Neural Networks
- Homework 9 -

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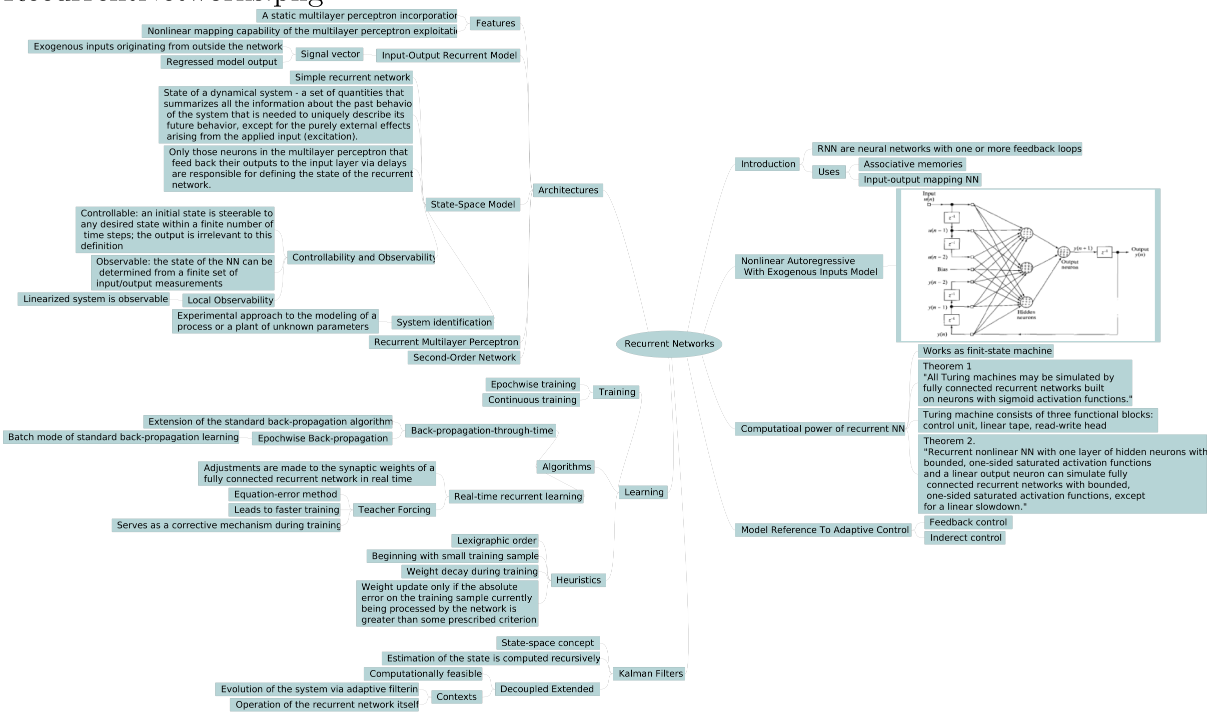
1 Mind map

Figure 1: Mind map. Chapter 15 from Haykin's book. A zoomed version is attached as RecurrentNetworks.png



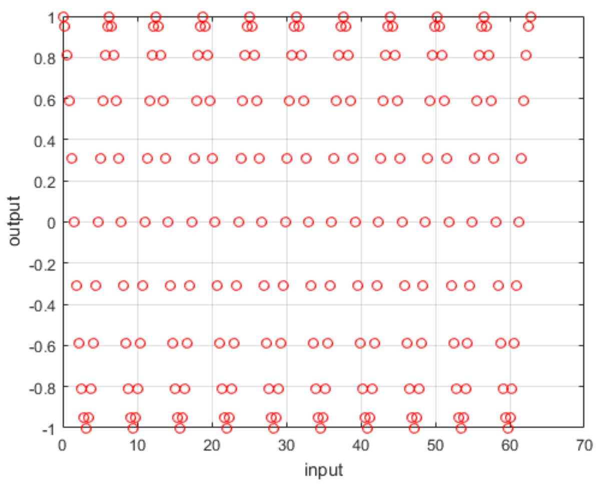
2 Exercises

Train an ESN:
Acquaint yourselves with the MATLAB based Reservoir Computing Toolbox v2.0 (RCT) or with Python version of RCT or use PGPs own ESN generic MATLAB. implementation (see folder Echo State Networks (Part1 + Part2)).
Using one of these tools suite do the following:

