REPORT

Project Name: Automatic detection of faults under various timing of occurrence and magnitudes of faults using reinforcement learning model in Micro power grid

BACKGROUND

Microgrids are building blocks of resilient and sustainable smart cities. A microgrid is a self-sufficient energy system that serves a discrete geographic footprint, such as a college campus, hospital complex, business center, or neighborhood. It integrates and distribute energy sources of different kinds. A solar microgrid makes use of photovoltaic systems to generate energy are great for the environment. Besides, in case of natural disasters, a solar microgrid can isolate itself from the area of complication, meaning energy can still be provided to unaffected areas that are working off the same main grid.

This project is based on a Simulink model of a small-scale micro grid during 24 hours on a typical day. It was modified with three kinds of faults: three-phase faults at the main grid side, partial shading to the solar panel and tripping faults to the main breaker of House 3 at the microgrid side. The energy sources are main power grid, a solar power generation system and a storage battery.

The storage battery is controlled by a battery controller. It absorbs surplus power when there is excess energy in the micro-network and provides additional power if there is a power shortage in the micro-network. The control strategy assumes that the microgrid does not depend entirely on the power supplied by the power grid, and the power supplied by the solar power generation and storage are always sufficient.

The storage battery supplies the insufficient current when the power of the micro-grid is insufficient and absorbs surplus current from the micro-grid when its power is surpasses the electric load. Three ordinary houses consume energy (maximum of 2.5 kW) as electric charges. The microgrid is connected to the main power grid via a transformer mounted on a post which lowers the voltage of 6.6 kV to 200 V.

From 20h to 4h, the solar power generation is 0 W. It reaches the peak amount (5 kW) from 14h to 15h. As a typical load change in ordinary houses, the amount of electric power load reaches peak consumption at 9h (6,500 W), 19h, and 22h (7,500 W).

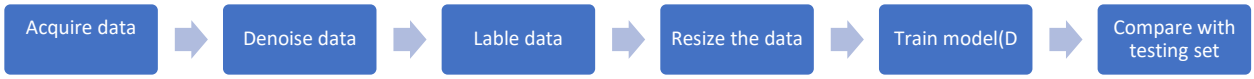
From 0h to 12h and from 18h to 24h, battery control is performed by battery controller. The battery control performs tracking control of the current so that active power which flows into system power from the secondary side of the pole transformer is set to 0. Then, the active power of secondary side of the pole mounted transformer is always around zero.

From 12h to 18h, battery control is not performed. SOC (State of Charge) of the storage battery is fixed to a constant and does not change since charge or discharge of the storage battery are not performed by the battery controller. When there is a power shortage in the micro- grid, the system power supplies insufficient power. When there is a surplus power in the micro-grid, surplus power is returned to the system power.

Description

The simple approach is to first denoise the signal and then pass the signal through the deep learning layers to obtain the result. The described model in the code will provide an accuracy of more than 85% for the noisy data and around 99% for noiseless data.

Approach: First we need to denoise the signal using we denoise method then the data is labeled using signal labeler app then the data is resized for parallel computing then the into training and testing data is passed through the Deep layer network (using deep-learning toolbox).



Denoise process

The input signal is the Load3+Noise data. The variation of the wavelets did not impact the denoising, but the method used played an important role in denoising. The best results were obtained with using Daubechies 10 wavelets and the universal threshold method. The parameter used is as follows: • Wavelet: Daubechies 10

