A Multi-Agent System for Real-Time Microgrid Integration of Renewable Energy Systems

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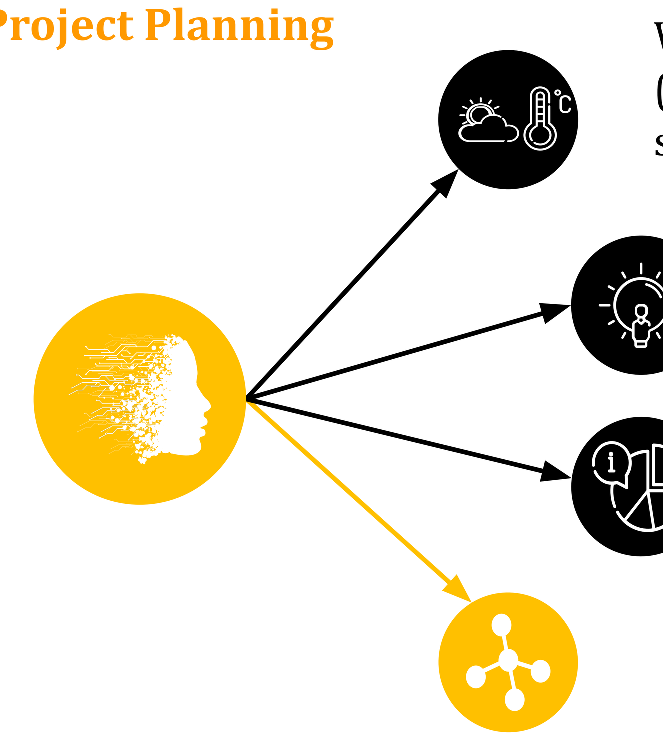
Objectives

- The first objective of our project is to forecast environmental conditions that can be used to accurately predict the power generation of renewable energy systems. Our goal is to achieve a correlation coefficient (R) of >95%
- The second objective is to forecast loads and and then integrate the generation and load forecasting systems to forecast energy demand for guiding utility power planning decisions.

Project Planning



Phase 1

Weather forecasting models (wind speed, rise and fall of tide, solar radiation and temperature)

Phase 2

Load forecasting model + Renewable energy generation

Phase 3

Optimize renewable energy systems

Phase 4

Integrate all the Neural Networks

Design Process

Our application called for a MATLAB neural network that was optimized for nonlinear time-series forecasting as weather and load conditions are highly nonlinear in nature and are indexed with respect to time

1. **Collect Input Data**

- Time (Jan, 2018 - Dec, 2019)
- Temperature (℃)
- Wind Speed (km/h)
- Relative Humidity
- Pressure (kPa)
- Dew point temp (℃)
- Visibility (km)

2. **Preprocess data**

- Merge data
- Removing outliers
- Formatting data
- Normalize numerical variables
- Calculate the average rate of change of weather data

3. **Testing Network Parameters**

- Nonlinear Autoregressive with External Input (NARX)
- Nonlinear Input-Output (NAR)
- Nonlinear Input-Output

4. **Network Architecture & Training Algorithm**

- Number of Hidden Neurons
- Number of Delays

- Levenberg Marquardt
- Bayesian Regularization
- Scaled Conjugated Gradient

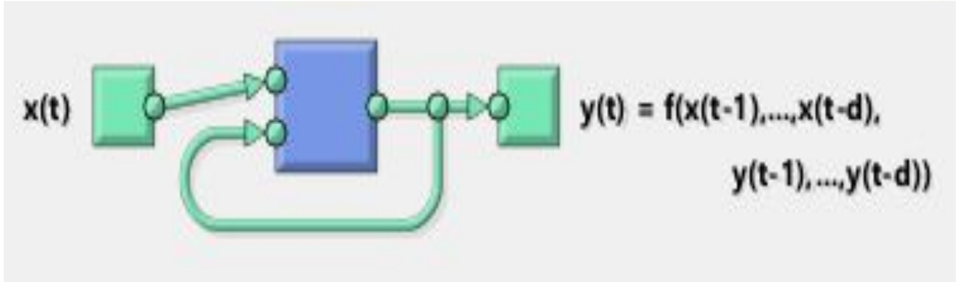
5. **Optimization**

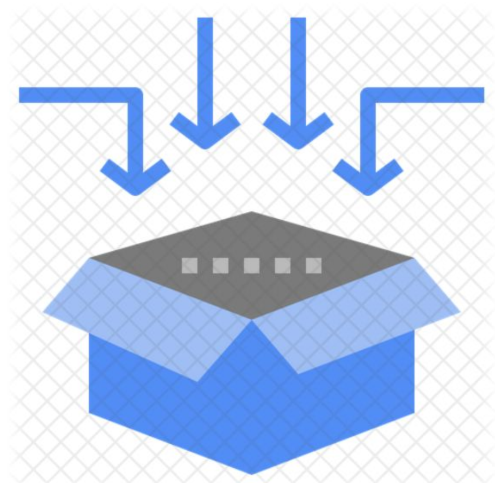
- Select significant feature subset
- Compare models to find the best model
- Tune parameters of the models

