Together is Better! Integrating BDI and RL Agents for Safe Learning and Effective Collaboration

Manuel Parmiggiani, Angelo Ferrando and Viviana Mascardi

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Introduction and Motivation

Innovative combination of symbolic – i.e., Belief-Desire-Intention (BDI) – and sub-symbolic – i.e., Reinforcement Learning (RL) – agents.

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[*]https://jason-lang.github.io/

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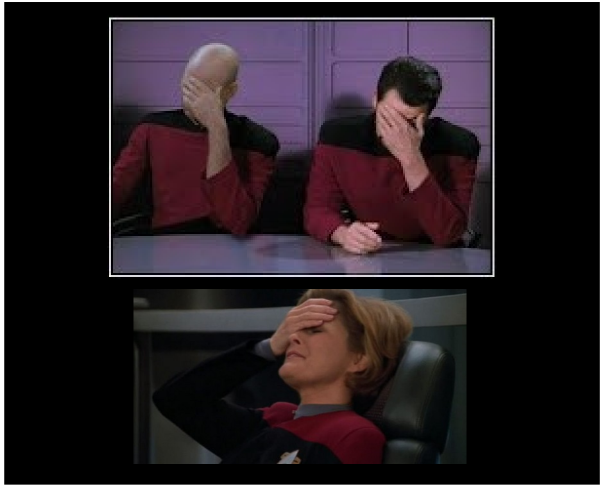
(and yes, the code **is** given…!)



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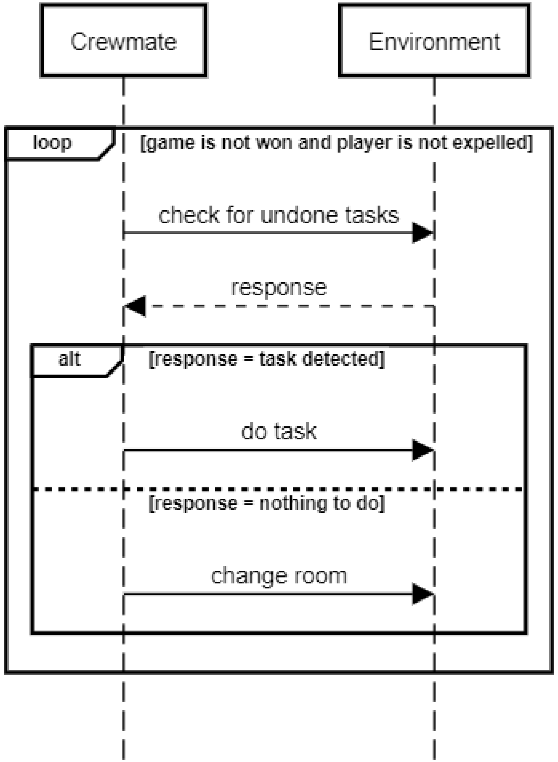
Case study

