Multiple Islanding Detection Using Machine Learning Algorithms

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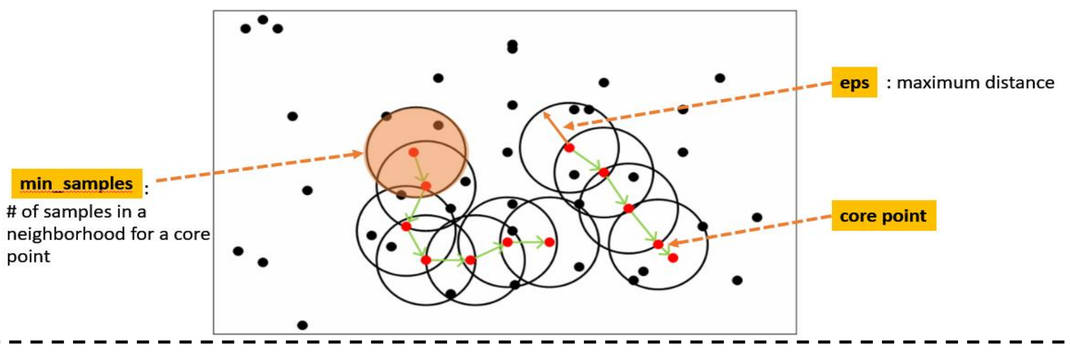
Introduction

PMU data provides great value for fast islanding detection. Many previously developed methods can only detect two islands by using frequency signals or deviations in voltage angle signals. However, multiple islanding conditions do happen in real world. Large scale PMU data sets make it possible to use a machine learning method for islanding detection. A Density Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm has been implemented and tested for various islanding scenarios. One real event and five simulated events were used to test the application. The proposed method can identify multiple islanding conditions accurately and robustly, especially detection of corner cases with frequencies close to each other in multiple islands. Test results validate effectiveness of the proposed method.

Method

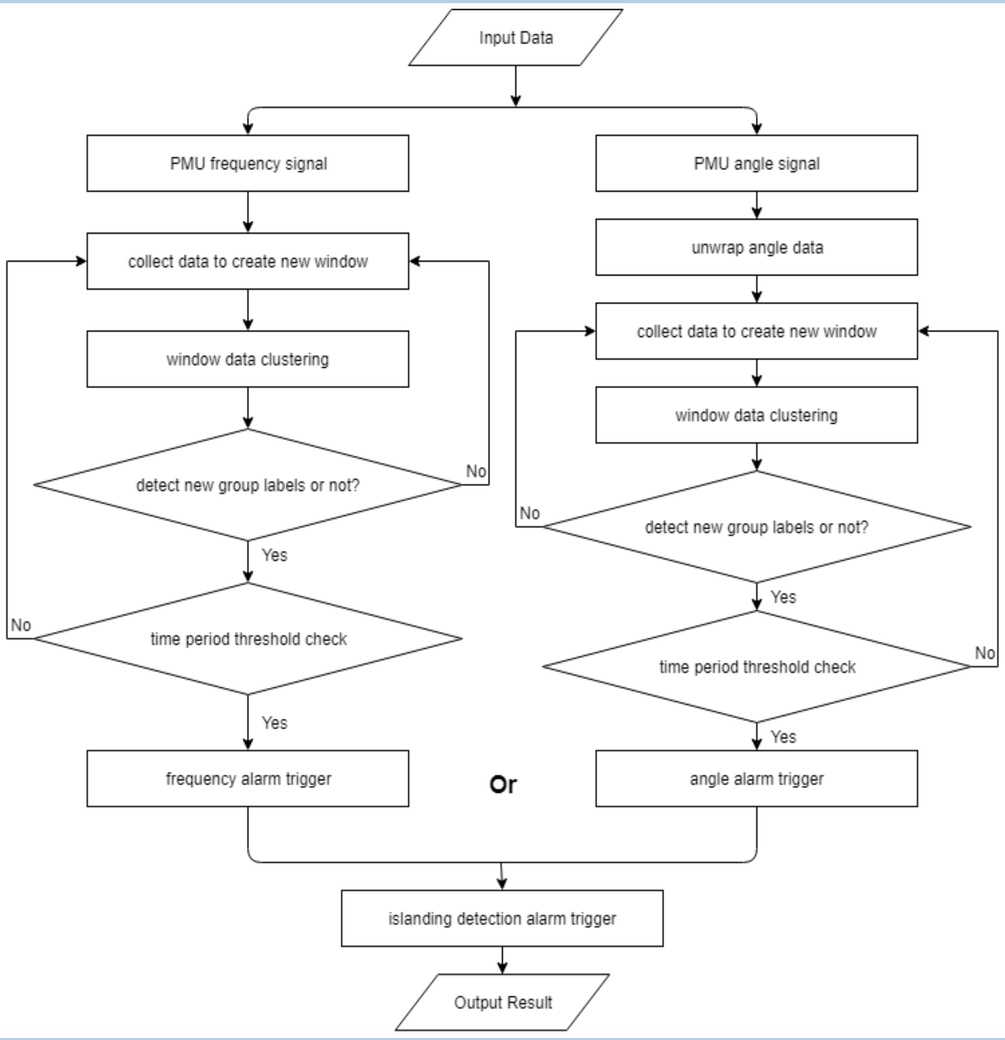
- **DBSCAN clustering method**
  - Density Based Spatial Clustering of Applications with Noise
- **Usage**
  - Frequency – PMUs in different islands usually have different values
  - Voltage Angle – Angle differences of PMUs in different islands increase with time