Details of Design

Criteria 1 : Network Type

- Various dynamic time series models were ran to see which would have the best performance
- The NARX gave us the most accurate and replicable results. This network relates the current value of a time series to the past values of the same series and the present and past values of an exogenous (external) input



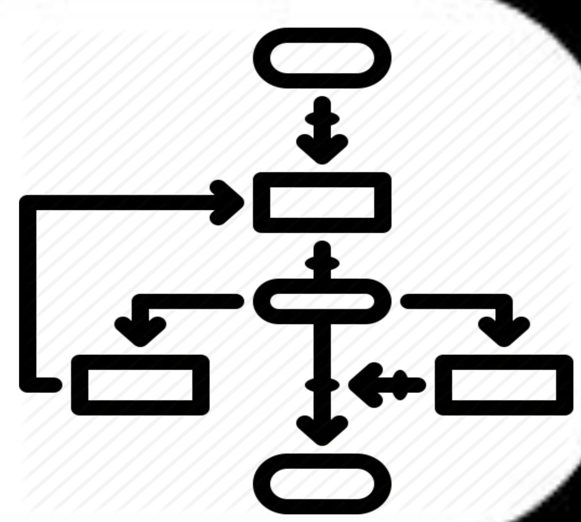


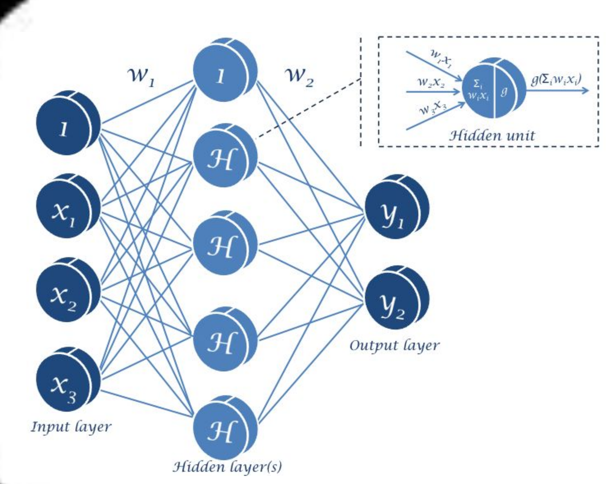
Criteria 2 : Input Features Selection

- We experimented with different sets of inputs to determine which factors directly or indirectly influence our targets of real time wind speed and temperature
- Included : dew point, humidity, visibility, pressure

Criteria 3 : Algorithm Selection

- Optimum training speed and performance was obtained from the Levenberg Marquardt algorithm.
- In many cases, trainlm was able to obtain lower mean square errors than any of the other algorithms tested. It also required very few iterations to train compared to other algorithms





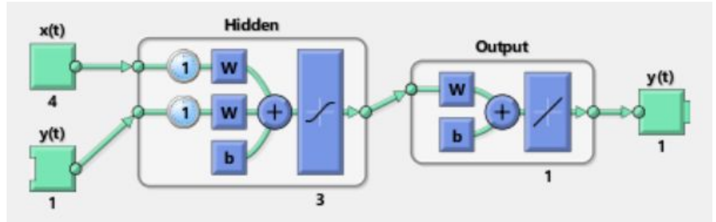
Criteria 4 : Network tuning

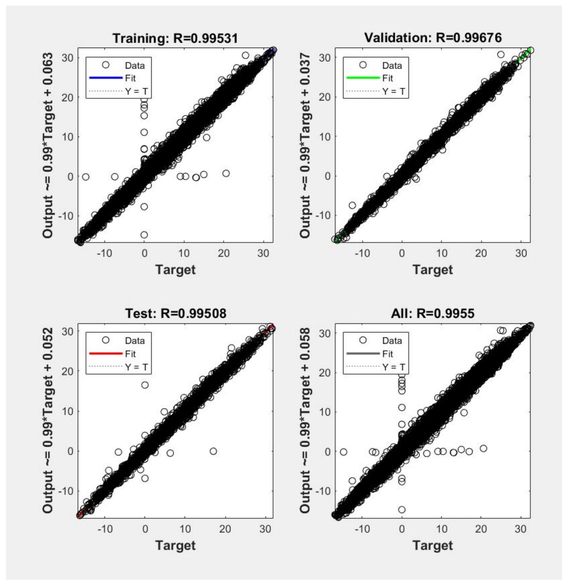
- We experimented with different numbers of neurons, delays, and training ratio to find the optimum combinations
- Training Ratio: This is how the input data is divided for training, testing and some for validation. With MATLAB, default values are 70% training, 15% testing and 15% validation. Another popular ratio is 70% training, 20% testing and 10% validation.