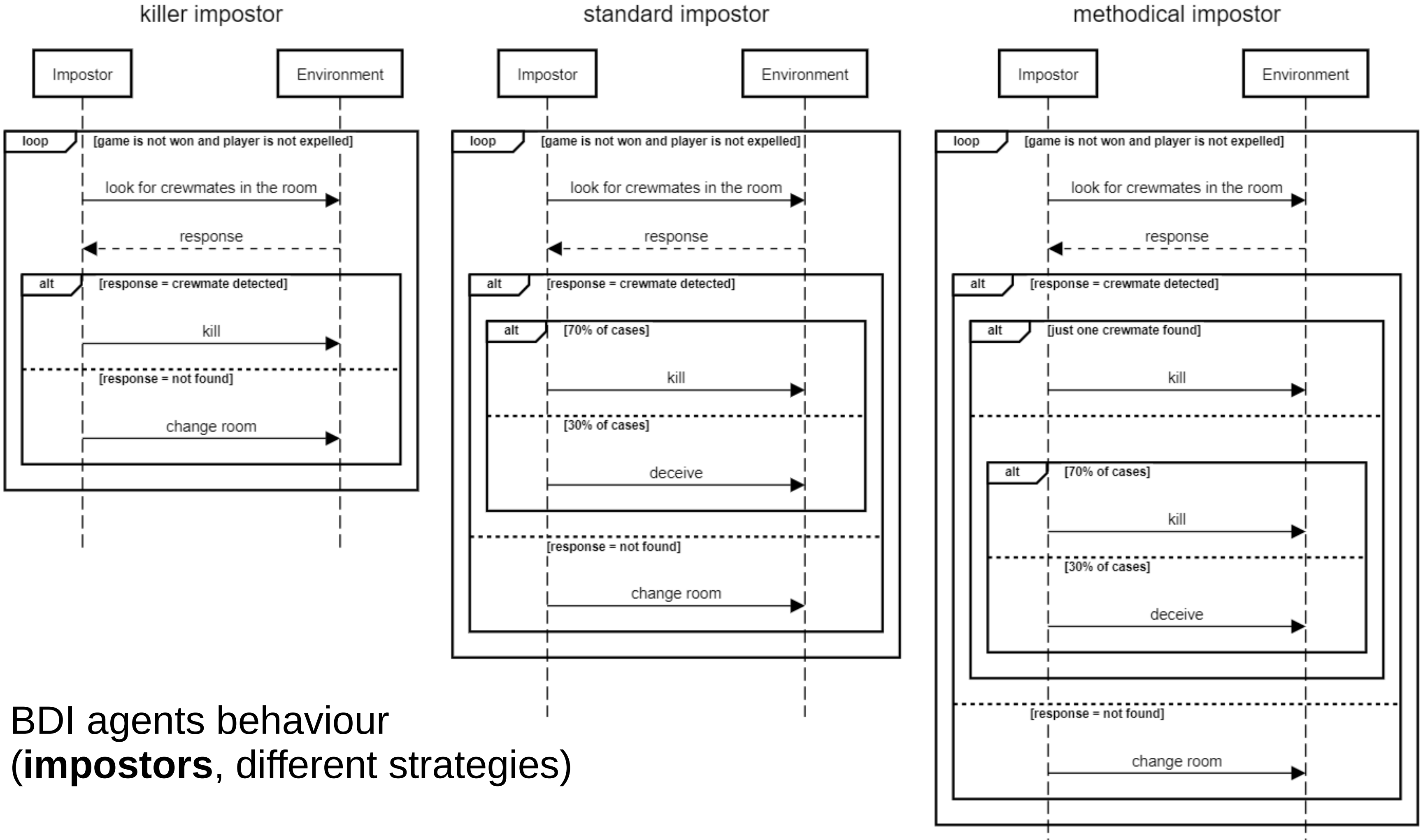

AMONG US


TOTAL TASKS COMPLETED
Ping: 50 ms
Tasks
Hannako
Tallclass
Meanfeet
Blaustoise
Saltycar
Chris A
ENGINE
ELECTRICAL
60
PROTECT
REPORT
USE

BDI agents



BDI agents behaviour
(**crewmates**, single strategy; crewmates have a skill level between 0 and 1)



BDI agents behaviour
(**impostors**, different strategies)

BDI agents implementation

First batch of experiments aimed at ***understanding which impostor strategy and which crewmate skill level would make the game as balanced as possible.***

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We wanted to find balanced behaviours, for the **second** batch of experiments: ***having fixed (balanced) BDI crewmates, does the impostor team benefit from mixing BDI and RL agents?***

RL agents

RL agents implementation

```
learning_rate(0.2).
discount_factor(0.1).
epsilon(0.3).

@startPlan[atomic]
+start <-
          .print("starting");
          +myState(standing,noSubState).

@myStatePlan[atomic]
+myState(S1,S2) : epsilon(EPSILON) <-
          .findall(action_value(V,A),state_action(S1,S2,A,V),L);
          .random(R);
          if (R < EPSILON) {
                    .max(L,action_value(Value,Action));
          } else {
                    .shuffle(L,L1);
                    .nth(0,L1,action_value(Value,Action));
          }
          +myAction(Action);
          executeAction(Action,S1,S2).
```

Standard Q-Learning algorithm implemented in Jason

Integration of BDI and RL - Agent level

Integration of symbolic and sub-symbolic techniques at agent level

The implementation of the safe RL approach based on the teacher *[García J. and Fernández F., 2015 A comprehensive survey on safe reinforcement learning. J. Mach. Learn. Res., 16:1437–1480]* in our RL agents only requires the addition of a few lines of code to the RL agent implemented in Jason and gives the advantage of full transparency of the process, explainability, and traceability of the information learnt from the teacher.

Integration of symbolic and sub-symbolic techniques at agent level

```
!teach([s(found2orMore, kill, 3), s(found1, kill, -3)]).

@teachingPlan[atomic]
+!teach([s(State, Action, Value)|Tail]) : true
<- .send(impostor_RL_, tell,
        given_state_action(State,_,Action,Value));
!teach(Tail).

+!teach([]).
```

Integration of BDI and RL - MAS level

Integration of symbolic and sub-symbolic techniques at MAS level

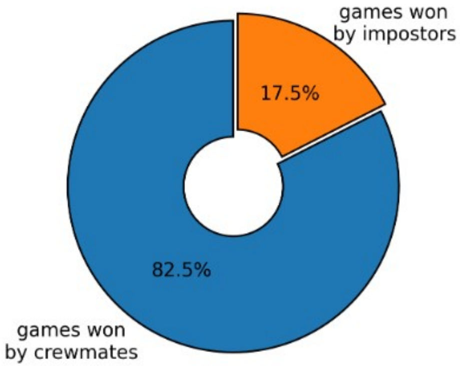

Figure 8: Win ratio when the impostor team consists **solely of RL impostors** and BDI crewmates have skill level **0.52**.

