A Fourier Series-Based Neural Network Model to Predict Especially Fluctuating Data

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Machine learning is the study and design of algorithms that allow computer systems to perform tasks without explicit human instructions. Several of these algorithms are based on network-like structures called artificial neural networks. The purpose of my project was to analyze the performance of a Fourier series-based neural network, especially for data that tend to fluctuate. Fourier series can model any square-integrable function, and by the definition of a limit, their partial sums make good approximations. Because of this, I hypothesized that a neural network behaving as the partial sum of a Fourier series could perform better, with fewer necessary nodes, than other models for fluctuating data. To test my hypothesis, I simulated many datasets of fluctuating data and used the data to train several randomly initialized copies of my Fourier series-based neural network and other neural network models. After training the simulated data, I downloaded and tested several large publicly available datasets including pollution, seismic, respiratory, and ECG heartbeat data. Loss and accuracy data were collected and statistical tests were performed. Results show that for large datasets, both simulated and real, my model typically performed as well or better than other models ($p < 0.01$), but for small datasets, my model performed worse. While predicting heart problems using ECG data, a recurrent form of my model performed better than other recurrent neural networks. For other real datasets I have not yet tested recurrent models, and all tested networks performed badly and about equally. Prior research on Fourier neural networks was largely theoretical and was only used to model specific applications, whereas my model was tested on a variety of different data.

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