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State and Action Factorization in Power Grids

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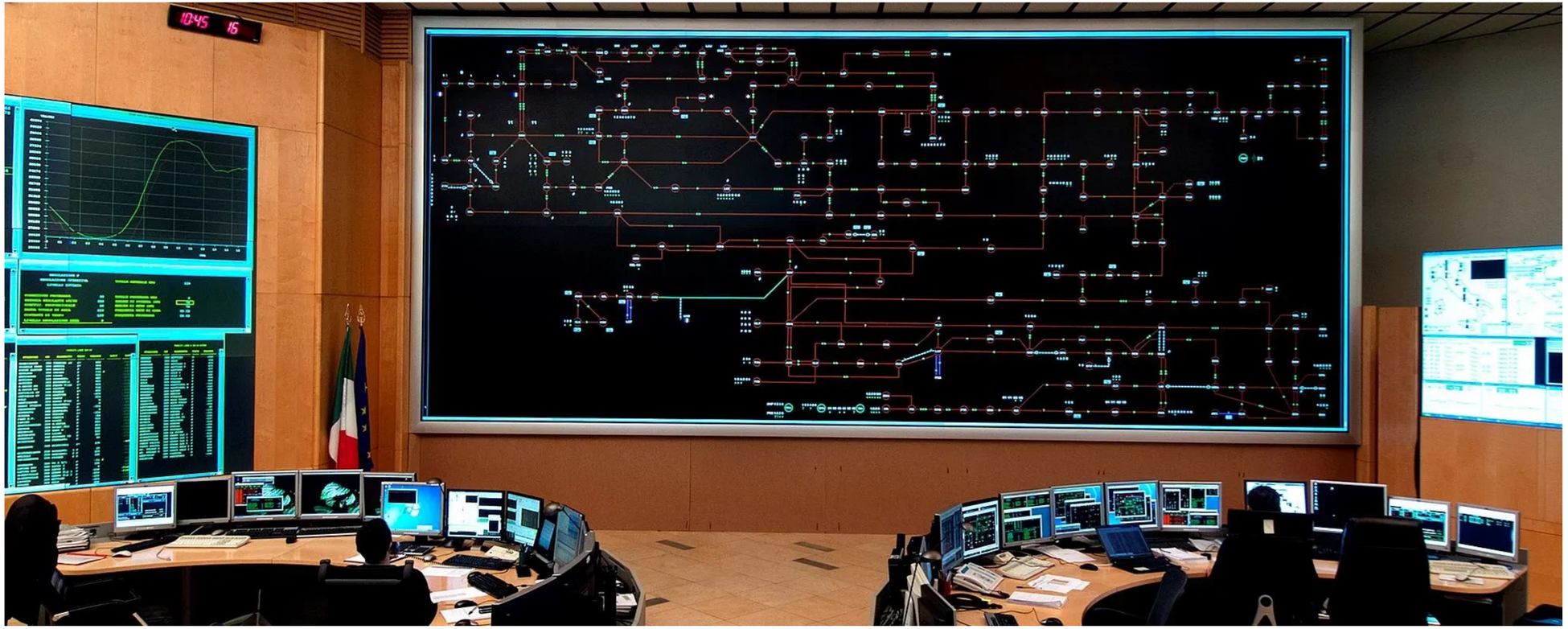
AI to support control room operators



Increasingly complex towards carbon neutrality!