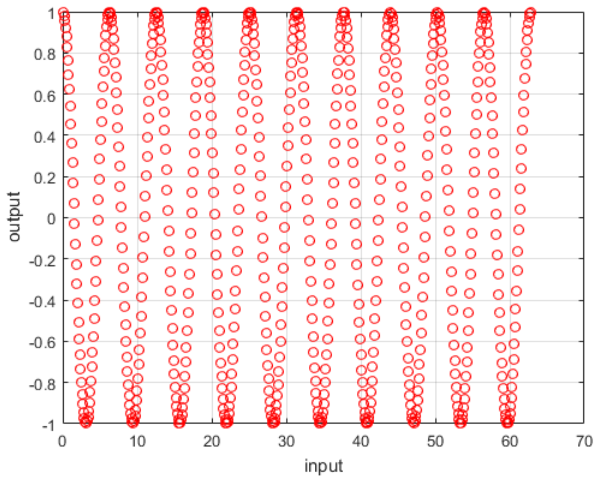
- Sample the function $\cos(x)$ function for ten full cycles with 20 data points per cycle;
- get a data vector;
- choose one supported off-line training method (for analog neurons);
- train an ESN on these (no inputs => free runtime);
- after training run the ESN for a long time such that the output of the ESN is;
- significantly different from the original cos() function;
- now think: why can this happen?

3 Solution

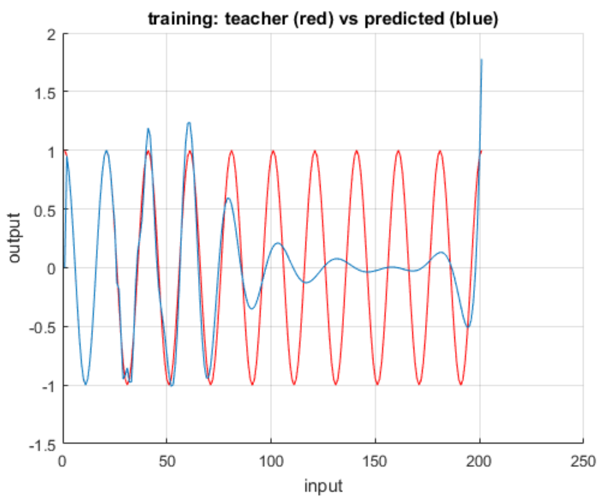
Reservoir computing Matlab toolbox by Herbert Jaege was used in this assignment. ESN will be used to model cos over 10 periods. Training data is $\cos(x)$ where $x \in [0, 10\pi]$ with step $\pi/20$, that makes 201 datapoints. The function looks like this:

