Project Assignment – Electrical Power Eng. Track
Scenario Classification of Power Quality Issues
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Context

Power quality (PQ) issues are caused by power quality disturbances (PQDs) that mean the deviation/disturbance manifested in the voltage, current and frequency from the standard rating. With the transition of energy systems, there are more and more deterioration risks of power quality in different energy production, transformation, delivery, and consumption stages. For instance, increasing installations of renewable energy sources, e.g., photovoltaic (PV) panels and wind turbines, bring more harmonic pollution. Meanwhile, safe operations of power systems rely on the compliance of power quality, which requires preventing PQDs. A foundation to deal with PQ issues is to correctly recognize the existence of PQDs through the measured grid voltage waveforms, and identify the type of the PQD, if any. Such leads to the increasing demand for automatic classification of power quality disturbances (PQDs). Normally, the identification process of PQDs is divided into three independent stages: signal analysis, feature selection and classification. In the signal analysis stage, the measured time series data, i.e., voltage waveform, is processed with signal-processing techniques, e.g., Fourier Transform, S-transform, and Wavelet Transform. Based on the processing outcomes, key features will be selected for the training of the classifier. In this Final Project Assignment, you will develop models to (1) determine which features should be used for the certain PQD recognition, and (2) classify the PQDs.

Purpose

By developing this assignment, you will practice how to implement clustering algorithm, practice how to realize classifiers, and compare the performance of three different classifiers. This assignment covers this course learning objectives (LOs): LO3, LO4 and LO5.

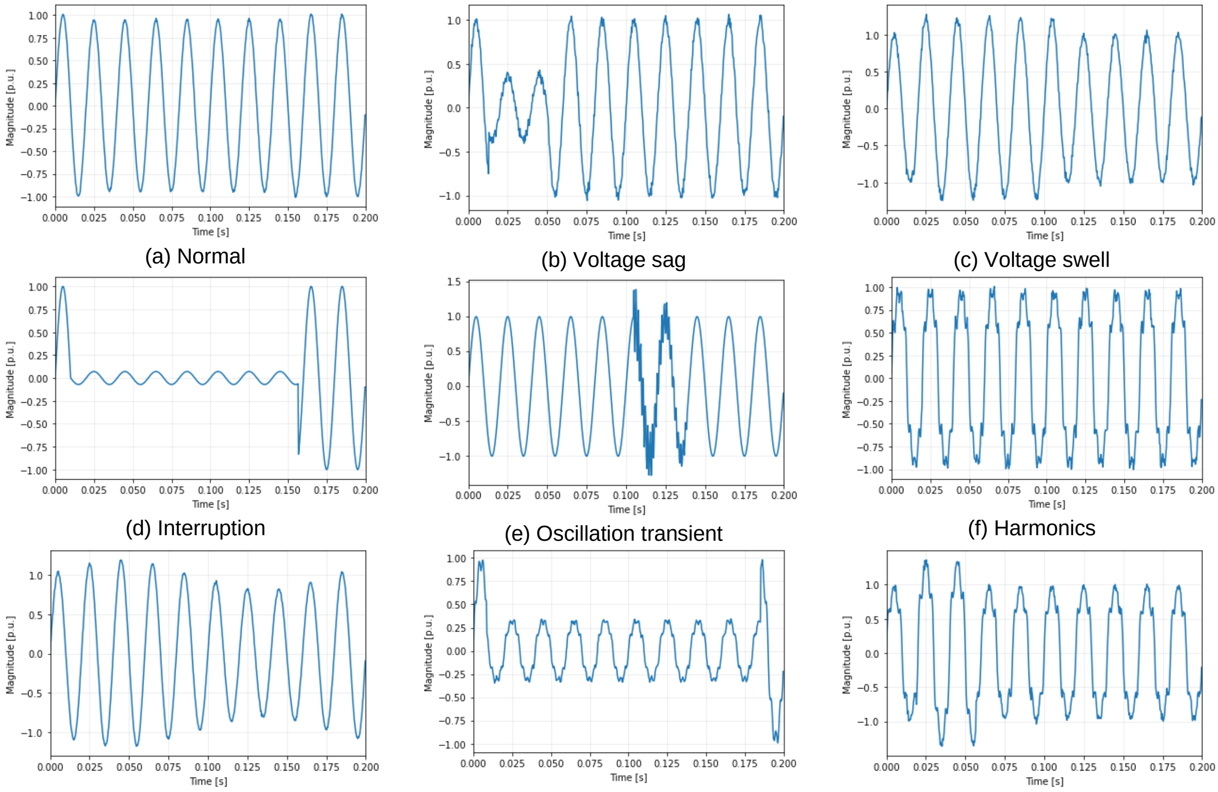
Resources

You will receive feedback from a Lecturer on Week 7.