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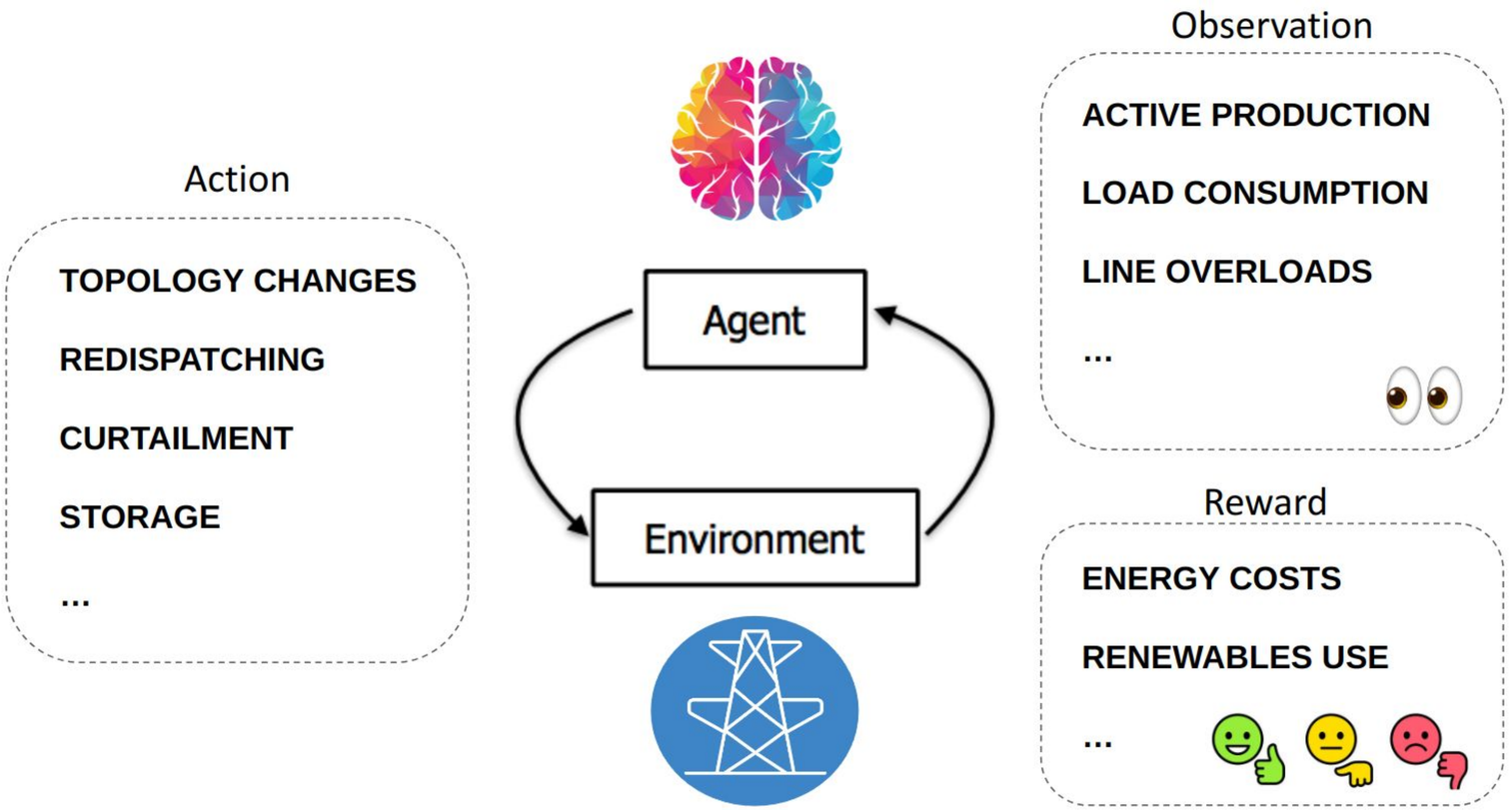
Reinforcement learning for power grids



GOAL: "Find remedial actions that human operators are unaware of or unaccustomed to"

Lots of papers in the last few years (mainly after the L2RPN competition series)

