Karlsruhe Institute of Technology

ENERGY LAB 2.0

Institute for Automation and Applied Informatics (IAI)

Earliest start: Now

Master‘s Thesis

Learning the power system frequency dynamics under large disturbances using effective information

The integration of renewable energy has fundamentally changed the frequency dynamics of power systems, challenging conventional modelling approaches during significant disturbances. While artificial intelligence excels at predictive tasks, it often fails to improve our understanding of the underlying system characteristics. In particular, if an AI model achieves a low error function value during the training phase, does this necessarily indicate that the model has truly captured the dynamic characteristics of the system? How can we improve the ability of AI models to learn authentic representations of dynamical systems?

This research combines information theory with autoencoder structures to learn and represent post-disturbance frequency dynamics, potentially providing insights into macroscopic behaviour. The approach aims to bridge the gap between predictive accuracy and interpretable system knowledge, providing a more robust framework for analysing increasingly complex power systems with high penetration of renewable energy.

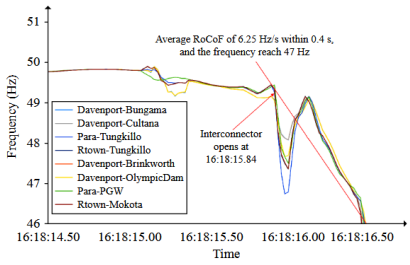

Fig.1 Power system blackout in South Australia in 2016.[1]

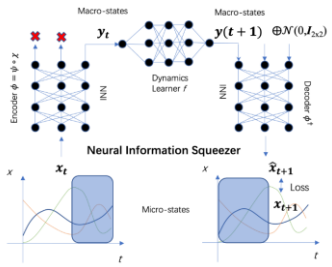

Fig.2 The basic structure of autoencoder for maximizing effective information.[2]

Tasks:

The investigation covers the following aspects:

- Literature review of state-of-the-art coarse-graining methods with a focus on time series data and complex systems
- Design and training of the autoencoder on power system frequency time series data
- Comparison of different encoders for large disturbances
- Design and compare different generalisation techniques

Education, Experience, and Skills:

The following skills, abilities, and knowledge are necessary:

- Studies in Computer Science / Engineering or related fields
- Experience with programming in Python
- Basic knowledge of neural networks, or a strong interest in them
- Interest in Information theory or willingness to learn new theory

We offer:

- Excellent support from the DRACOS group and close supervision
- Flexible working environment

1. “Analysis and Control of Frequency Stability in Low-Inertia Power Systems: A Review”.
2. “Neural Information Squeezer for Causal Emergence”.

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