Reinforcement Learning for Electrical Power System Control

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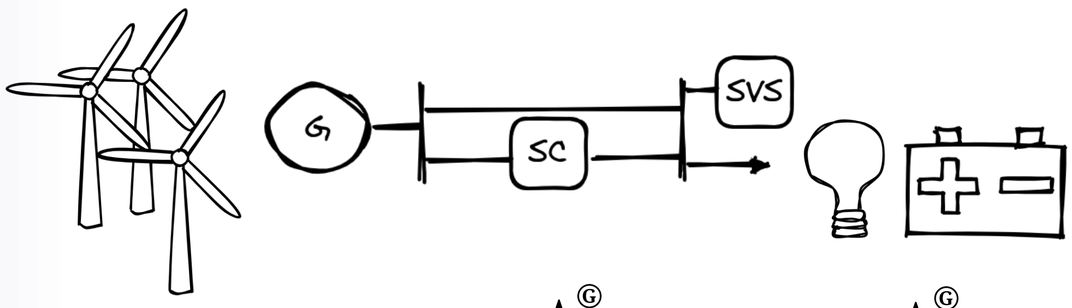
Abstract

With the growing amount of renewables and the electrification of vehicles, the electrical power system is facing substantial challenges. To meet the challenges of this system, a coordinated control of power electronic converters is investigated by use of reinforcement learning-based architectures. The aim is to enhance the power quality and increase the existing transfer capacity.

Background & Motivation

- The ongoing **electrification** and growth of **renewables** create **new challenges** for the **electrical power system**.
- Result is more volatile power flows and **elevated risk** of both system splits and **poor power quality**.
- **Power electronic converters** have been historically installed at locations with poor power quality or large electrical stress.



- A **coordinated control** of power electronic converters may **enhance power quality** and **increase transfer capacity** further.
- Model-based approaches yet to be fully adopted because of many challenges.
- **Reinforcement learning** (RL) can learn by interaction with its environment.
- RL could potentially be used for coordinated control, however **RL safety** is **crucial**.

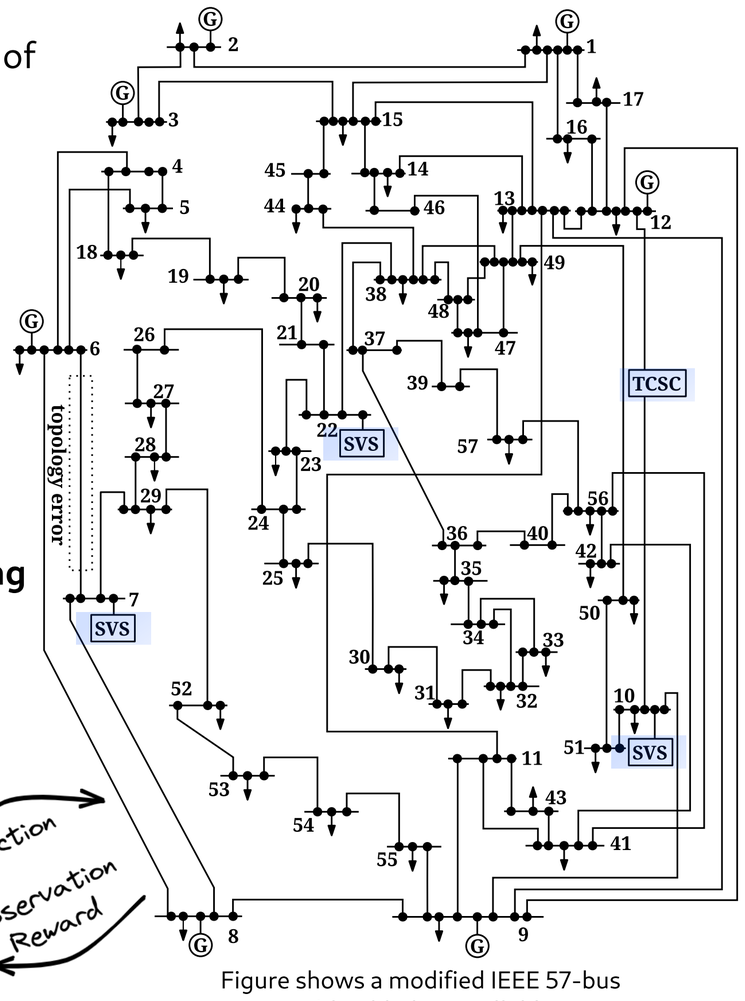
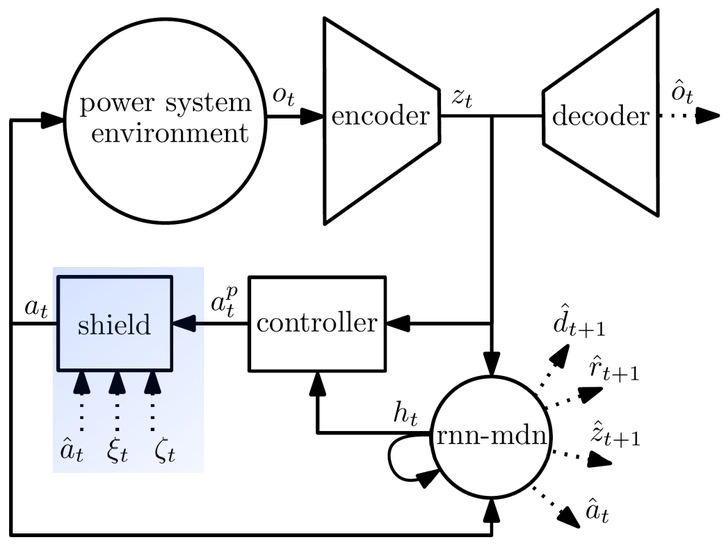
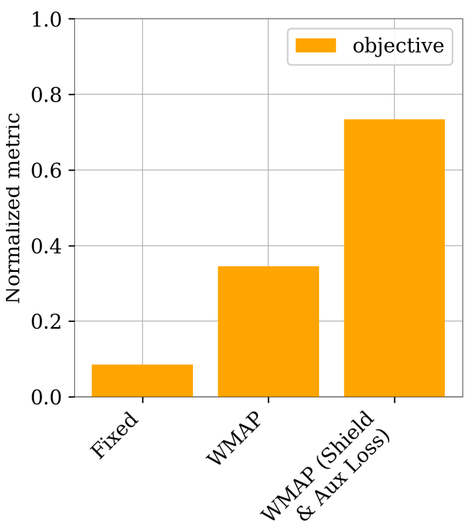