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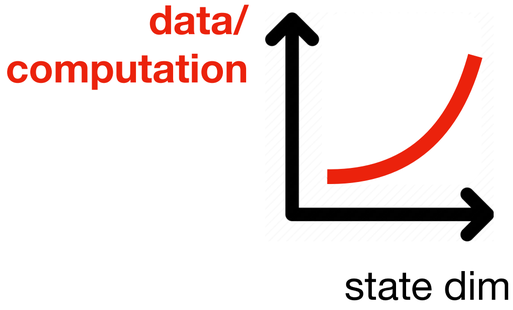
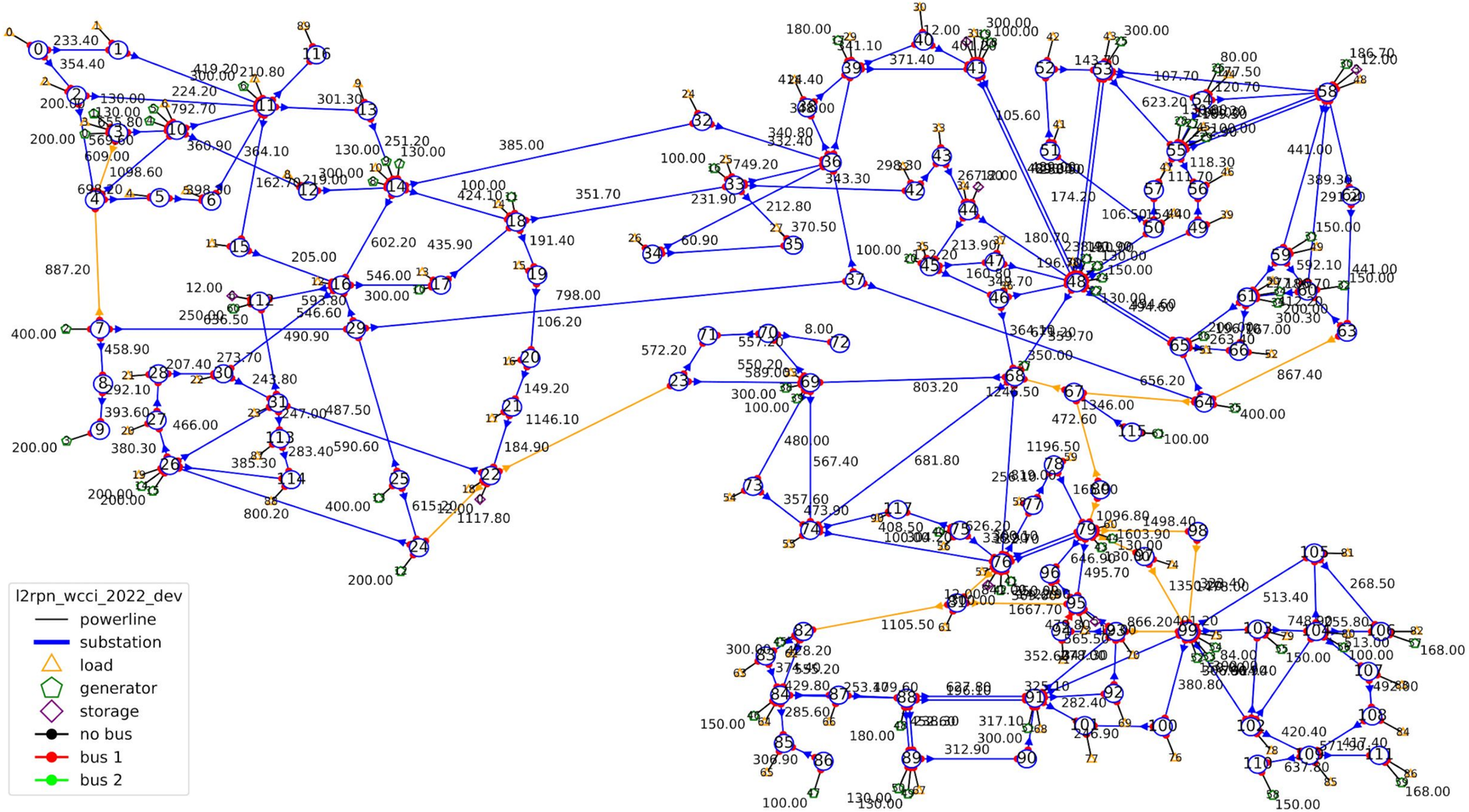
The curse of dimensionality





Solution: power grid segmentation

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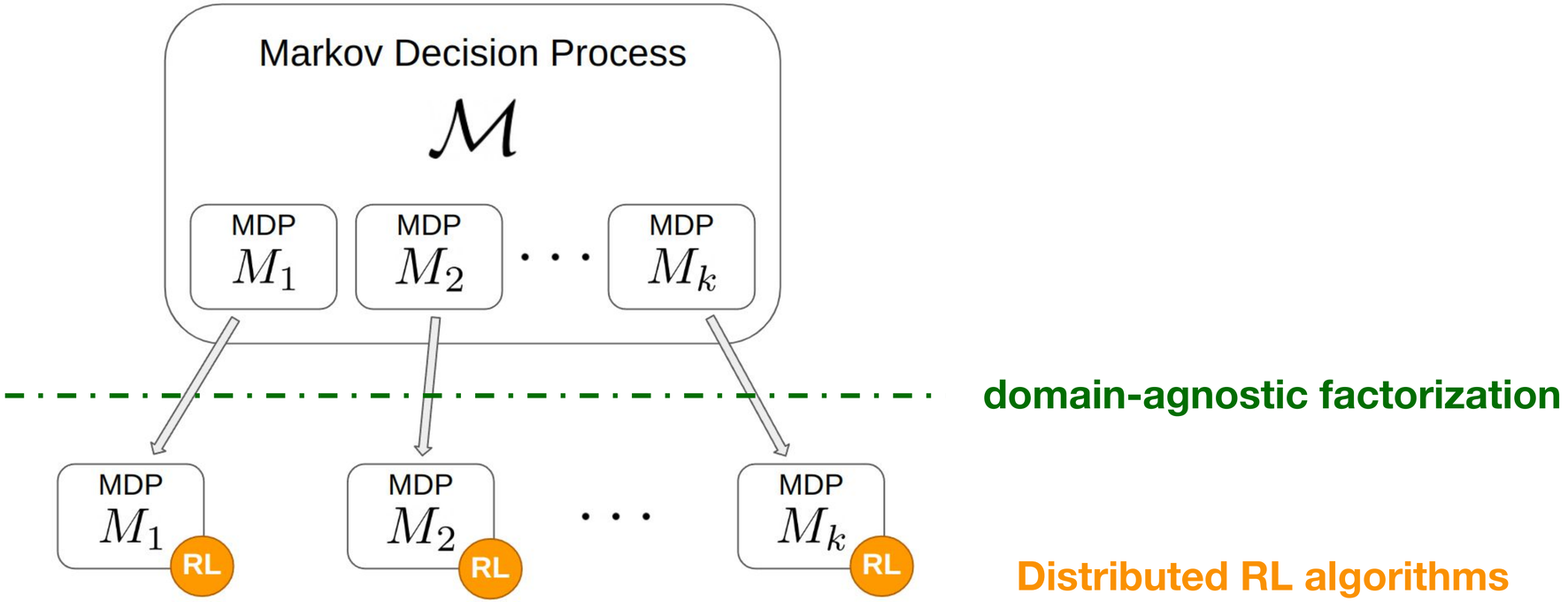
Original contribution

