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A Decision Support Assistant to Operate a Power Grids with Zonal Automaton

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1. Context

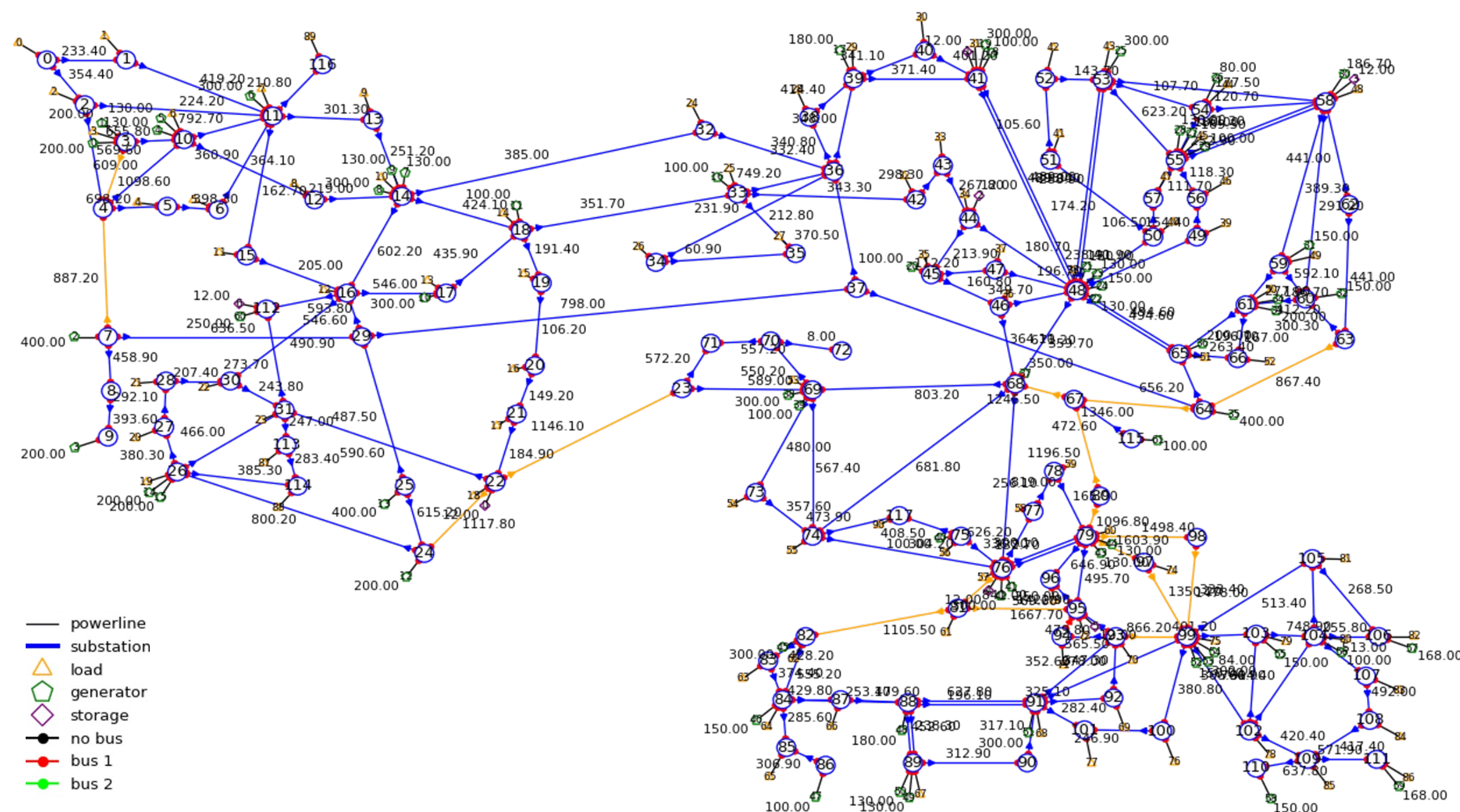
Renewable energy sources are forcing power grid operators to review their grid management strategies

R seau de Transport d' lectricit  (RTE) is developing new adaptive zonal automatons

- Each automaton monitors a zone of the power grid (up to 40 lines) thanks to an optimization algorithm.
- An automaton can act on the power grid configuration and on the electricity production.
- Each automaton can receive a target path or additional information from operators to decide the appropriate actions to be done. Examples of target path include (un)desirable configurations in future hours or information about other zones.

