recurrent neural network (RNN) and convolutional autoencoder, which recursively update its state (hidden layer) to generate consecutive time steps of wave propagation. Through the training of a sufficiently large number of simple problems, a new model problem can be solve rapidly with a high probability of correct response.