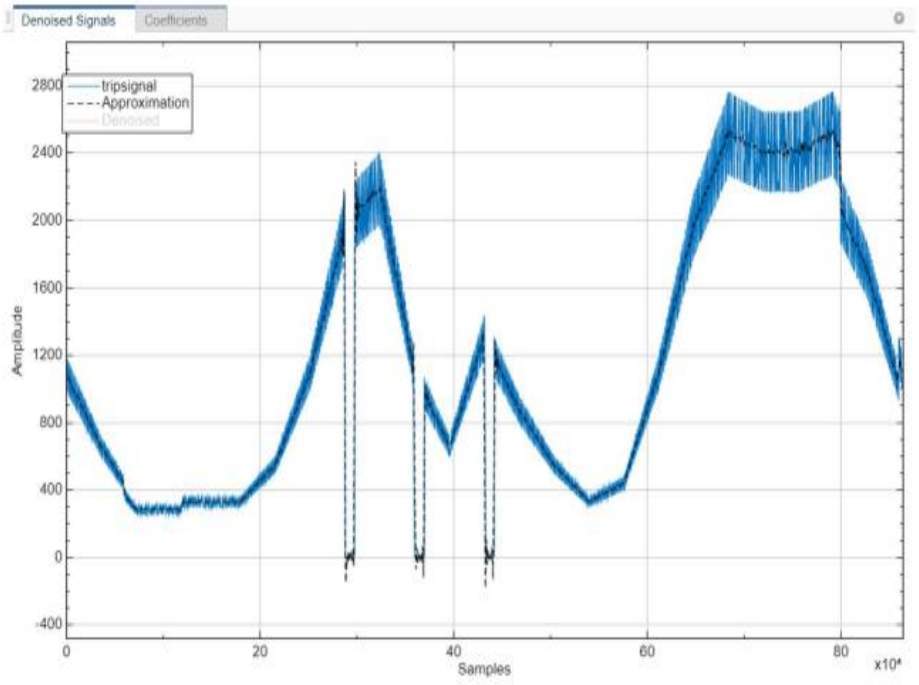
• Method: Universal Threshold

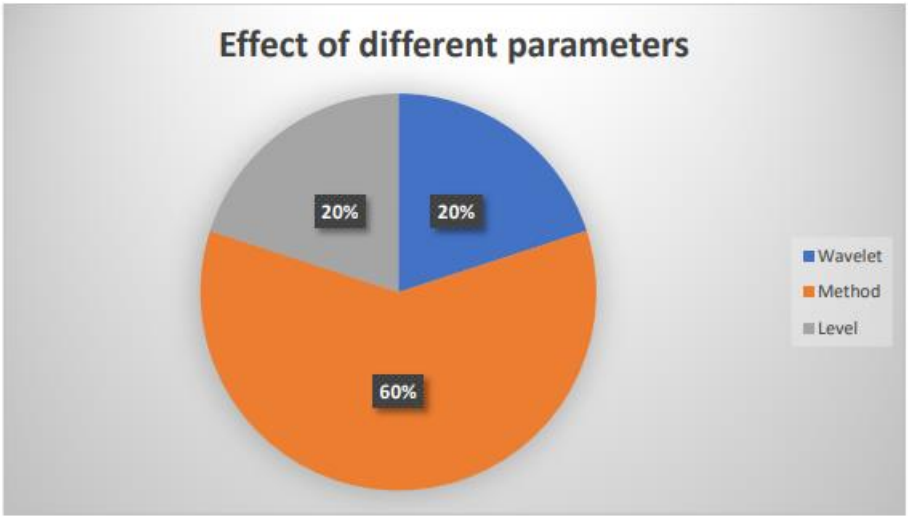
• Level: 10

• Threshold: Soft with Q-Value of 0.5

• Noise Estimate: Level Dependent

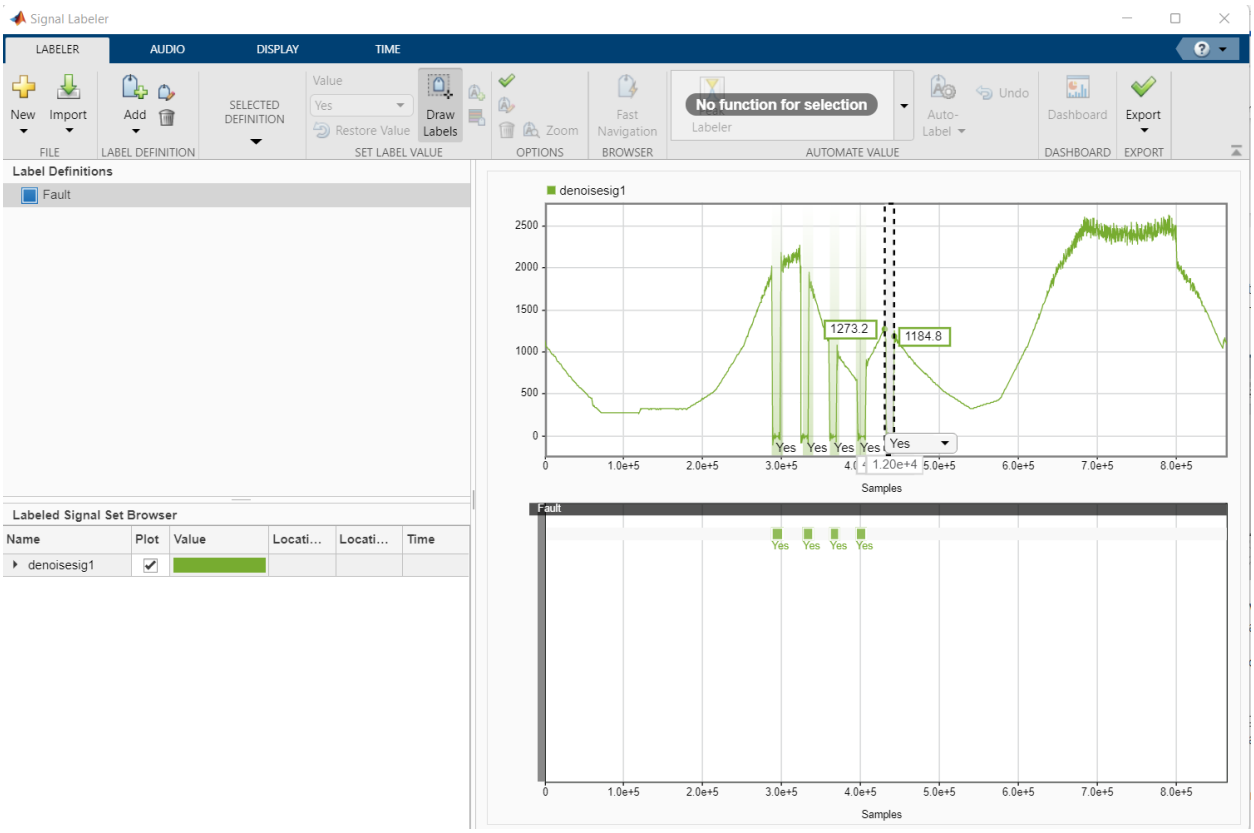
How the noise vs denoise signal looks like: Black line is the denoised and blue is the noise signal.