2. Objective

Design a decision support assistant for the supervision of zonal automatons able to recommend relevant target paths/information for automatons based on the power grid's configuration and constraints



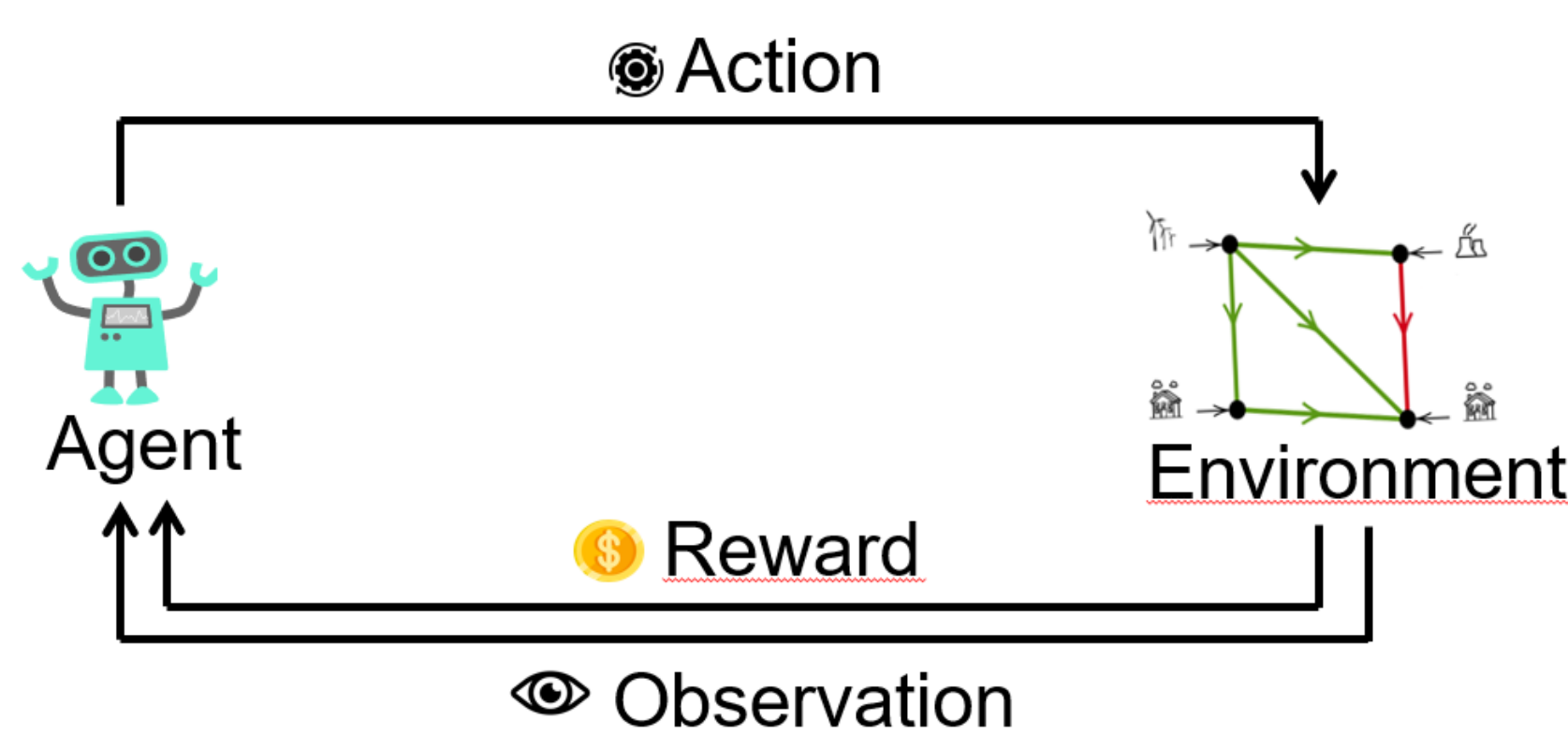
Example of a simulated power grid

3. Considered method

Reinforcement learning (RL)

