Revisiting Some Common Practices in Cooperative Multi-Agent Reinforcement Learning

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Goal

Revisiting common design principles in
Cooperative Multi-Agent ML

- Value Decomposition (VD)
- parameter sharing

Propose method to resolve limitation of common methods

Background: Value-Decomposition (VD)

$$Q_{\text{tot}}\left(s, \mathbf{a}\right) = f_{\text{mix}}\left(Q_1\left(o^1, a^1\right), \ldots, Q_n\left(o^n, a^n\right); s\right),$$

XOR game:

	1	2
1	0	1
2	1	1

Can’t solve multi-modal problem

Policy Gradient

- parameter sharing → can’t solve
- Individual policy → single optimal mode &
  may challenge optimization
- ID-conditioned policy → single optimal mode

Policy for Multi-modal

Executing Individual PG with every agent order can achieve this, but need large computation

Covering all modes with single policy??

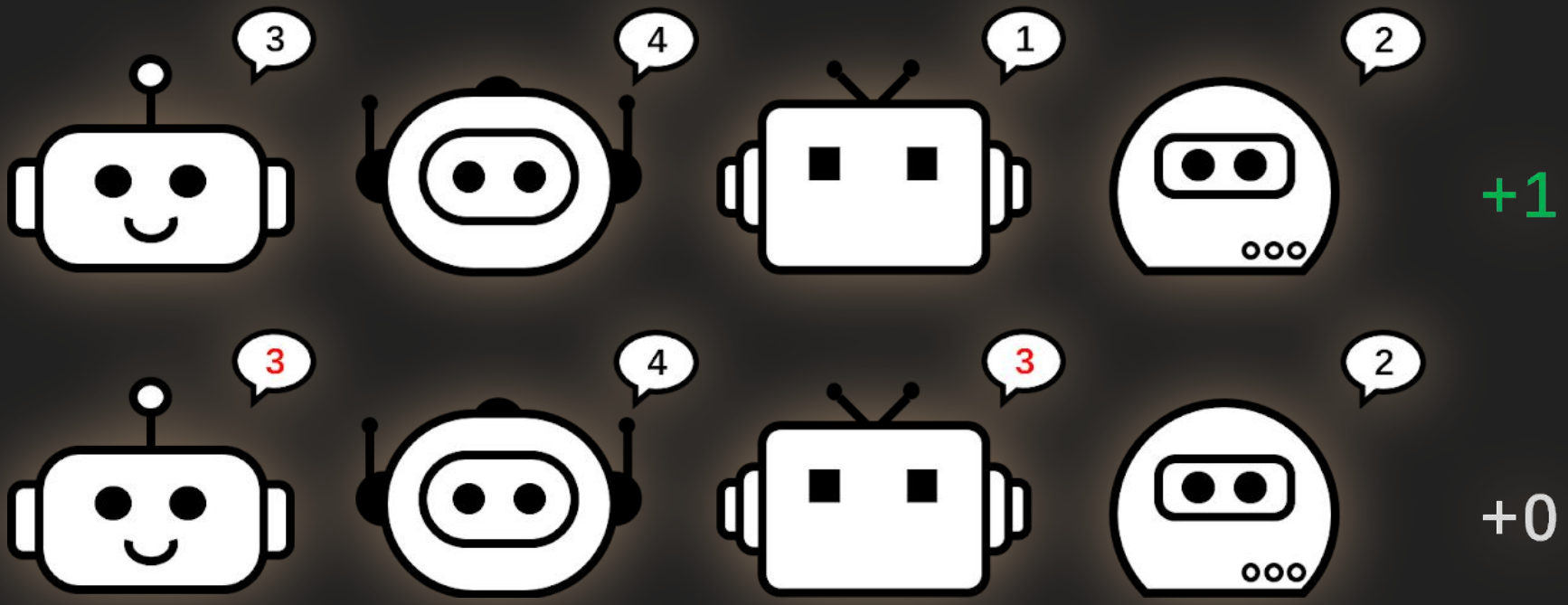
PG-AR (Auto-Regressive)

Individual: $\pi(\mathbf{a} \mid \mathbf{o}) \approx \prod_{i=1} \pi_{\theta_i}\left(a^i \mid o^i\right)$

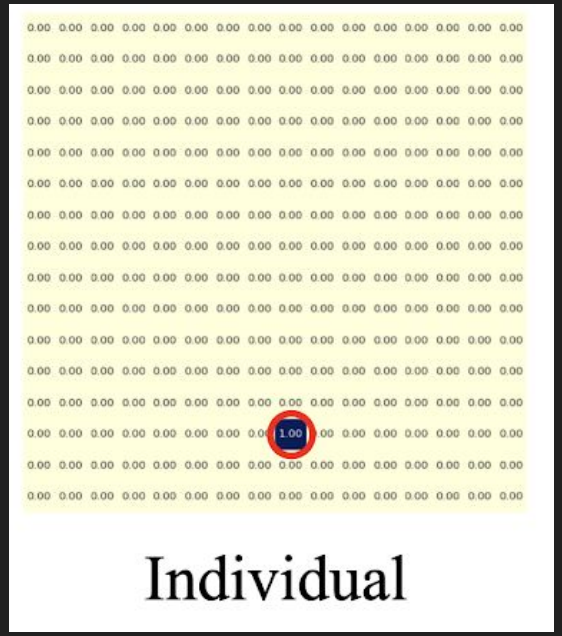
PG-AR: $\pi_\theta(\mathbf{a} \mid \mathbf{o}) \approx \prod_{i=1}^{n} \pi_{\theta^{x_i}}\left(a^{x_i} \mid o^{x_i}, a^{x_1}, \ldots, a^{x_{i-1}}\right)$

