Deep Learning for Feature Extraction in Power System Security Assessment

Supervisors: Spyros Chatzivasileiadis, Andreas Venzke
Group: Energy Analytics & Markets, Centre for Electric Power and Energy, Department of Electrical Engineering

Context
The increase in fluctuating renewable energy, such as wind and solar, and the increase in electricity demand driven by the electrification of heat and transport sectors challenge traditional power system operation. Power system operators routinely perform system security assessments to ensure a safe and stable operation. With growing uncertainty, the complexity of this computationally intensive task further increases calling for the development of new approaches.

Deep learning has shown tremendous potential in a wide range of scientific and technological applications, recently publicized for the game of Go with the computer program AlphaGo winning against the world champion [1]. However, the application of deep learning in power systems has been limited so far. One promising direction is deep learning for feature extraction. The goal is to map the high-dimensional power system state to a significantly lower-dimensional feature space more suitable for a classifier to discriminate between safe and unsafe operation. The resulting tool could aid operators in maintaining a stable power system operation.

Objectives
The objectives of this project are the following: First, a deep autoencoder for feature extraction in security assessment is implemented and validated. Second, the improvement in the accuracy of a classifier predicting safe/unsafe operation trained on the extracted features is evaluated. Third, possible connections between physical states in the power system and the identified features are investigated.

Methodology
In the beginning, the basic concepts of deep learning including deep autoencoders will be reviewed (e.g. by following the online lectures on deep learning: http://introtodeeplearning.com/). Using a small example, first a shallow, then a deep autoencoder will be trained for the security constrained DC optimal power flow based on the work [2]. Possible physical explanations for the identified features will be investigated and the performance of a classifier based on these extracted features will be evaluated. Then, a deep autoencoder for feature extraction in a more realistic setup is implemented and its performance validated. For this purpose, training databases for a 14-bus and 162-bus system of the security constrained AC optimal power flow will be used considering N-1 security and small signal stability [3].

Expected results
The expected outcome includes an implementation of the deep autoencoders, classifiers trained on the extracted features and a scientific report containing the documentation and obtained results.

Prerequisites
Power system modeling or machine learning, good knowledge of Matlab, Python or another programming language, high interest in deep learning.

References
[1] https://deepmind.com/research/alphago/
[2] Sun, Mingyang, Ioannis Konstantelos, and Goran Strbac. "A deep learning-based feature extraction framework for system security assessment." IEEE Transactions on Smart Grid (2018).
[3] Thams, Florian, et al. "Efficient Database Generation for Data-driven Security Assessment of Power Systems." IEEE Transactions on Power Systems (2019).