Communication in Multi-agent Reinforcement Learning

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MAM4001W: Advanced Topics in Reinforcement Learning

Motivation

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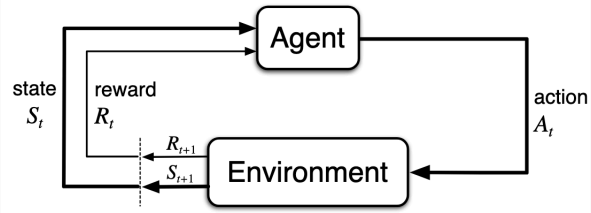
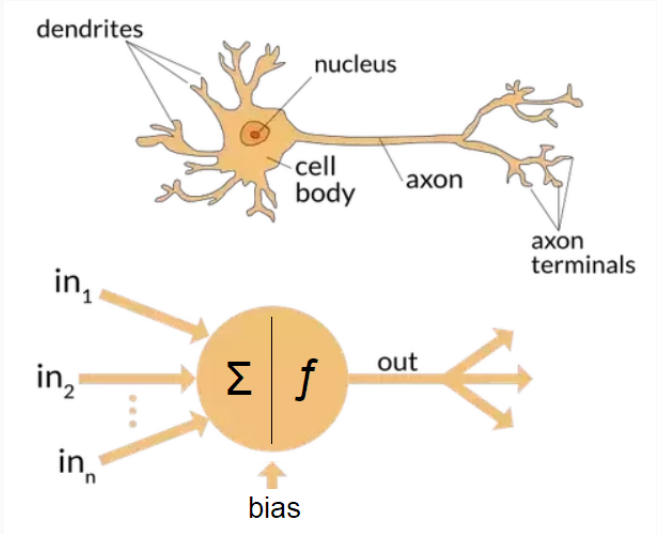
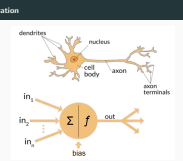


Motivation

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. Phycology: Classical conditioning: how and why animals behaviour happens when you give them a treat

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

Motivation

- Non-stationarity
- Credit Assignment
- Scaling

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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

Comm-MARL

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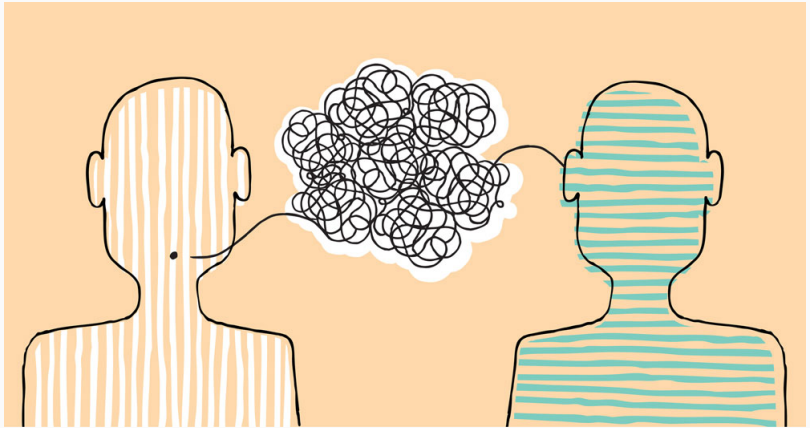
How do we communicate?



How do we communicate?

1. Sign language, inflection
2. finite lexicon with infinite utterances
3. Norm Chomsky

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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Dimensions of Comm-MARL

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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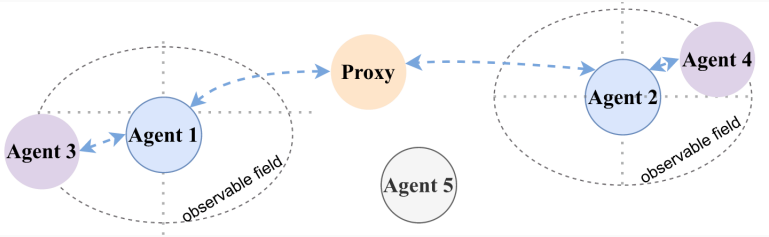
1. Differentiable and Reinforced Inter Agent Learning: Messages are output as part of a neural network
2. Communication Network: Messages are not explicitly output but rather average of the states of the neural network
3. Bidirectionally-Coordinated Networks: Bidirectional RNN hidden states passes forward 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

