NEURAL INFORMATION PROCESSING SYSTEMS

IMP-MARL: a Suite of Environments for Large-scale Infrastructure Management Planning via MARL

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Paper: https://arxiv.org/abs/2306.11551

Project page: https://github.com/moratodpg/imp_marl

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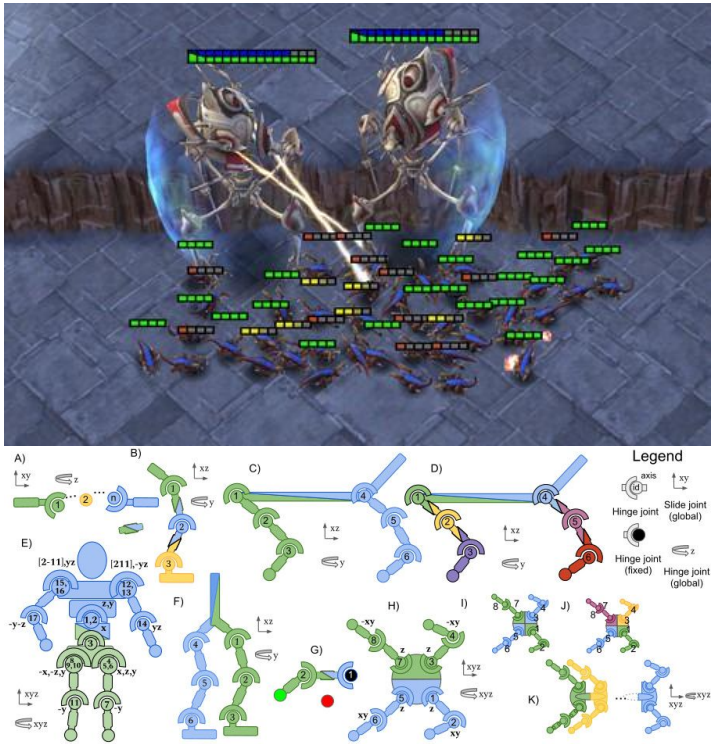
Motivation

Multi-agent reinforcement learning (MARL)

- Cooperative settings
- Many available **open-source** methods
- Common benchmarks are **games** or **simulators**



SMAC, MaMuJoCo, MPE, Hanabi,...

Gap:
Only few **real-world** environments
Only few **large-scale** environments

Motivation

Infrastructure management planning (IMP)

- Impactful **real-world** application
- Inspections and maintenance planning, minimising system failure risk and maintenance costs
- Effective multi-component policies can be learned via **MARL**

Gap:
Most studies are **not open-sourced**
Most development **are not compared** against SOTA MARL algorithms

Wind turbines, bridges, water networks, …

IMP-MARL: Main contributions

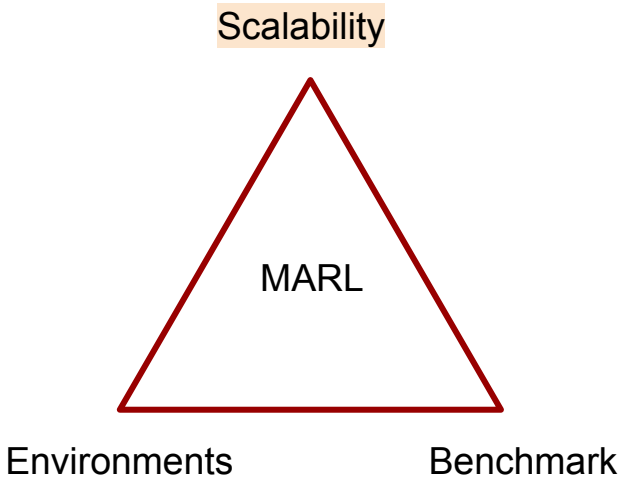
1. A novel **open-source** suite with **real-world** environments

   "Up to 100 agents!"