Figure shows a modified IEEE 57-bus system with added controllable power electronic converters marked in blue.

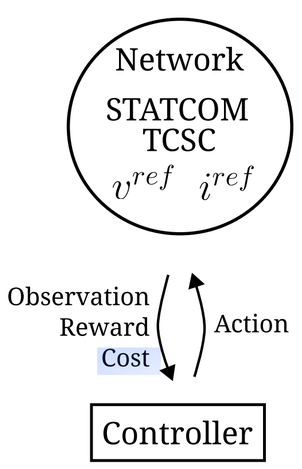
Methods & Preliminary Results

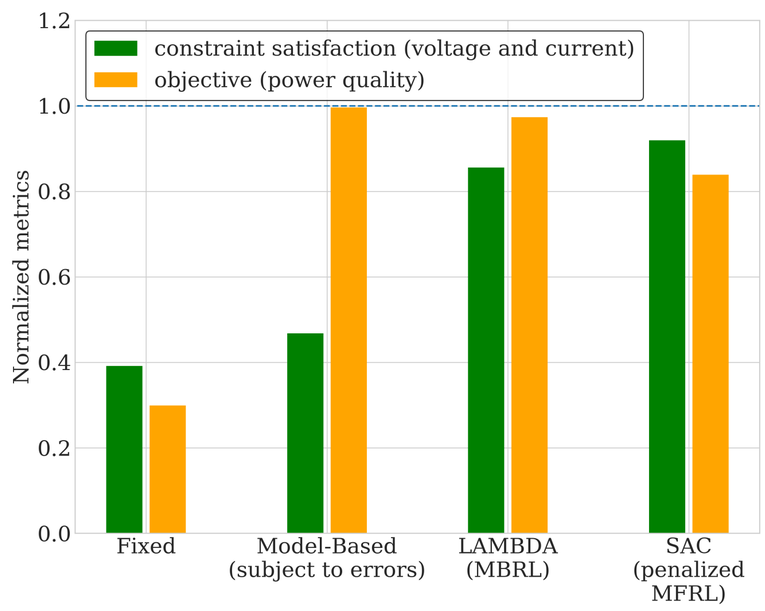
☒ Adapted a **world model-based** architecture and added an **auxiliary loss** and a **shield** to **increase safety** [1].





☒ Adapted a **Lagrangian model-based agent** architecture which uses an **augmented Lagrangian** to **increase safety** [2].



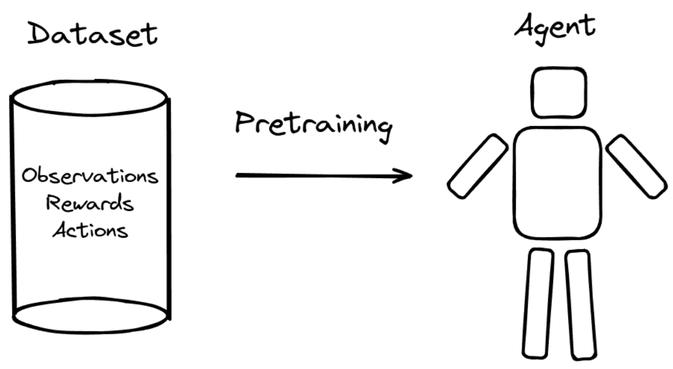


☒ Investigated the effect of **limited information** to represent cases where a significant portion of measurements are missing [3].

Future Work

☐ Ongoing:
- Extensions of [2] and [3] (papers submitted).
- **Offline RL pretraining** and online fine-tuning for **improved safety** (paper submitted).

☐ Future work considerations:
- Faster RL environment.
- Curriculum learning.



References

[1] M. Tarle, M. Björkman, M. Larsson, L. Nordström and G. Ingeström, "A World Model Based Reinforcement Learning Architecture for Autonomous Power System Control", 2021 IEEE Int. Conf. Commun. Control. Comput. Technol. Smart Grids, SmartGridComm 2021, pp. 364–370, 2021.

[2] M. Tarle, M. Larsson, L. Nordström G. Ingeström and M. Björkman, "Safe Reinforcement Learning for Mitigation of Model Errors in FACTS Setpoint Control", 2023 IEEE Int. Conf. Smart Energy Systems and Technol., 2023.

[3] M. Tarle, M. Larsson and G. Ingeström and M. Björkman, "Reinforcement Learning for FACTS Setpoint Control with Limited Information", 2024 IEEE ISGT, 2024 (paper accepted).

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SSF Swedish Foundation for Strategic Research