From the above pie chart, it is observed that the method used to denoise the signal plays an important role.

Label data: We can label the data using the signal labeler app which will look something like below figure.

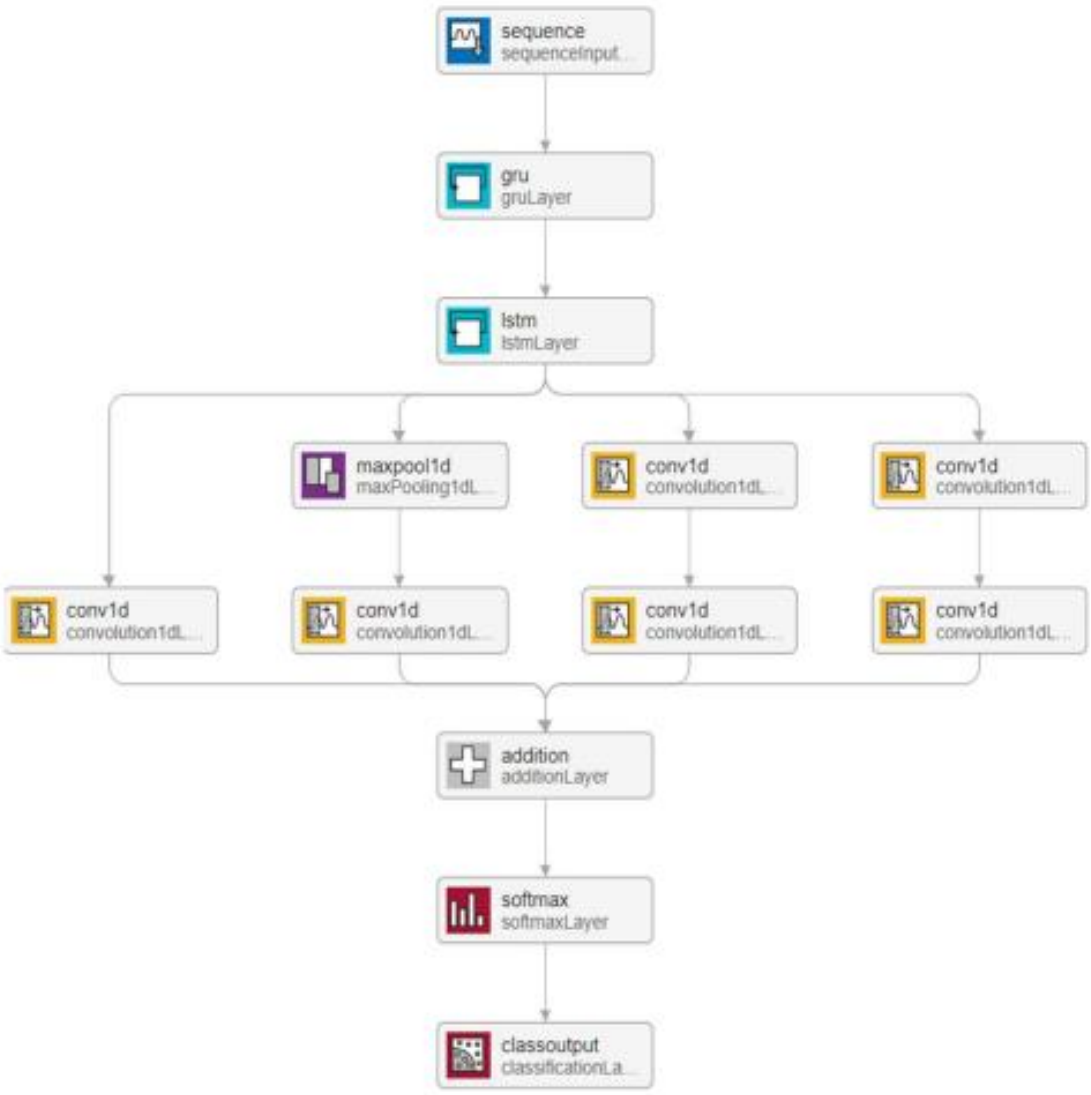


Train the data with model

Reinforcement learning model with Multilayer network layer using LSTM and GRU Sequence (13 layers):

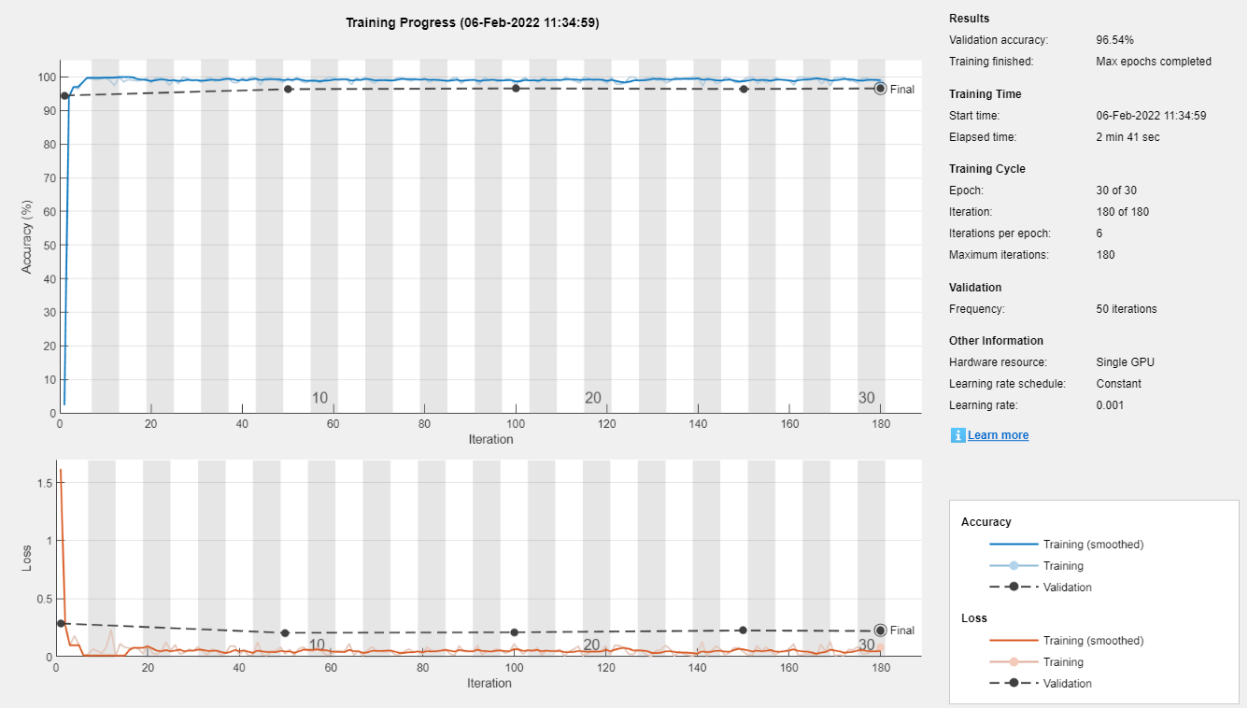
In this layer the input layer is the sequence input, and it is an addition combination of both LSTM and the GRU layer with the maximum polling with five 1d convolution layer with the SoftMax layer and classifier output layer. The Deep layer network reference was taken from the Hindawi journal. Article name Short-Term Load Forecasting Method Based on Deep Reinforcement Learning for Smart Grid. Made a few modifications as per my training data.

(https://www.hindawi.com/journals/misy/2021/8453896/)



Results

Training results:



Final Testing with actual data

Without noise	With noise