2. Benchmark **SOTA** cooperative MARL methods

3. Highlight important challenges that must be resolved

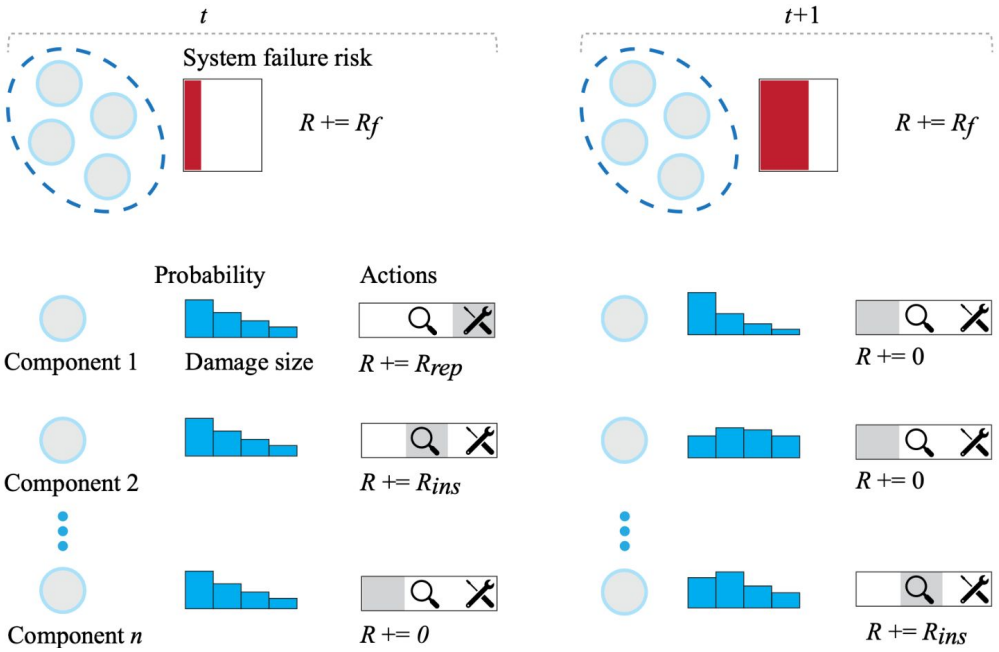
   "Are cooperative MARL methods **scalable?"**



Infrastructure Management Planning (IMP)

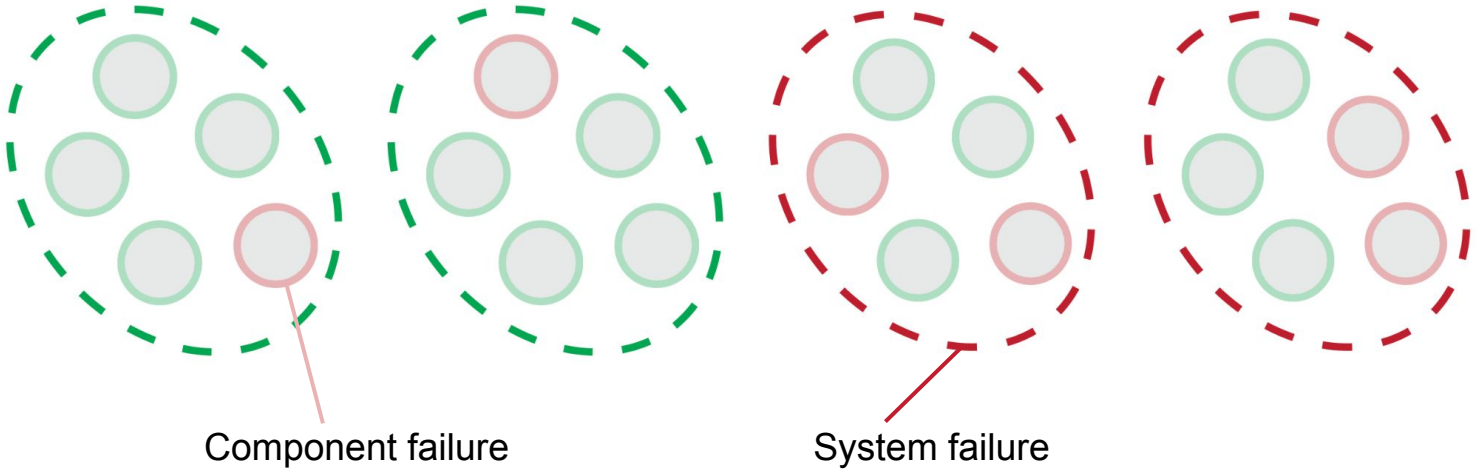
Managing *n* components:

- *Inspect* or *repair* or *do-nothing* based on components' damage probability?
- **System** failure risk **depends** on the **components'** failure probability
- Goal:
  - Minimise maintenance costs
  - Avoid system's failure
- Challenge:
  - Joint **action space** exponentially growing with ***n*** (number of agents)
  - Do-nothing action usually dominates (class imbalance)



IMP-MARL: Environments

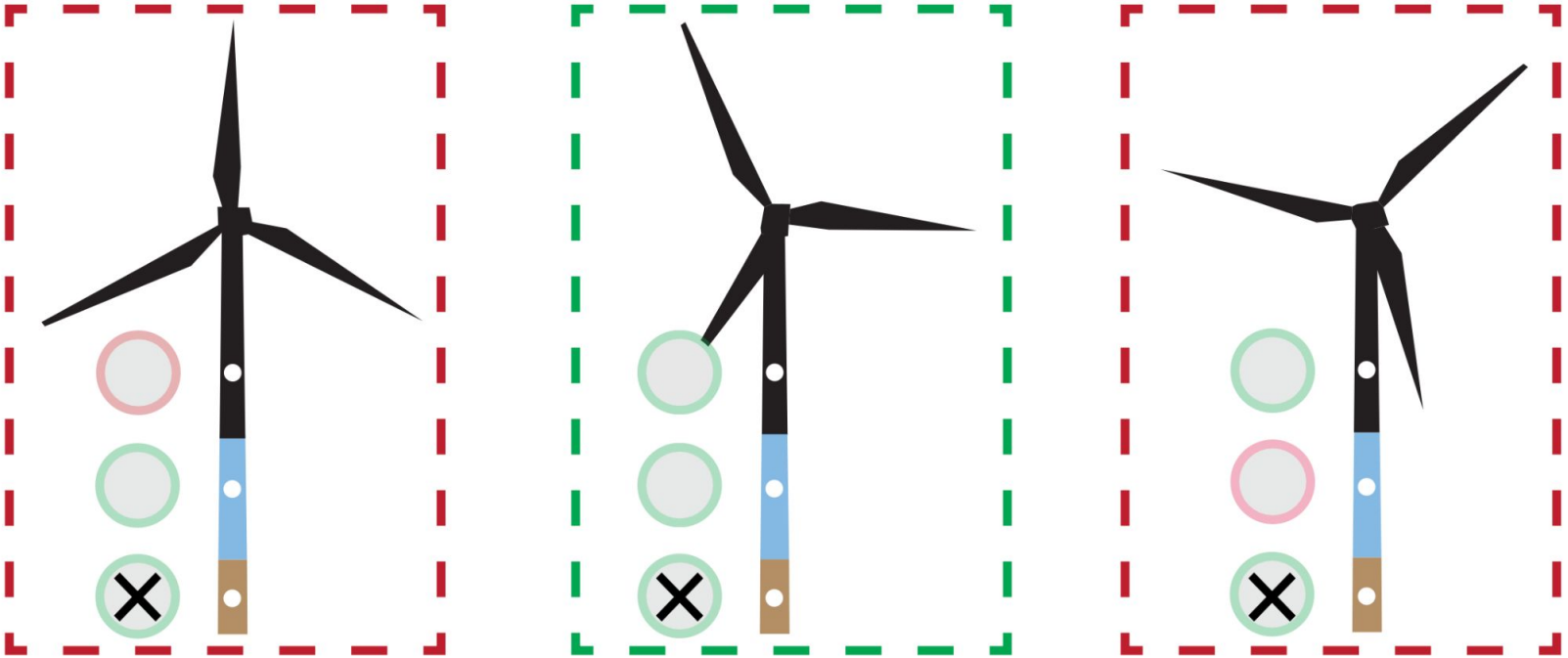
k-out-of-n systems: (4-out-of-5 system)