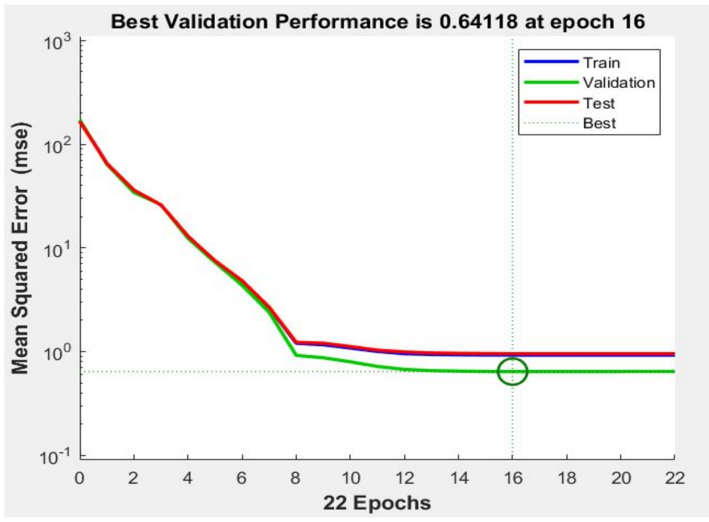
Results and Future Work

Temperature forecasting Model

The neural network was able to achieve an R value or 99.5% with a NARX model having 3 hidden neurons and 1 delay. This demonstrates the predictability of temperature over time.

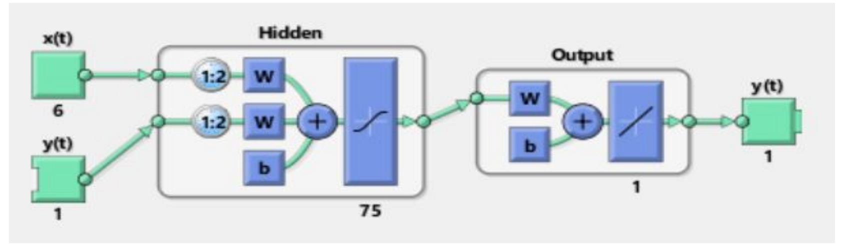


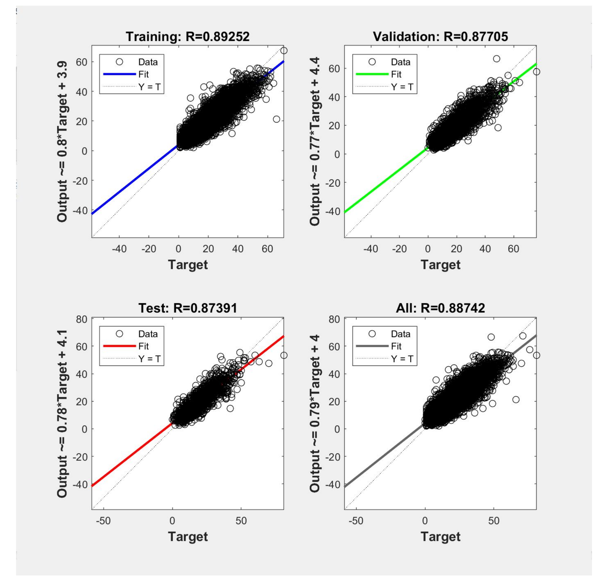


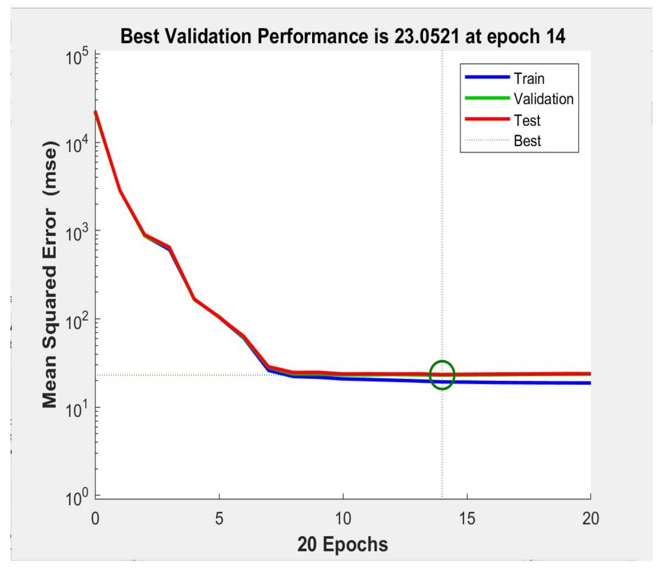


Wind Forecasting Model

The highest performing model was found with R of 89% and the lowest recorded MSE of 19.3 with training data. This is insufficient and will give us poor generation forecasts. We are in the process of gathering additional spatial pressure data to improve the performance of the wind model.







Future term

Tidal, solar and load forecasting models will be developed in the coming term as well as further improvements to the wind model. Ensemble networks may need to be implemented for highly unpredictable sources such as wind and solar.

References

A Tch 2017. The mostly complete chart of Neural Networks, explained.
https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464