

Communication in Multi-agent Reinforcement Learning

Jack Montgomery

November 14, 2024

MAM4001W: Advanced Topics in Reinforcement Learning

2024-11-14

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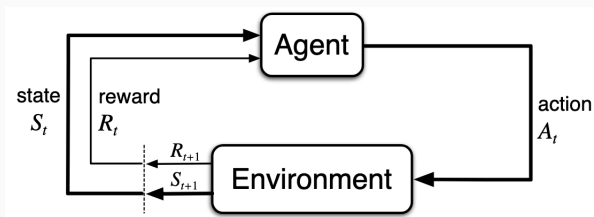
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Communication in Multi-agent Reinforcement
Learning
└
Motivation

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Communication in Multi-agent Reinforcement

Learning

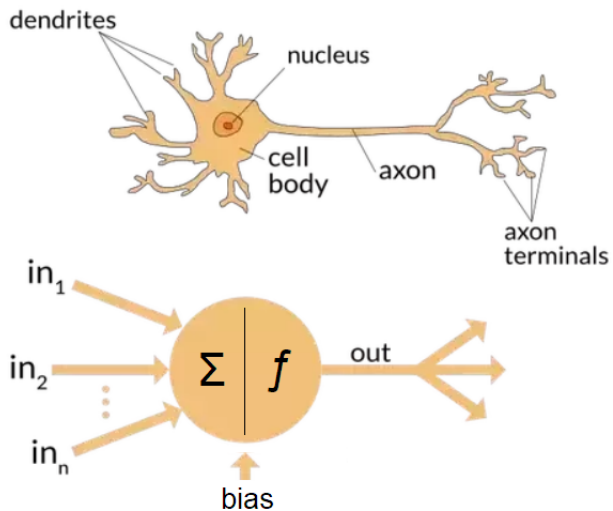
└ Motivation

└ Motivation



1. joke: spend a lot of time here
2. Neuroscience: human brain is believed to be devoted to the dopamine system reflects the reinforcement learning loop
3. Psychology: Classical conditioning: how and why animals behaviour happens when you give them a treat

Motivation



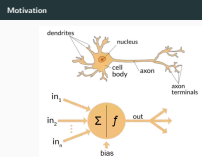
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Communication in Multi-agent Reinforcement

Learning

Motivation

Motivation



1. Neural networks structured on how our brain performs computations with neurons
2. Varying degrees of biological plausibility, but the point is that it was motivated by the human experience

- Non-stationarity
- Credit Assignment
- Scaling

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Communication in Multi-agent Reinforcement
Learning
└─ Motivation
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Motivation

- Non-stationarity
- Credit Assignment
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1. It is reasonable to then approach problems we see in multi-agent reinforcement learning too with the tools from human coordination/competition - communication

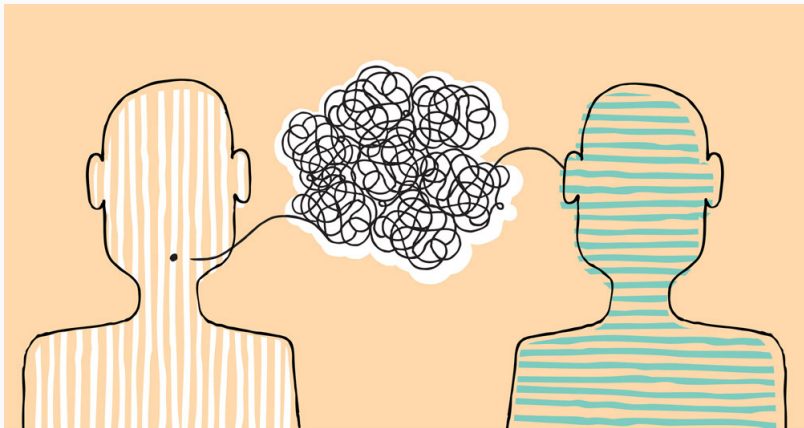
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Communication in Multi-agent Reinforcement
Learning
└─ Comm-MARL

Comm-MARL

Comm-MARL

How do we communicate?



