Machine Learning for Rooftop PV Fault Detection

Michael Oberdorf, Sunil Rao, Andreas Spanias, Elias Kyriakides
SenSIP Center, School of ECEE, Arizona State University, KIOS Center, University of Cyprus

***Abstract*— Renewable sources of energy are becoming more common, replacing traditional methods that use fossil fuels to produce power. The use of solar energy is a current type of renewable energy, however currently the production of power is not very efficient and reliable fault detection methods need to be used to increase efficiency. Machine learning techniques can be used such as neural networks. These networks take inputs such as current, voltage, temperature, and weather conditions and use those to predict faulty or non-faulty outputs. In order for this to be done the network must be trained on both faulty and non-fault data.**

Key terms – PV, Fault detection, Machine Learning, Rooftop Solar Monitoring

I. Introduction

The operation of a Photovoltaic (PV) cell coverts sunlight into electricity. This is done by absorbing photons through the use of semiconductors set up as a p-n junction [1].

PV faults can be hazardous and cause potential fires [2]. Types of these faults include ground faults, line-to-line faults, and arc faults. Ground faults occur when there is an unintentional path of current to ground. Line-to-line faults occur when the circuit is shorted between two points. For arc faults there are two specific types, series and parallel. Series faults usually occur from faulty wire connections that result in an increased resistance. Parallel faults commonly occur from insulation damage of wires, causing shorts.

Other common faults that can occur with solar energy include shading and soiling of PV cells causing individual cells to produce different currents when they must produce the same amount of current. Another fault, PV module mismatches, are due to the construction of modules not being exactly the same, causing voltage differences [2].

The use of machine learning can be used to also help prevent faults while also increasing the efficiency of the system. Machine learning is a technique that can compress and extract information from a collection of data in multiple different learning styles described in [3]. The k-means algorithm can be used as the starting point for machine learning fault detection [4]. The k-means algorithm is a type of unsupervised learning that finds clusters in unlabeled data allowing groupings to be formed mathematically.

For PV arrays the k-means algorithm can be used to group data based off of different I-V characteristics. The clusters created can be used to distinguish certain faults. Faults that are easily distinguishable are arc and ground faults. Faults that are difficult to distinguish are those due to soiling and shading. This is due to more features being needed than just I-V characteristics.

Neural networks are another machine learning technique that can be used to detect faults. A forward pass of the neural network is performed by sending signals from the input layer through the hidden layer and out the output layer. Back-propagation can then be used to adjust the weights of the hidden layer by taking the margin between actual and expected outputs. Applications with the use of a neural network with a back-propagation algorithm were performed in [5], using five input features and one hidden layer with 9 neurons producing high accuracy.

In utility scale PV data is collected from sensing modules located between each solar panel. This gives unique data values for every individual solar panel. In rooftop PV the data is aggregated from all households at a single point. The goal is to apply machine learning techniques previously used for utility scale solar and apply them to rooftop solar applications.

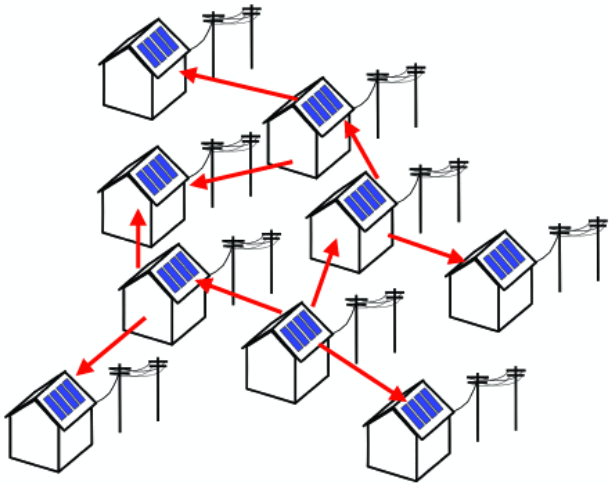

Figure 1: Shows communication between multiple grid connected rooftop PV installations. [6]

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