https://github.com/moratodpg/imp_marl

IMP-MARL: Environments

Offshore wind farm: 3 representative components per wind turbine



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IMP-MARL benchmark

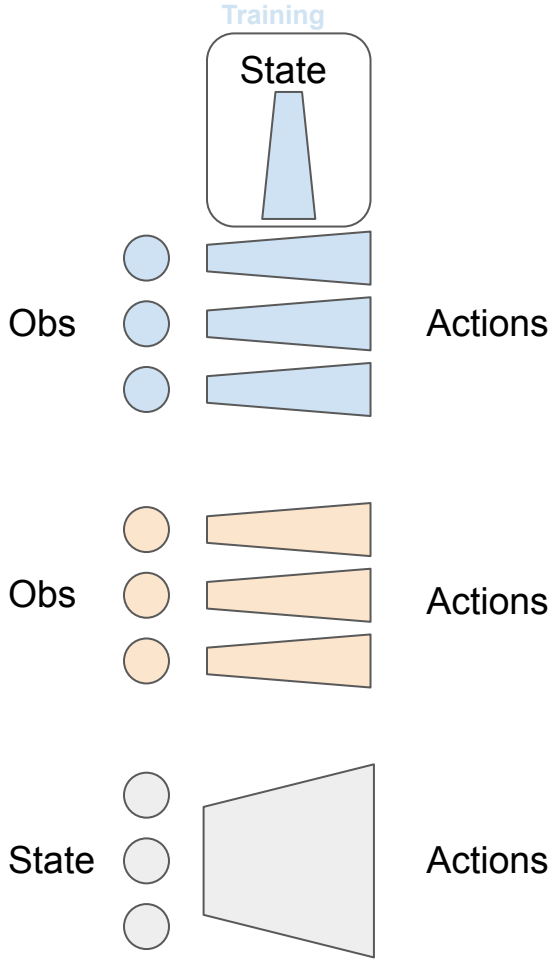
Goals:

- MARL vs heuristic ?
- Scalability ?

Methods

- Centralised training with decentralised execution: QMIX, QVMIX, QPLEX, COMA, FACMAC
- Decentralised: IQL (DQN for each agent)
- Centralised: DQN
- Heuristic: rule-based **baseline** from the reliability community

