POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Towards dynamic stability analysis of sustainable power grids using graph neural networks

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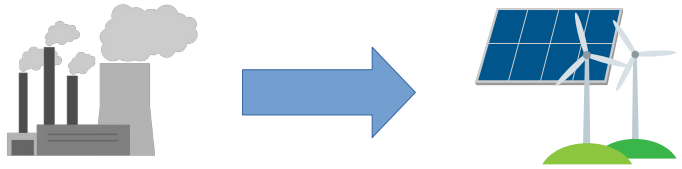
Leibniz Association

The role of power grids when replacing fossil fuels

Mitigation



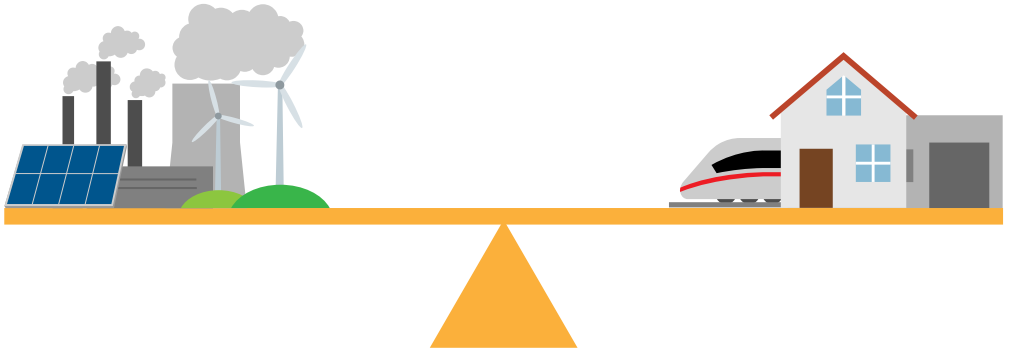
Challenges

- Decentralization
- Reduced inertia
- Volatility

Adaptation

Challenges

- Extreme weather events



Goal of power grids

- Transport of energy
- Stable grid frequency

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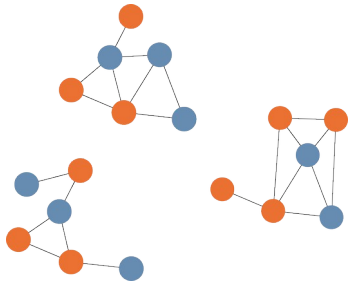
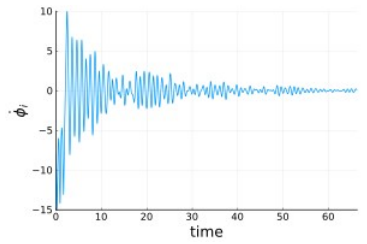
Procedure of predicting dynamic stability

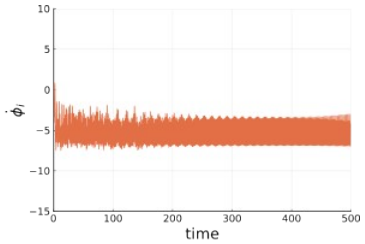
A) Generation of synthetic power grids



B) Monte-Carlo simulations to compute dynamic stability

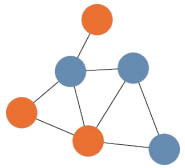


stable



unstable

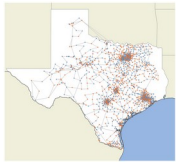
C) Training of GNN models



GNN

Dynamic stability

D) Evaluation on a large Texan power grid



GNN

Dynamic stability

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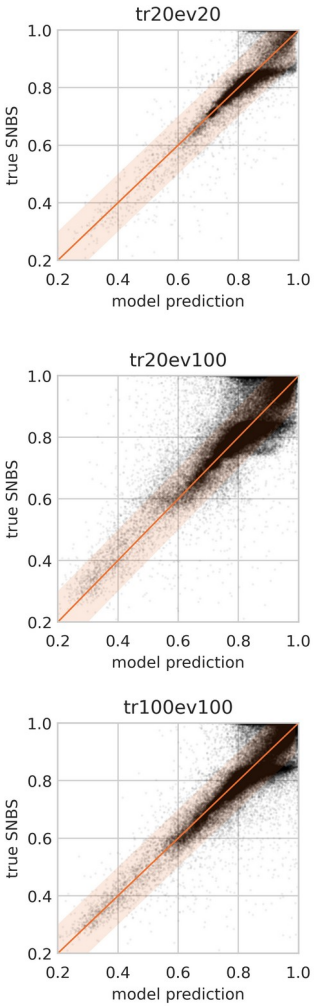
Results of predicting dynamic stability

Table 1: Results of predicting SNBS represented by R^2 score in %. Each column represents a different setup, e.g. for *tr20ev100* models are trained on dataset20 and evaluated on dataset100.

model	tr20ev20	tr100ev100	tr20ev100	tr20evTexas	tr100evTexas
Ar-bench	51.20 ± 2.762	60.24 ± 0.758	37.87 ± 2.724	40.34 ± 2.833	56.86 ± 1.444
ArmaNet	80.17 ± 1.226	87.50 ± 0.081	**68.11** ± 1.933	57.09 ± 3.079	75.43 ± 0.635
GCNNet	71.18 ± 0.137	75.25 ± 0.151	58.23 ± 0.059	-5.29 ± 3.688	65.65 ± 0.114
SAGENet	65.51 ± 0.253	75.66 ± 0.138	51.27 ± 0.298	32.63 ± 0.515	53.14 ± 2.118
TAGNet	**83.19** ± 0.080	**88.14** ± 0.081	67.00 ± 0.293	**56.05** ± 3.530	**82.50** ± 0.438
linreg	41.75	36.29	5.98	-11.39	-22.62
MLP1	58.47 ± 0.149	63.59 ± 0.051	28.49 ± 1.493	-34.52 ± 17.93	19.79 ± 8.659
MLP2	58.20 ± 0.042	65.52 ± 0.038	19.65 ± 2.109	5.81 ±10.58	58.46 ± 0.480

- Larger GNNs outperform smaller GNNs and baselines
- Models generalize out-of-distribution
- Application to real-sized grid feasible

Scatter plots of model prediction of ArmaNet for three different tasks



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Looking forward to the discussion…