RL approaches are particularly efficient for sequential problems because:

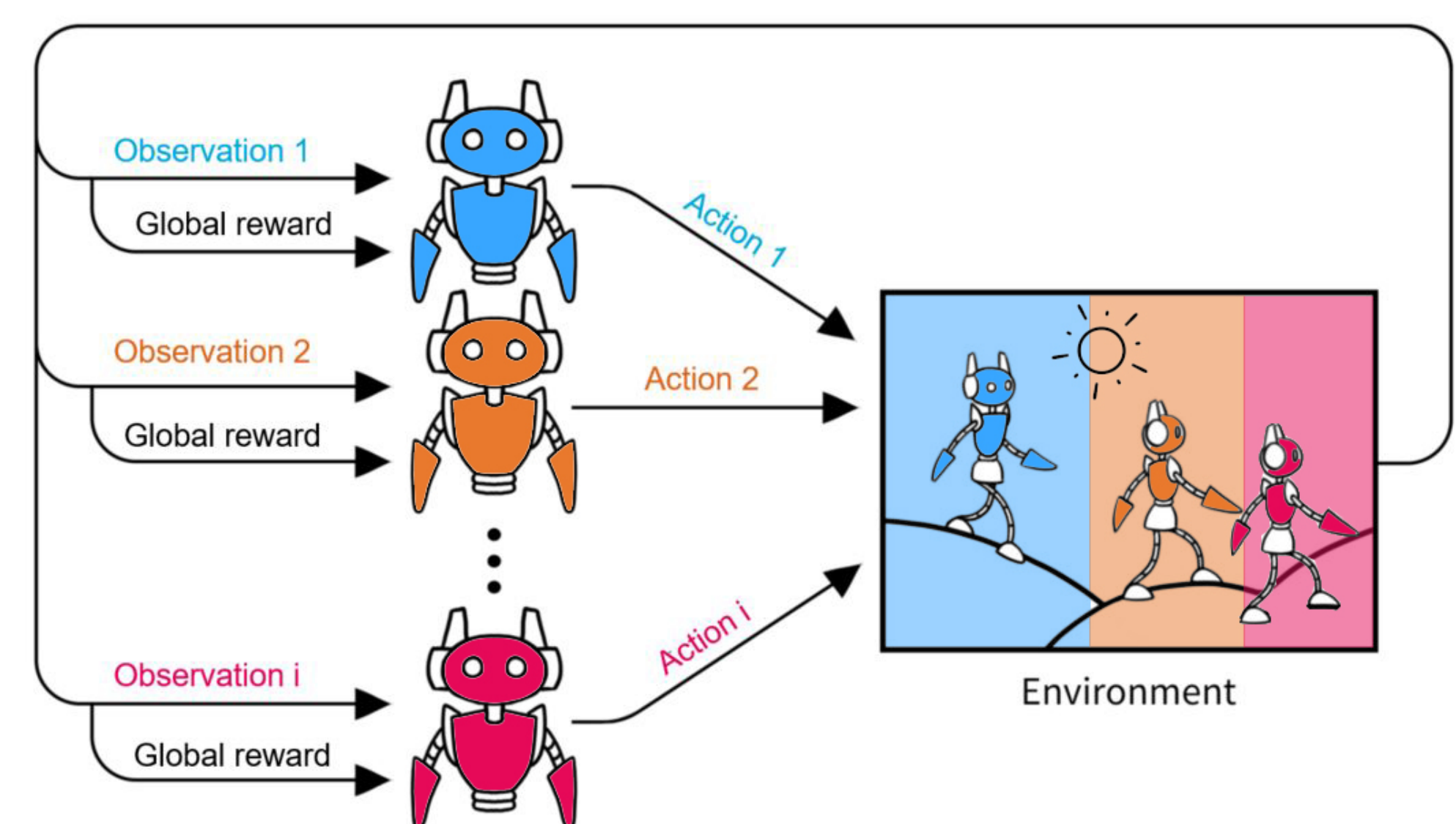
- RL is able to **anticipate** future events
- RL can take into account **uncertainties**