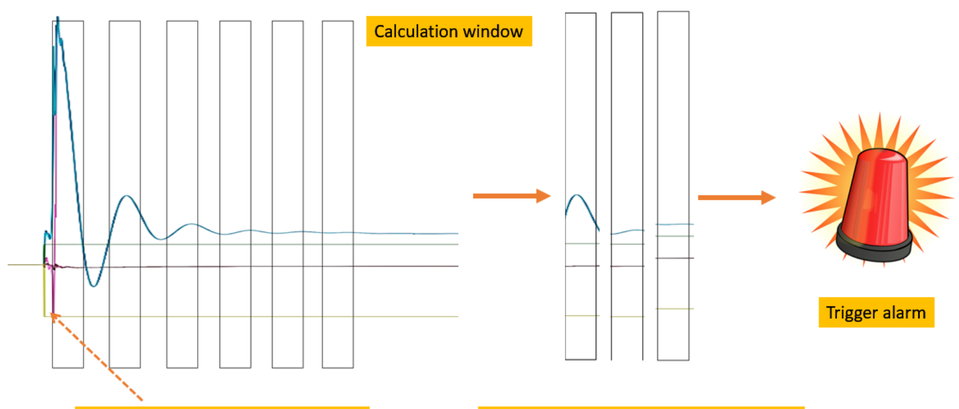
DBSCAN Algorithm

- **Input**
  - Real time frequency signal
  - Real time voltage angle signal
- **Output**
  - Islanding detection alarm
  - PMU(s) within each island
- **Configuration parameters**
  - Calculation window
  - Step
  - EPS: max. distance between 2 samples for them to be considered in the same neighborhood
  - Min samples: no. of samples in a neighborhood for a point to be considered as a core point
  - N continuous change