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Communication in Multi-agent Reinforcement Learning

└ Comm-MARL

└ How do we communicate?



1. Sign language, inflection
2. finite lexicon with infinite utterances
3. Norm Chomsky
4. Identify and classify

Dimensions of Comm-MARL

Component	Index	Question	Dimension
Problem Setting	1	What kind of behaviours are desired to emerge with communication?	Controlled Goals
	2	How to fulfil realistic requirements?	Communication Constraints
	3	Which type of agents to communicate with?	Communicatee Types
Communication Processes	4	When and how to build communication links among agents?	Communication policy
	5	How to combine received messages?	Message combination
	6	Which piece of information to share?	Communicated messages
	7	How to integrate combined messages into learning models?	Inner integration
Training Processes	8	How to train and improve communication?	Learning methods
	9	How to utilise collected experience from agents?	Training schemes

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Communication in Multi-agent Reinforcement Learning

- └─ Comm-MARL
 - └─ Method

Method

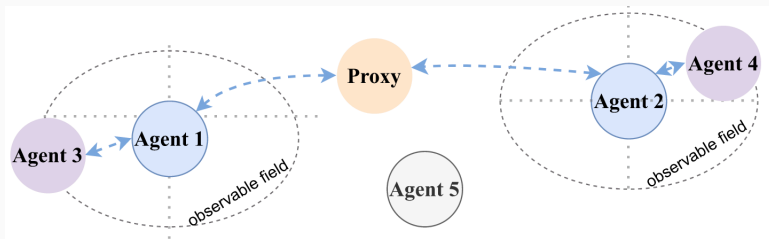
1. RIAL and DIAL (Foerster et al., 2016)
2. CommNet (Sukhbaatar et al., 2016)
3. BiCNet (Peng et al., 2017)
4. IC3Net (Singh et al., 2019)
5. NeurComm (Chu et al., 2020)
6. HAMMER (Gupta et al., 2022)

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Introduce briefly

1. Differentiable and Reinforced Inter Agent Learning: Messages are output as part of a neural network
2. Communication Network: Messages are not explicitly output but rather average of the states of the neural network
3. Bidirectionally-Coordinated Networks: Bidirectional RNN hidden states passes forward then backward
4. Individualized Controlled Continuous Communication Network: CommNet with a gating mechanism
5. Neural communication protocol: Networked model where messages are the unions of observations, policy fingerprint, hidden state
6. Heterogeneous Agents Mastering Messaging to Enhance Reinforcement learning: PPO with a central communicator called a proxy

Communcatee Types



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Communication in Multi-agent Reinforcement Learning

Comm-MARL

Communcatee Types

Communcatee Types



1. Nearby: Neurcomm create a network of agents connected
2. IC3Net: Gating mechanism to communicate or not with other agents - competitive and mixed scenarios
3. Proxy: Hammer - differentiable and reinforced