Instructions

Activities

You will be using data generated by using parametric equations of eight most popular PQDs, i.e., voltage sag, voltage swell, interruption, oscillatory transient, harmonics, voltage fluctuation, voltage sag with harmonics, and voltage swell with harmonics. Additionally, the normal voltage signal is also provided. The typical waveforms of the PQDs are shown in Fig. 1.



(a) Normal (b) Voltage sag (c) Voltage swell

(d) Interruption (e) Oscillation transient (f) Harmonics

(g) Voltage fluctuation (h) Voltage sag with harmonics (i) Voltage swell with harmonics

Fig. 1 Waveforms of the selected power quality disturbances

Since the single processing is not covered in the course content, the processed data instead of the raw time-series data is provided. For the signal processing, S-transform is used to generate a complex matrix whose columns pertain to time and rows to frequency. From the generated matrix, two characteristic curves, as follows, are extracted.

- Frequency-maximum-Amplitude (FmA) plot: It is built by finding the maximum value of each row of the ST matrix. It represents the maximum amplitude of all times for each frequency value.
- Time maximum Amplitude (TmA) plot: It is built by finding the maximum value of each column of the ST matrix. It represents the maximum amplitude of all frequencies for each time value.

The provided dataset contains eight features which are extracted from the processed data and explained below. The data in each column in the '.csv' file is corresponding to one feature in the sequence from one to eight. For each PQD, 150 samples are provided.

- Feature 1: Average absolute value of the ST matrix row corresponding to the third harmonic.
- Feature 2: Standard deviation of the TmA-plot.
- Feature 3: Maximum value of the TmA-plot.
- Feature 4: Minimum value of the TmA-plot.
- Feature 5: Number of peaks in the TmA-plot with prominence in the range [0.0005, 0.2] plus the number of local minima in the TmA-plot.
- Feature 6: Standard deviation of the FmA-plot corresponding to frequencies between the third and seventh harmonics.
- Feature 7: Standard deviation of the FmA-plot corresponding to frequencies above the third harmonic.
- Feature 8: Number of points near zero, i.e., in the range [-0.1,0.1], in one cycle minus the typical number of points found in an undistorted signal.

Since measurement noise is unavoidable. Gaussian white noises are added to the signals with five different signal-to-noise ratio (SNR), namely noiseless, 50 dB, 40 dB, 30 dB, 20 dB. A higher SNR indicates a lower noise contamination.

Two tasks are planned for this Final Project Assignment.

Task 1 Feature selection for the recognition of each PQD
For each PQD, you need to select one or several features from the provided eight features to separate it from the other PQDs. Enough reasoning and results should be provided to support your selection. Then, based on your selection, implement a classifier to test the effectiveness of your selection. Your classifier should have only one output which indicates the possibility of the fed sample belonging to the PQD under study. The dataset should be split into training set and validation set with cross validation. *Hint: you may consider two or three features for visualization to support your feature selection.*

Task 2 Multiclass classification
Develop three classifiers, namely Decision Tree (DT), Random Forest (RF) and Multilayer Perceptron (MLP) to classify the PQDs. The dataset should be split into training set and validation set with cross validation. The effectiveness of your classifier should be proved with the index introduced in the lectures.

Other instructions

- You will work in pairs.
- Decisions need to be made together, but Tasks can be done individually.
- We recommend splitting the tasks. Any member must be capable of arguing any decision made.
- At least one of the models must be a *deep neural network (Lecture 5)*.
- One report per pair. The report must follow the proposed structure with a maximum number of pages of 10.
- Deadline: Week 8.

Deliverables

- Final Project Report (see instructions below)
- Project Assignment Python code

Report Structure

- Members, emails, student numbers.
- Summary (less than 200 words)
- Task 1
- Task 2
- Conclusions (less than 200 words)

For Task 1 and 2, explanation of your implementation without showing the complete code and reasoning of the results are indispensable. However, showing some short key steps in the code is acceptable.

Assessment Criteria

You will be evaluated based on a predefined rubric. Check the course Brightspace page to get access to the rubric.

The Project Final Report can be considered *inadmissible*, which will render a FAIL grade for the group, if

- English is not understandable (e.g., full of typos).
- Figures are not legible.
- The report does not follow the proposed structure.
- Only results without necessary reasoning and explanations.

If the report is considered *admissible*:

– English will *not* render extra points.
– Quality of the Python code will *not* render extra points.

Submission Instructions

Please submit your Final Project Report in a PDF format and your Python code in Brightspace before the deadline.