The principle of Reinforcement Learning

Multi-Agent Reinforcement Learning

Several agents cooperate to ensure the safety of the power grid. We think a decentralized approach could greatly **improve scalability** compared to traditional deep learning methods [1].



Decentralized multi-agent reinforcement learning

For example, each agent can be associated with a subset of automatons and their zones. In this context, at each time-step t :

- Each agent i chooses an **action** according to its observation.
- The **actions** are combined and executed
- A **reward** representing the safety of the hole grid is returned.

4. How to emulate a zonal automaton?

To obtain **reasonable computation times** during training, we need a trade-off between speed and realism.

Emulate an automaton through a reinforcement learning agent to:

- Operate the grid
- Follow a target setpoint

We designed an agent able to operate a 14-nodes power grid by controlling storage power

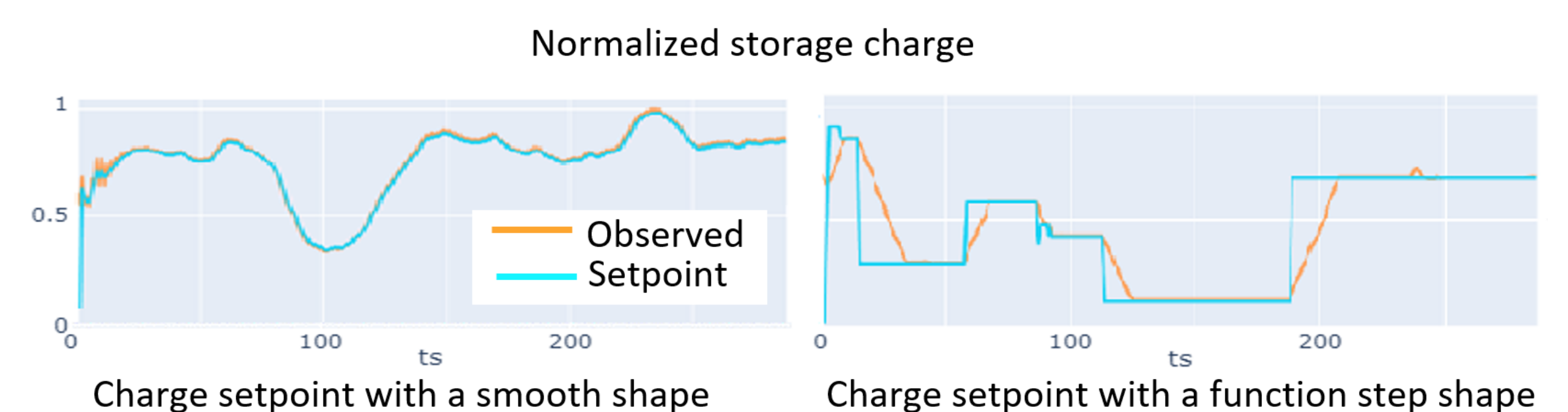
	Do Nothing Agent	RL Agent
Average number of survived	206/288	279/288
time steps per episode		

Performances of our agent on a 14-nodes simulated grid

We designed an agent able to follow a storage charge setpoint

We got interesting results about:

- how to penalize deviations from the setpoint.
- the impact of hyperparameters.
- the ability to **generalize to other shapes of setpoint** which is great as illustrated in the figures below.



Comparison of observed charge with a smooth setpoint or a step function setpoint

References

- [1] Karl Johan  str m. Optimal control of markov processes with incomplete state information. *Journal of mathematical analysis and applications*, 10(1):174–205, 1965.