Joint Attention for Multi-Agent Coordination and Social Learning

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Joint attention—the ability to purposefully coordinate attention with another agent, and mutually attend to the same thing—is a critical component of human social cognition. We develop a multi-agent RL training technique inspired by joint attention.

Benefits:

- Reduced cost of multi-agent exploration
- Scales linearly with the number of agents
- Enhanced coordination
- Improved social learning from expert agents

Social Intrinsic Motivation

Agents are given an intrinsic reward bonus for matching their computed attention map A with other agents.

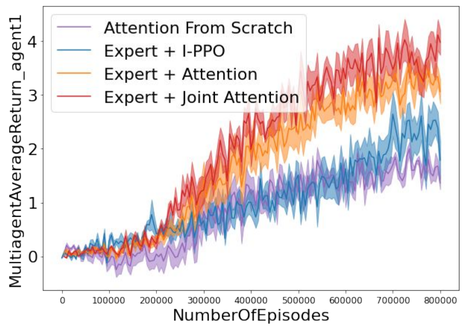
$$r_t^{JA} = -\sum_{j=1}^{K}\sum_{k=1}^{K} JSD(A_t^k||A_t^j)$$

$$= -\sum_{j=1}^{K}\sum_{k=1}^{K} \frac{1}{2}D_{KL}(A_t^k||M_t^{jk}) + \frac{1}{2}D_{KL}(A_t^j||M_t^{jk})$$

[1]Because it is optimized with RL, agents are not forced to constantly match attention, but can trade-off a short term loss in joint attention for a long term gain in environment reward, or vice versa.

Social Learning from Experts

Fig 4. Agents with joint attention learn faster from an expert agent present in their environment.



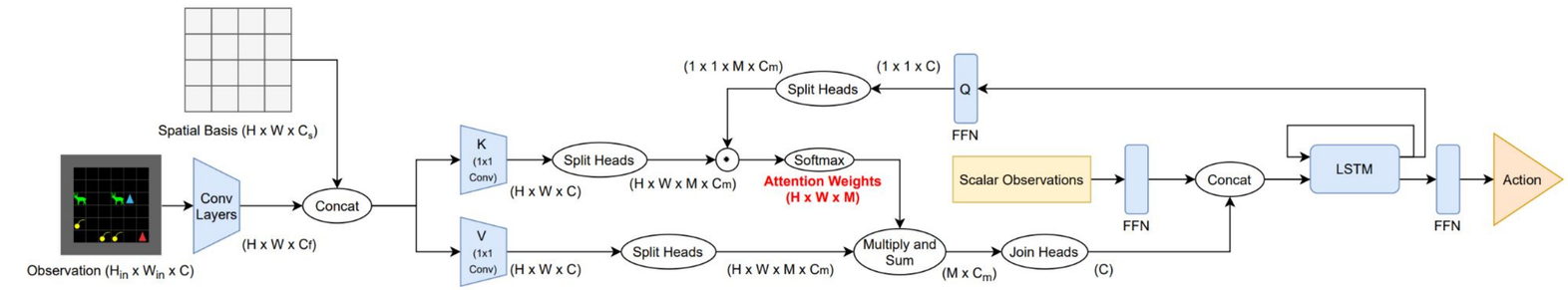
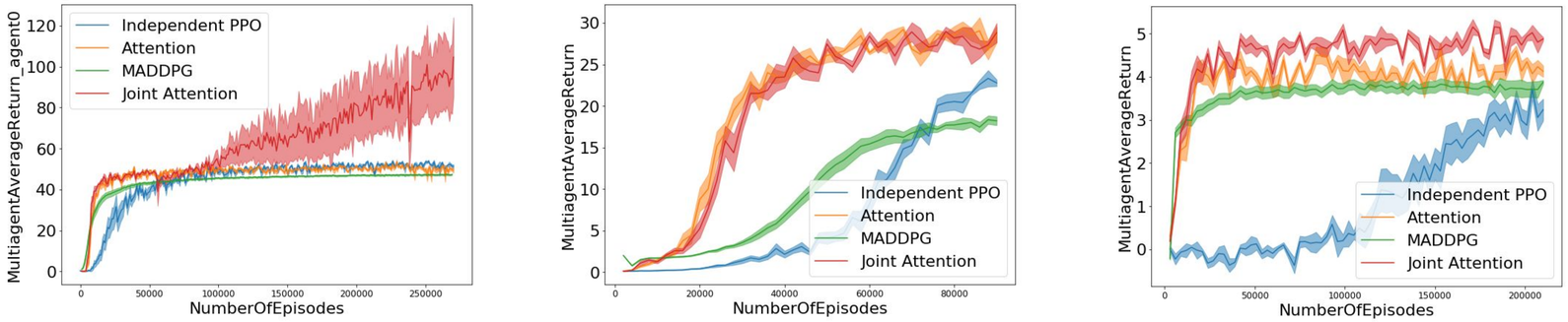


Fig. 1: Architecture. Each agent uses a recurrent visual attention architecture. Attention on the input image is conditioned on RNN hidden state. Thus, agents compute top-down, goal-driven attention.

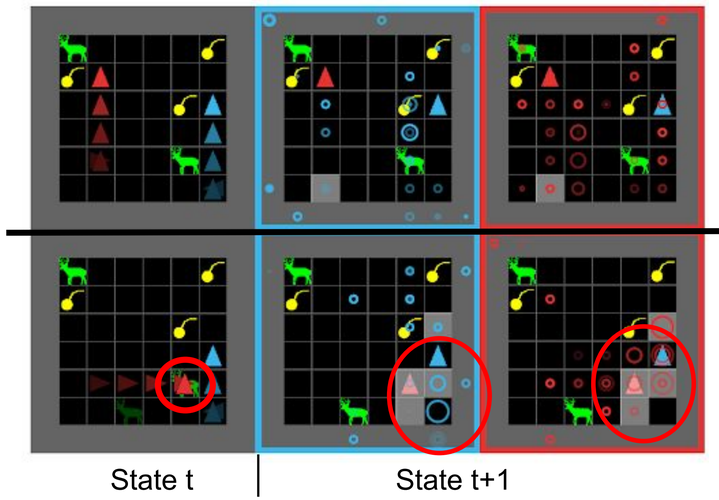
Improved Multi-Agent Coordination



(a) Stag Hunt (b) Colour Gather (c) Meetup

Fig. 2: Coordination. Joint attention allows agents to learn coordination tasks more quickly and effectively than competitive baselines such as MADDPG and independent PPO.

Fig 3. Visualizing joint attention. Left panels show the game state of **Stag Hunt** at time t, middle and right panels show t+1. Triangles are agents' position over the last 5 timesteps. Circles are agents' attention over the last 5 timesteps, with width representing attention strength. Faded images are farther in the past. Highlighted squares are attended to by both agents.



(a) **No joint attention:** agents cannot coordinate and only collect berries

(b) **With joint attention,** agents **catch a stag** by coordinating their attention on each other and the stag