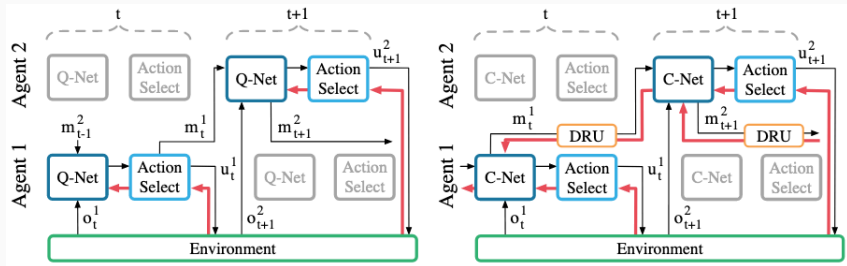
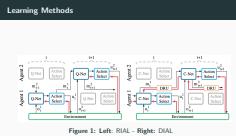
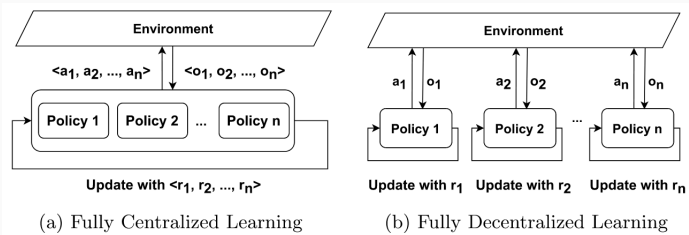
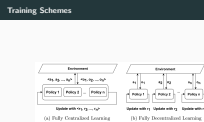
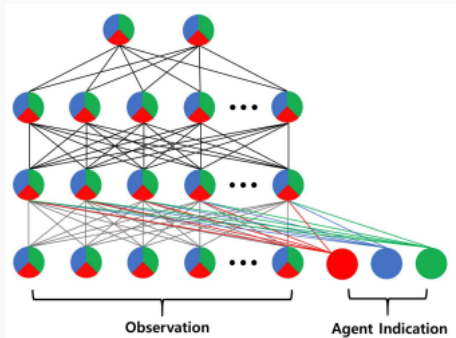


Figure 1: Left: RIAL - Right: DIAL

1. RIAL and HAMMERv1: Reinforced
2. FIAL and HAMMERv2,3: Differentiable



1. Fully Centralised Learning: None
2. Fully Decentralised Learning: NeurComm

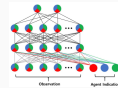


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Communication in Multi-agent Reinforcement Learning

- Comm-MARL
 - Training Schemes

Training Schemes



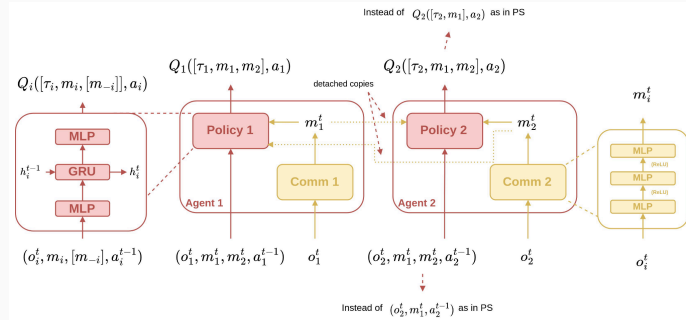
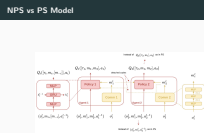
1. Everything: DIAL and RIAL, CommNet, IC3Net

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Communication in Multi-agent Reinforcement
Learning
└ Investigation of Parameter Sharing

Investigation of Parameter Sharing

Investigation of Parameter Sharing

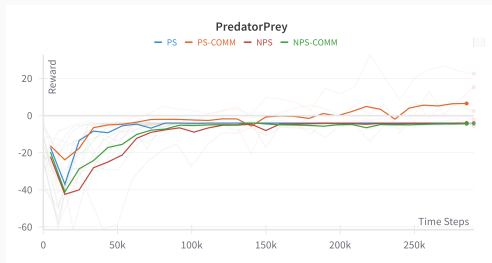


1. Detachment of the computational graph when not using parameter sharing - so they require their own message as input to keep the computational graph connected
2. Formally show how the gradients will be calculated in this independent scheme

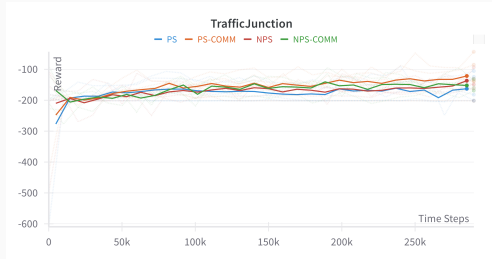
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Communication in Multi-agent Reinforcement Learning

Investigation of Parameter Sharing



(a)



(b)



1. Runtime: PS: 8 minutes, PS-COMM: 10 mins, NPS: 13 mins, NPS-COMM: 24 mins

References

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