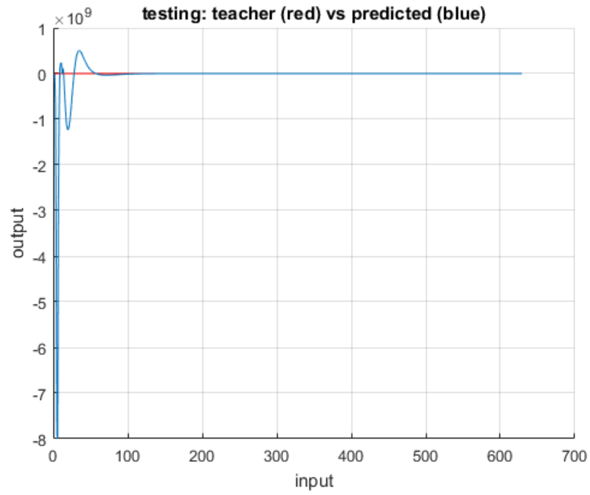


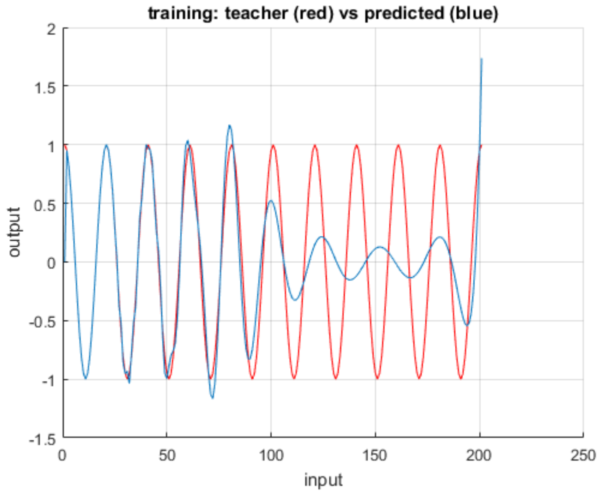
Training data is also $\cos(x)$ function on the same interval,but step size is smaller that gives 629 datapoints.

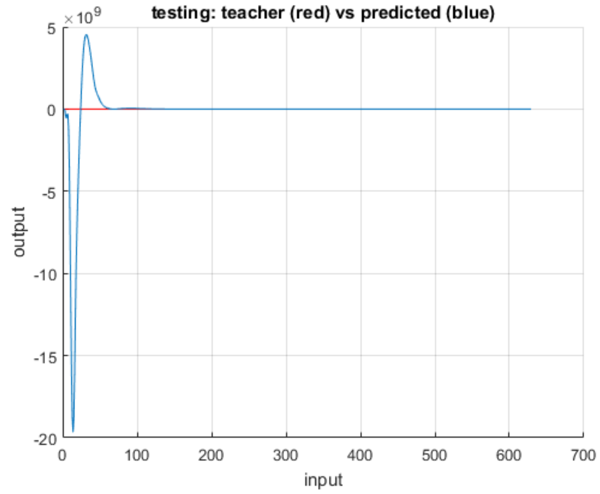


ESN were trained on the training set, with off line learning method and plain or leaky type.
First test: 100 internal nodes plain vs leaky.