- **Algorithm** for data-driven factorization of the state and action space in power grids



- **Validation** on a power grid benchmark (open-source simulator Grid2Op)

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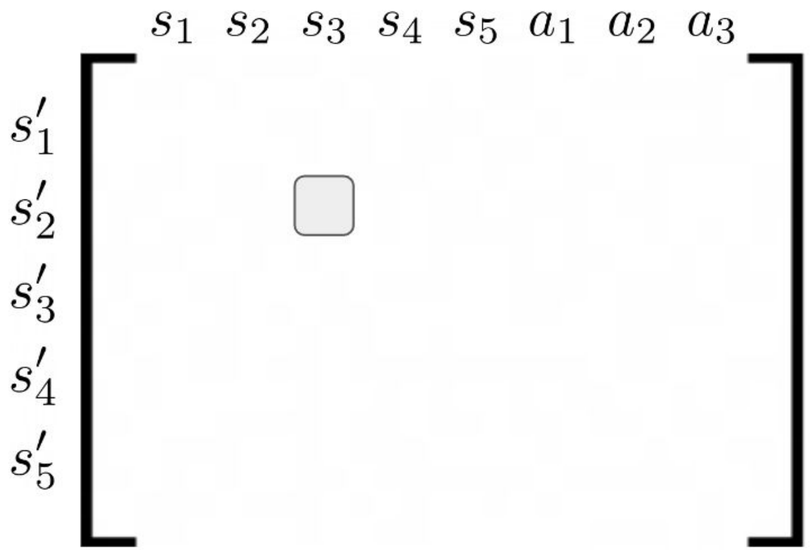
Algorithm

1. Collect a dataset of transitions from the original MDP → $\mathcal{D} = \left\{ (\mathbf{s}, \mathbf{a}, \mathbf{s}')_t \right\}_{t=1}^{T}$