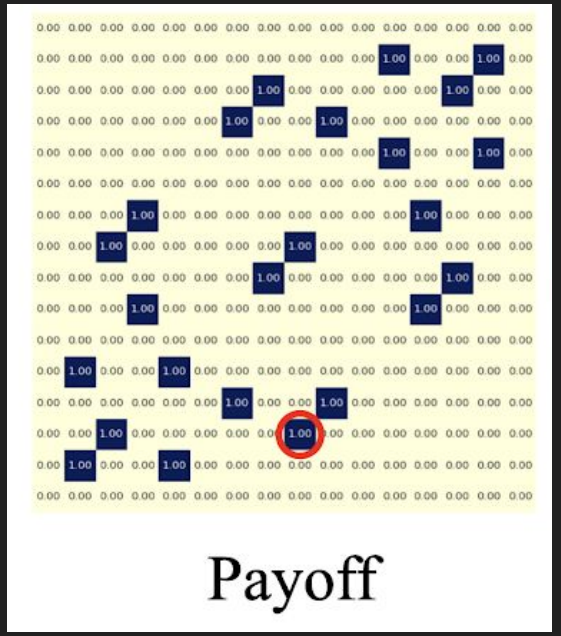
PG-AR
In XOR game: $\pi\left(a^1, a^2\right) = \pi\left(a^1\right) \pi\left(a^2 \mid a^1\right)$

Permutation game



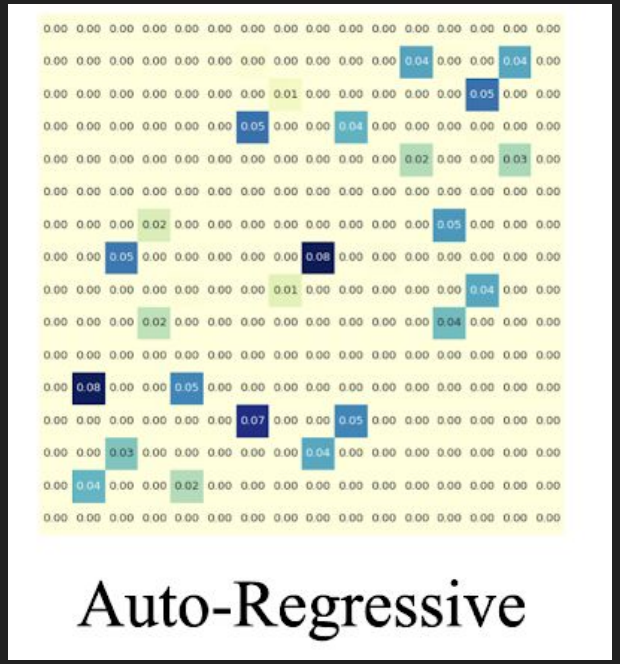
Individual policy: 4-agent permutation game

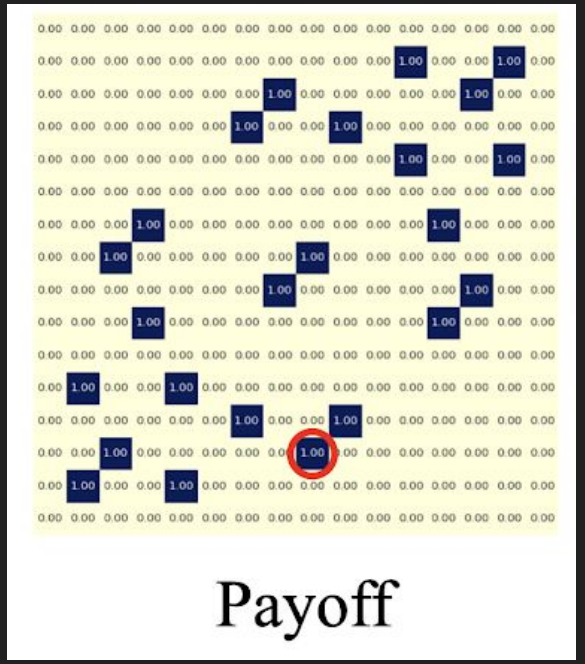




PG-AR (Auto-Regressive)

Multi-modal policy





Training Paradigms

- Multi-step optimization
  minimize calculation

- Randomized execution order
  prevent overfitting

PG-AR on Popular Testbeds

StarCraft

- Alternate attacking with other agents

Google Research Foot-ball

- keeps short passing the ball to other

It took a lot to optimize, but learned new behavior

Conclusion

In multi-modal scenarios, Value-decomposition and parameter sharing can lead unsatisfying behavior.

Policy gradient can learn multi-modal behavior by using auto-regressive.

Thank you for your attention.