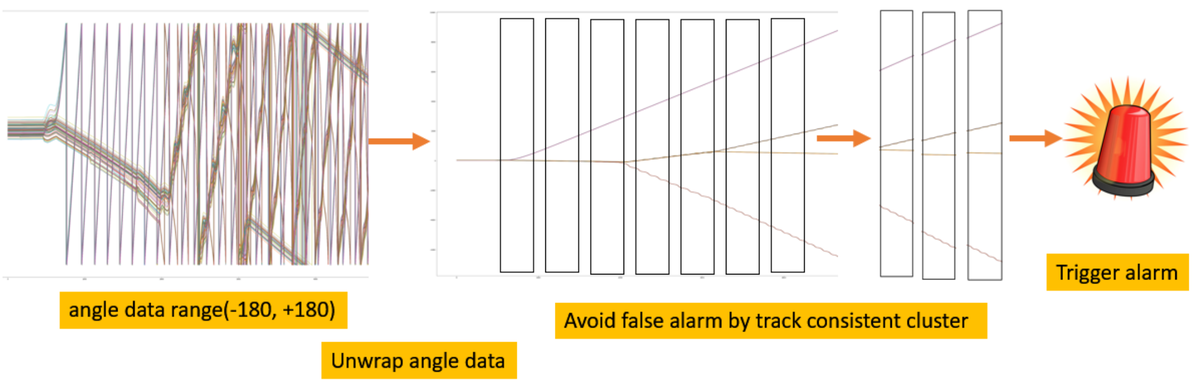
Flow Chart



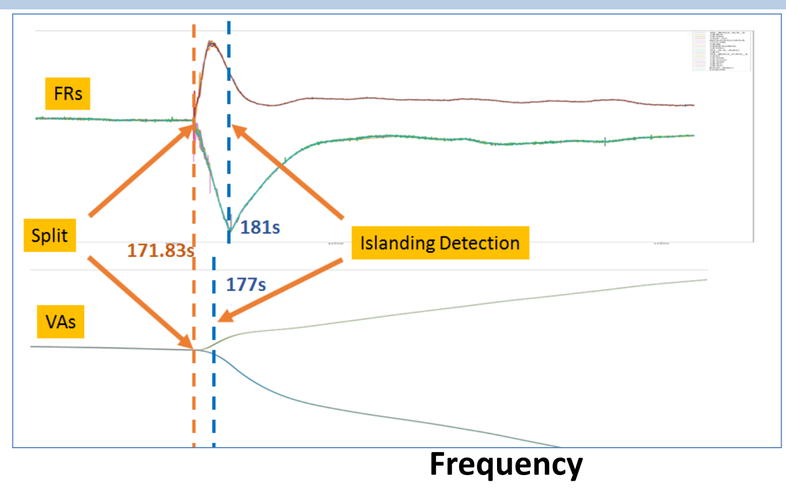
Using Frequency



Using Voltage Angle



Real Data Test

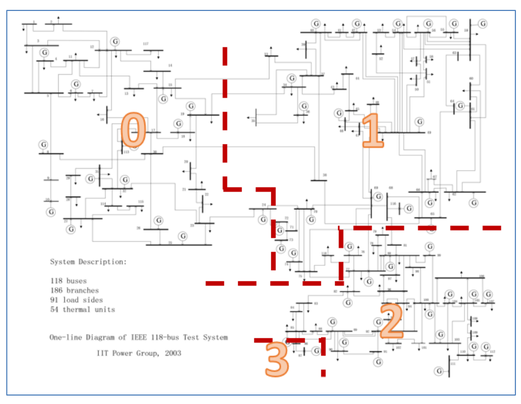


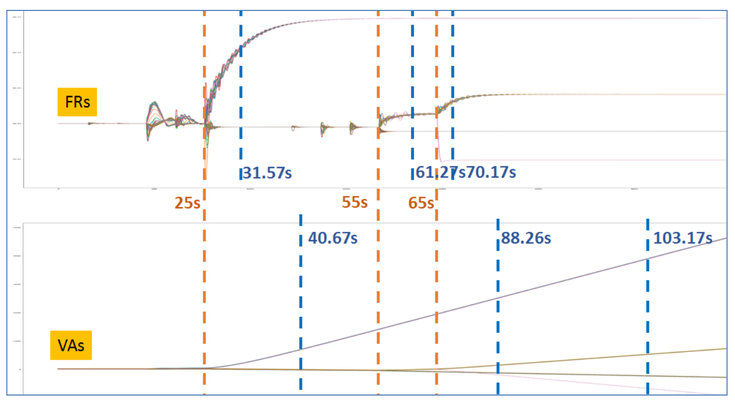
20 PMUs
(60 samples/second)

Frequency
- Detects 2 islands in **9.17s**

Voltage Angle
- Detects 2 islands in **5.17s**

Simulation Test





118 PMUs
(30 sample/second)

Frequency:
- Detects 2 islands in **6.57s**
- Detects 3 islands in **6.27s**
- Detects 4 islands in **5.17s**

Voltage Angle:
- Detects 2 islands in **15.67s**
- Detects 3 islands in **33.26s**
- Detects 4 islands in **38.17s**

Frequency analysis

- Pro:
  - Fast
  - Cover most practical cases
- Con:
  - Challenge for corner cases
    - Very close frequency
    - Frequency oscillation

Voltage Angle analysis

- Pro:
  - Accurate
  - Cross Validation
- Con:
  - Take longer time
  - Dependent on historical VA data quality (unwrapping)

Benefits

This work will deliver the following benefits to utilities:

- Works with both frequency and voltage angle data as input -- useful to cross-check with each other
- High accuracy even with bad data
- Robust solution for multiple islanding detection
- Covers corner cases with frequencies close to each other in multiple islands
- Integrate with existing synchrophasor application platforms for easy adoption

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