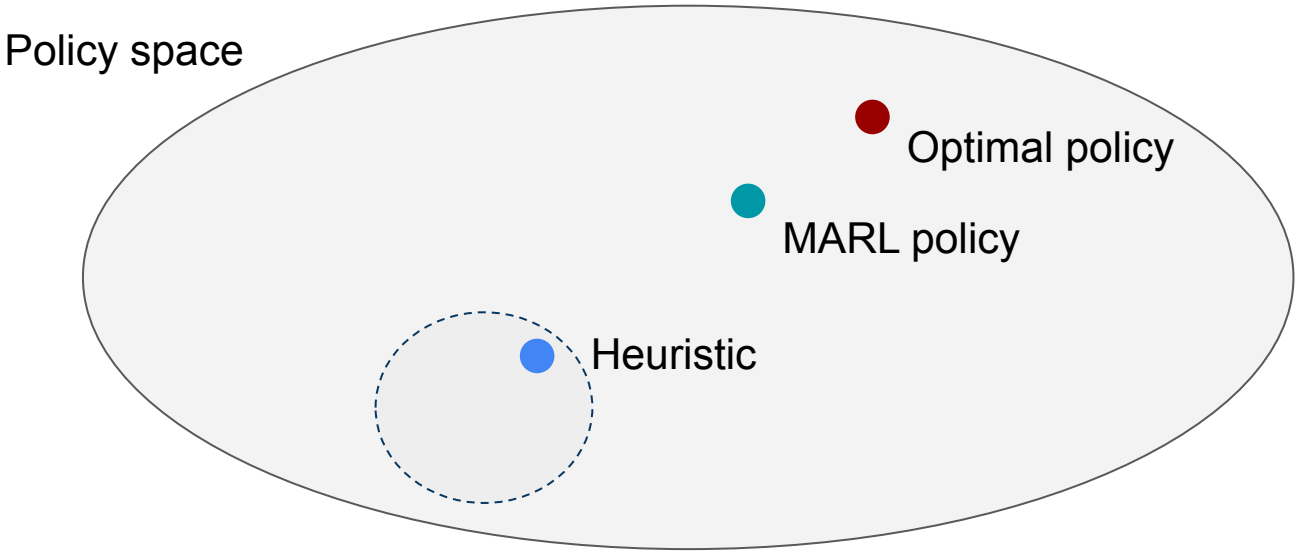
*Performance evaluated with respect to the heuristic



Benchmark results

MARL vs heuristic:

- **CTDE** methods generally **outperform heuristics**



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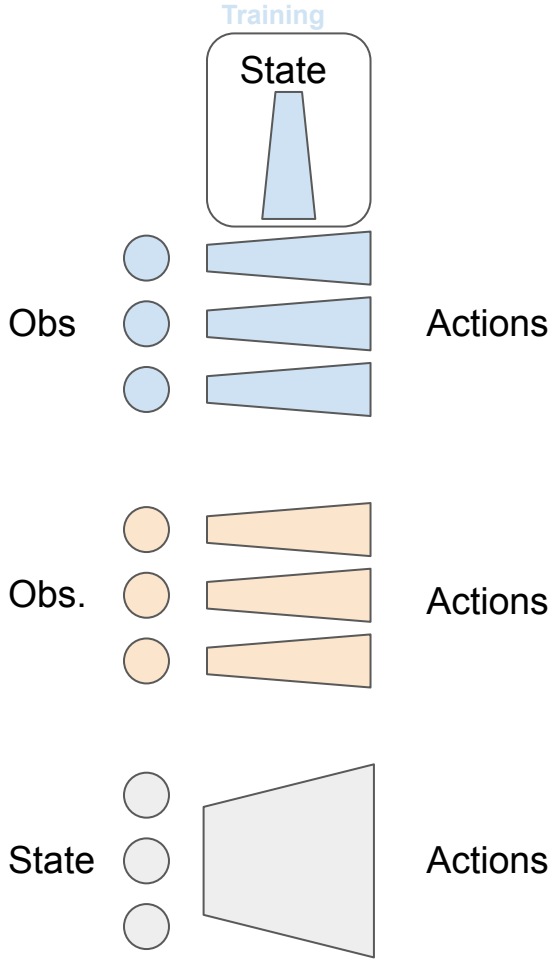
Benchmark results

Scalability ?

- **Centralised RL** methods **do not scale well** with the number of agents
- IMP environments demand **cooperation** among agents: CTDE >> decentralised
- Remaining challenges
  - Correlated environments
  - Group campaign costs



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Future work

Ultimate goal:

- **Scalable MARL** applied to real-world problems

What we did:

- Py**MARL** benchmark

What we have:

- **Compatibility** with CleanRL, TorchRL, BenchMARL, Epymarl,...

What we need:

- Use **IMP-MARL** in your study
- **New** IMP environments
- More **challenges**
- Contribute to the repository!