Commuicateee 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

Learning Methods

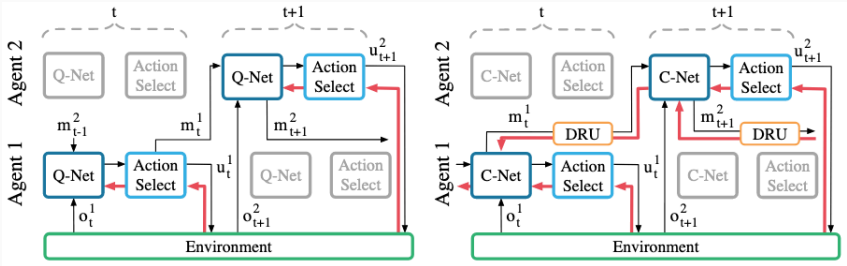
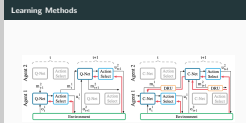
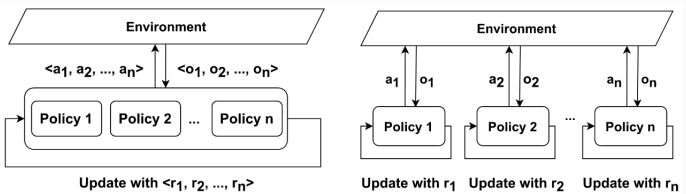


Figure 1: Left: RIAL - **Right:** DIAL



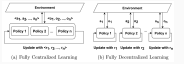
1. RIAL and HAMMERv1: Reinforced
2. FIAL and HAMMERv2,3: Differentiable

Training Schemes



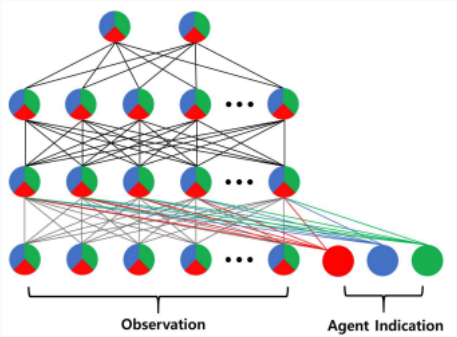
(a) Fully Centralized Learning (b) Fully Decentralized Learning

Training Schemes



1. Fully Centralised Learning: None
2. Fully Decentralised Learning: NeurComm
3. Individual Parameters: None (yet)

Training Schemes



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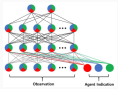
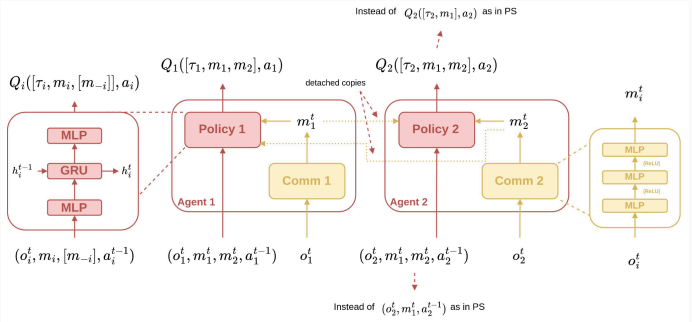
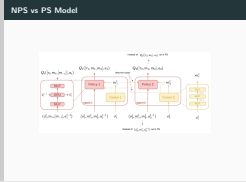


Investigation of Parameter Sharing

NPS vs PS Model





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

Results

Results

References

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