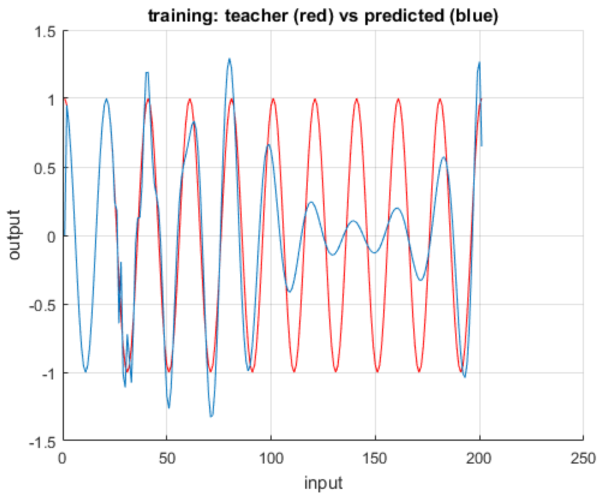


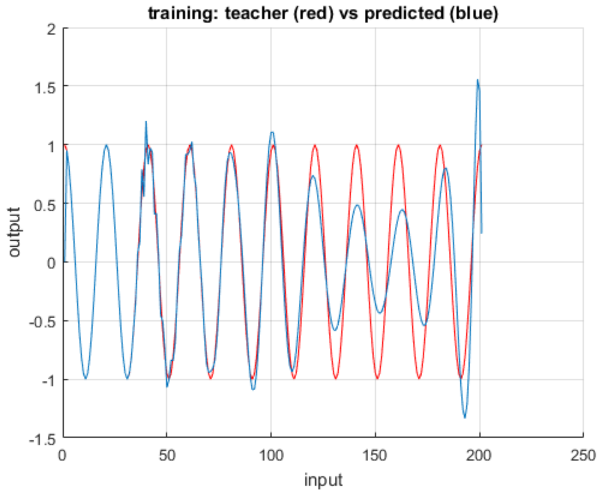




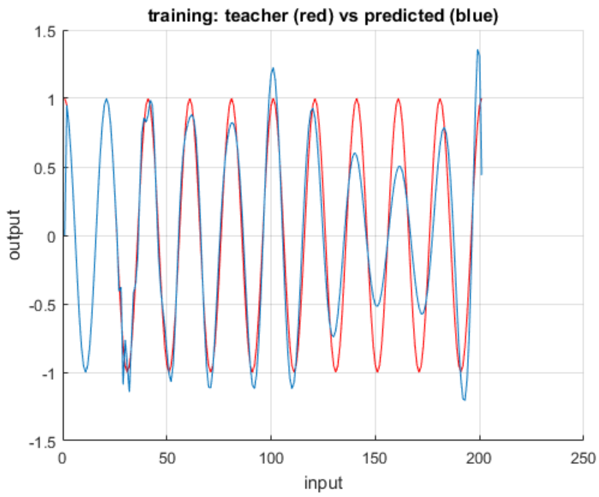


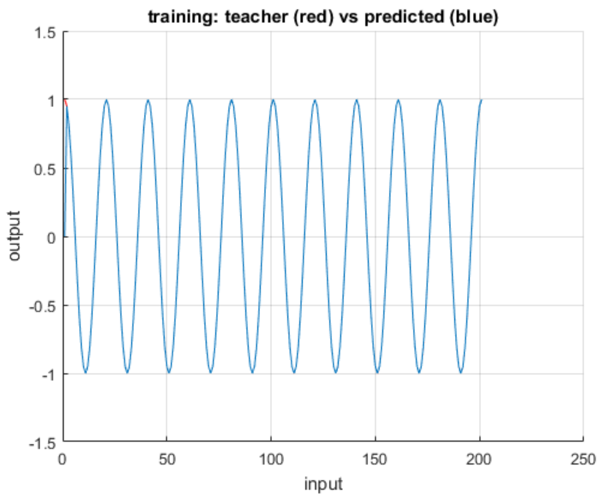
Using only 100 internal neurons, performance of the ESN is really low. However, Leaky network shows better results. Both failed in predicting data with other time sequence. Second test: 500 internal nodes plain vs leaky.



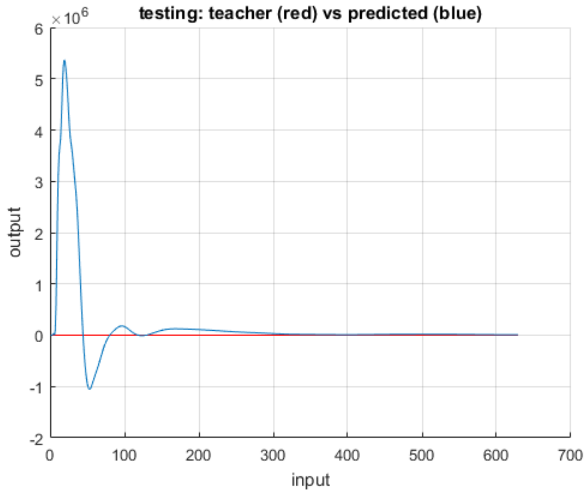


With 500 internal neurons, performance of the ESN is better, but still unsatisfying. Both failed in predicting data with other time sequence again.
Third test: 5000 internal nodes plain vs leaky.





With 5000 internal neurons, plain ESN still doing bad, when Leaky ESN shows good precision. But, other timeseries still can not be predicted:



If we increase number of testing data, we still will not obtain better prediction. This happens because ESN is strongly dependent on training dataset. Inner weights of the network are trained based on time series data. So, the ESN can only model data with similar time input.