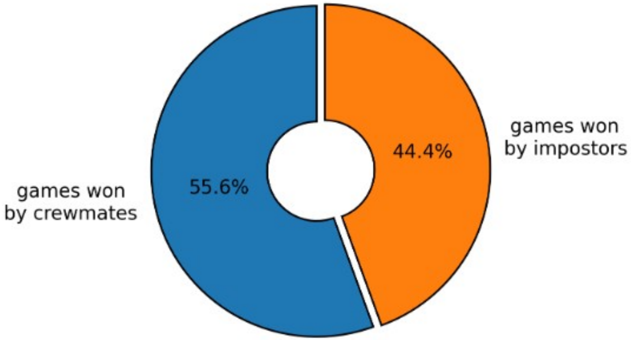

Figure 9: Win ratio when the impostor team consists of **2 RL and 2 BDI methodical impostors** and BDI crewmates have skill level **0.52**.

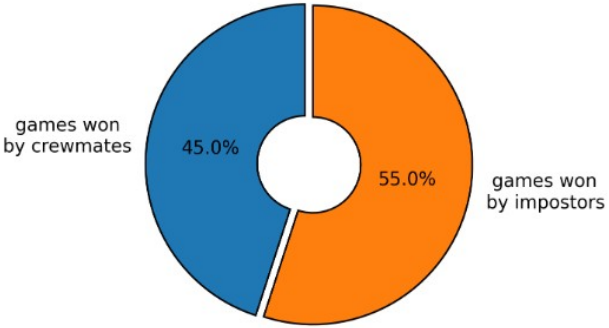

Figure 10: Win ratio when the impostor team consists of **1 RL impostor and 3 BDI methodical impostors** and BDI crew-mates have skill level **0.52**.

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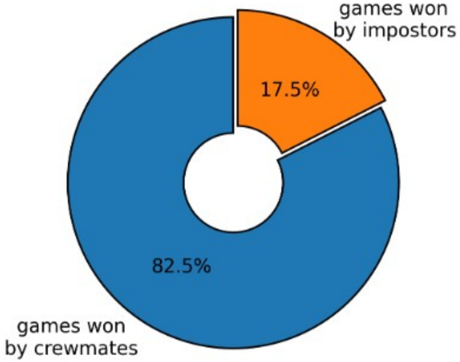

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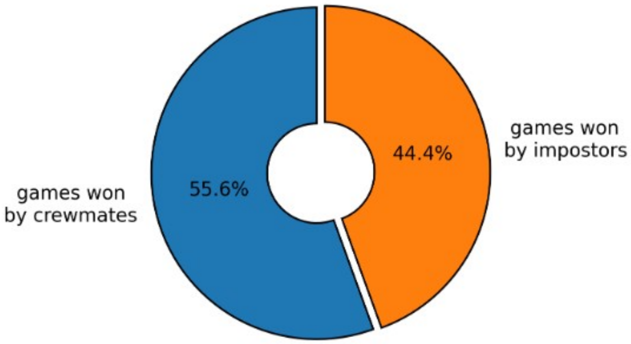
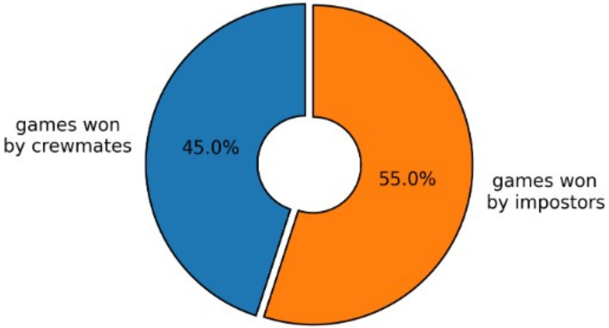


Figure 9: Win ratio when the impostor team consists of **2 RL and 2 BDI methodical impostors** and BDI crewmates have skill level **0.52**.

BDI impostor agents seem to disrupt crewmate clustering, prompting RL impostors to initiate kills earlier, resulting in a more effective team dynamics.



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Comparison

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→ SafeRLJ	2024	Jason 3.1	SARSA	Jason Plan

Table 2: Features, examples, and licensing of recent proposals for integrating BDI and RL agents.

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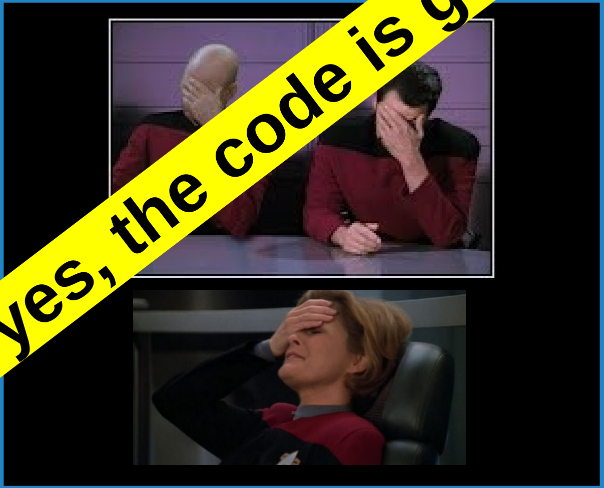

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