046211 - Deep Learning - Project Proposal Template

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Project Name: Time Series Prediction using RNNs

Short Description/Plan:

The goal of this project is to compare various recurrent neural networks (RNNs) for prediction of dynamic and chaotic time series data. RNNs like long short-term memory (LSTM), gated recurrent unit (GRU) and transformers will be compared with each other and with a novel RNN method called reservoir computing[1]. Python toolboxes like PyTorch and NumPy will be used to build the RNNs. Benchmark datasets like Lorentz-63, Mackey-Glass time series along with other temporal data like weather and EEG and ECG data will be used. The training will be supervised and the network must be able to predict the trajectory of the time-series without knowing model.

As a simple example, consider the following equation,

$$y(k) = 0.4y(k-1) + 0.4y(k-1)y(k-2) + 0.6u^3(k) + 0.1$$

Here, $y(k)$ is the output and $u(k)$ is the input sequence.

The goal is to train the network to be able to predict $y(k)$ given $u(k)$ without knowing the original relationship between $y(k)$ and $u(k)$ [2].

A challenge that will be encountered in building the reservoir computing system is that standard machine learning toolboxes like PyTorch do not directly support reservoir computing and its variants. In order to overcome this, an existing implementation from a paper will be used [1][4].

Available Resources:

[1]   D. J. Gauthier, E. Bollt, A. Griffith, and W. A. S. Barbosa, "Next generation reservoir computing," *Nat Commun*, vol. 12, no. 1, Dec. 2021, doi: 10.1038/s41467-021-25801-2.

[2]   C. Du, F. Cai, M. A. Zidan, W. Ma, S. H. Lee, and W. D. Lu, "Reservoir computing using dynamic memristors for temporal information processing," *Nat Commun*, vol. 8, no. 1, 2017, doi: 10.1038/s41467-017-02337-y.

[3]   S. Shahi, F. H. Fenton, and E. M. Cherry, "Prediction of chaotic time series using recurrent neural networks and reservoir computing techniques: A comparative study," *Machine Learning with Applications*, vol. 8, p. 100300, Jun. 2022, doi: 10.1016/j.mlwa.2022.100300.

[4]   https://github.com/quantinfo/ng-rc-paper-code

Does your project build upon previous projects?

In prior works, various traditional RNNs have been compared with reservoir computing as in [3]. However, the transformer architecture has not been included in this comparison which will be explored in this project.