2. Compute the matrix of Mutual Information (MI)



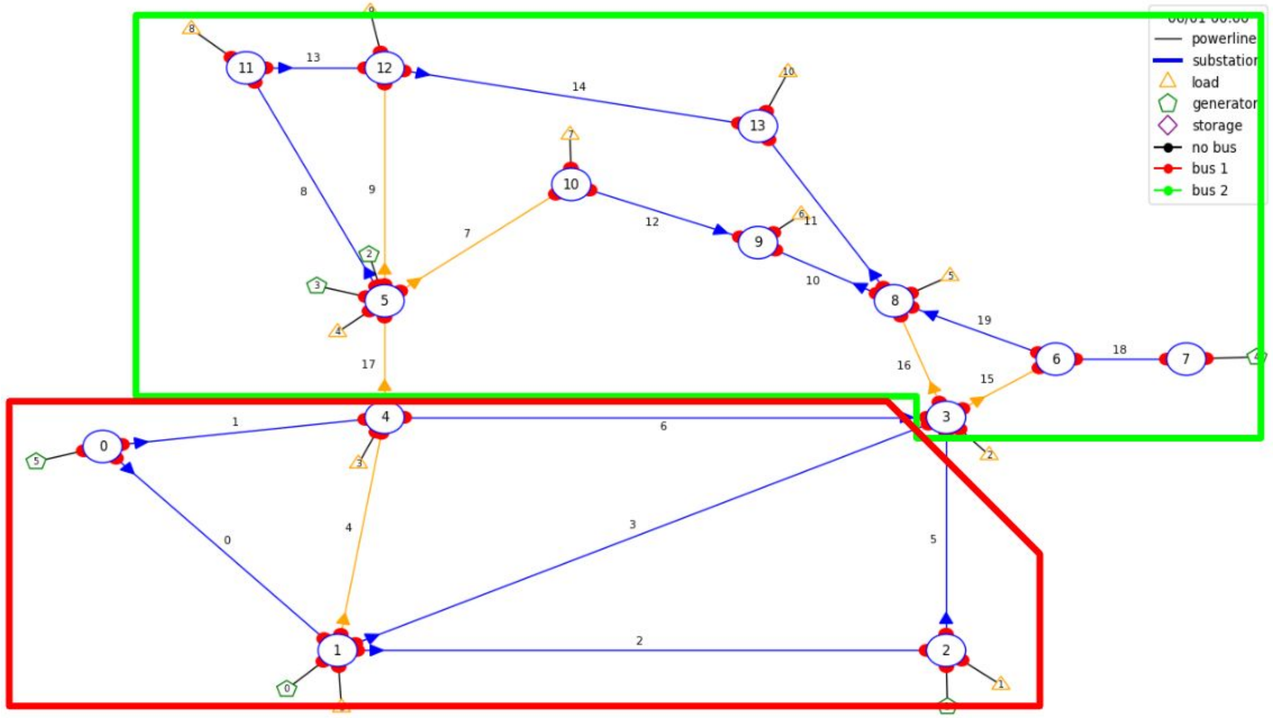
$= \mathrm{MI}\left(s'_2, s_3\right)$

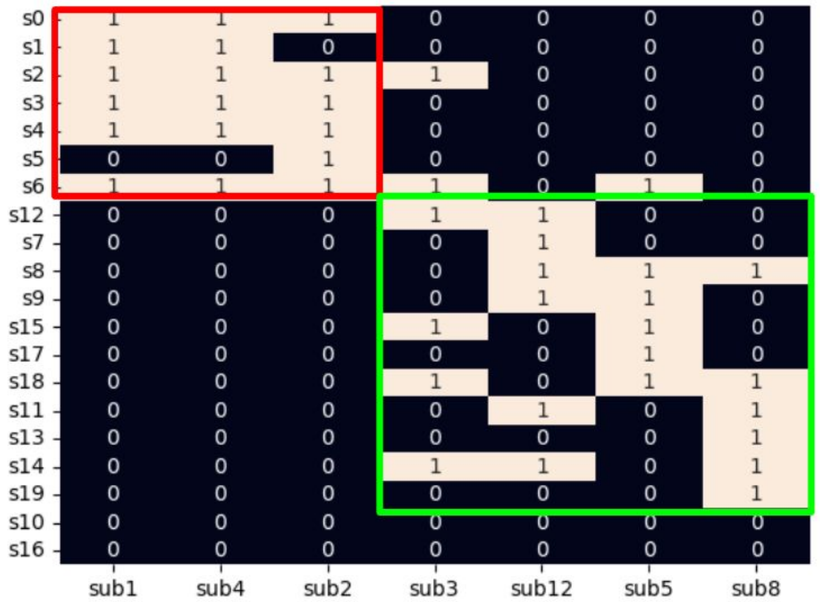
(estimated on the dataset $\mathcal{D}$)

3. Transform it into a pseudo block-diagonal matrix (after applying a threshold) → block = MDP

Experiment

IEEE case14 benchmark
(Grid2Op open-source simulator)
4 substations · 20 lines · 6 generators · 11 loads





Performance: $\left\| I_{\mathcal{G}} - \widehat{I}_{\mathcal{G}} \right\|_F^2$ approx. by similarity to domain-expert analysis*

*Marot et al. "Guided machine learning for power grid segmentation" (2018)

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Conclusion

- Scaling RL solutions to large power grids can be challenging (**curse of dimensionality**, ...)
- We introduced a **domain-agnostic algorithm** for the factorization of state and action spaces in power grids
- Each state/action subset is an MDP that can be solved with **distributed RL algorithms**
- **Promising results** on a power grid benchmark (in line with domain-expert analysis)

Future work = { larger grids, hyperparams, correlation metrics, clustering, ... **}**

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