Project Assignment – Electrical Power Eng. Track
Scenario Risk Estimation for Power Systems
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Context

Power system operational risk can be investigated in different time frames: from near real-time operation (a couple of seconds) to long-term planning (+5 years). In modern power systems, evaluating operational risk is getting more complex due to the introduction of renewable-based generation systems (e.g., wind, PV). These systems add more uncertainty while reducing the power system's inertia. As a result, a large number of possible operational scenarios may occur. The power system operator must be able to anticipate which of these operational scenarios may result in a risky operation. To do so, they rely on dynamic simulations with predefined contingency sets to estimate the system's strength. This kind of study is done based on power flow analysis, providing estimations of voltage magnitude, active and reactive power flows, and angles. Based on these estimations, any scenario can be translated into a risk measure (low/medium/high risk) based on the current power system conditions. In this Final Project Assignment, you will develop an ML model that estimates a power system risk index and defines its operational state.

Purpose

By developing this assignment, you will put into practice all the learning concepts introduced so far in Lectures 1 to 4. You will develop strategies for a specific power system problem and solve practical questions that arise when developing an ML model. This assignment covers this course learning objectives (LOs): LO3, LO4 and LO5.

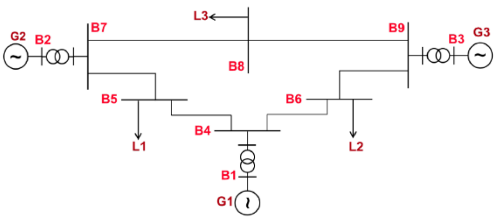
Resources

You can consult with the TAs on Practicums on Week 5 and 6. You will receive feedback from a Lecturer on Week 7.

Instructions

Activities

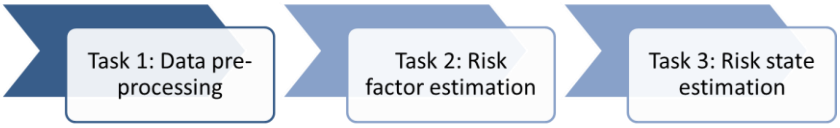
You will be using data from the IEEE 9 bus test system (shown in the figure). A large number of operating scenarios were generated by varying load consumption and generation to different levels. For each of these scenarios, a power flow simulation was executed obtaining the following feature matrix $F = (P_i, Q_i, V_i, \theta_i, P_{ij}, Q_{ij})$ *for* $i = \{1, \dots, 9\}$. We call this matrix as the *initial dataset* and you will use it to train your ML models. Note that if the line ij does not exist, then $P_{ij} = Q_{ij} = 0$. In total, 4955 scenarios (samples) are provided.



A risk factor (R) measure is defined to quantify risk against severe disturbances. R is normalized and continuous value between 0.0 and 1.0. Table below presents the defined power system state based on the value of R.

Class	Safe	Low Risk	Moderate Risk	High Risk
Threshold	$R < 0.1$	$0.1 \leq R < 0.35$	$0.35 \leq R < 0.7$	$0.7 < R$

Three tasks are planned for this Final Project Assignment, as shown below. Task 2 and 3 can be done in parallel.



Task 1
Perform data pre-processing activities. This may include data preparation, data cleaning, normalization, standardization, and feature analysis.

Task 2
Develop a model that allows you to estimate the risk factor (R) for new unseen operational scenarios. Provide arguments for the choice and design of your final model(s). Provide arguments for your final model(s) assessment and validation procedure.

Task 3
Develop a model that allows you to estimate the risk state (class) for new unseen operational scenarios. Provide arguments for the choice and design of your final model(s). Provide arguments for your final model(s) assessment and validation procedure.

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 6)*.
- One report per pair. The report must follow the proposed structure with a maximum number of pages of 10.
- Deadline: Week 9.

Deliverables

1. Final Project Report (see instructions below)
2. Project Assignment Python code

Report Structure

- Members, emails, student numbers.
- Summary (less than 200 words)
- Detailed ML pipeline (include workflow figure).
- Task 1: selected options, argumentation for the selection, model(s) developed, results, validation, comparisons.
- Task 2: argumentations for the model(s) developed, validations, results, comparisons.
- Task 3: argumentations for the model(s) developed, validations, results, comparisons.
- Conclusions (less than 200 words)

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).
- Deep neural networks were not used (as one of the tested models).
- Figures are not legible.
- The report does not follow the proposed structure.

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.