A Social Robot as a Card Game Player

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Goals

A social robotic player for a card game:

- Ability to play
- Perform social behaviours
The **Sueca** Card Game

- Portuguese trick-taking card game
- 4 players
- Team game
- The robot will partner a human
Social Robotic Player

- Game Module
- Social Module
Game Module

(1) Create a benchmark for further evaluation
(2) Apply PIMC to the Sueca
(3) Enhancing considering our requirements
Game Module

(1) Create a benchmark for further evaluation

- Rule-based Player (RbP)
Algorithm 1 PIMC search pseudo-code.

1: procedure PIMC(InfoSet $I$, int $N$)
2:     for all $m \in \text{Moves}(I)$ do
3:         $val[m] = 0$
4:     for all $i \in \{1..N\}$ do
5:         $x = \text{Sample}(I)$
6:     for all $m \in \text{Moves}(I)$ do
7:         $val[m] += \text{PerfectInfoValue}(x, m)$
8:     return $\arg\max_m \{val[m]\}$
Game Module

(2) Applying PIMC to the Sueca domain - Sample

- It does not consider already played cards

- It does not assign suits that players do not have (using a Constraint Satisfaction Problem (CSP))
Game Module

(2) Applying PIMC to the Sueca domain - **Search**

- MinMax algorithm
- Costly in early plays of the game
- Cannot meet the time constraint of 2 seconds!
(3) Enhancing considering our requirements

- Hybrid Player (HP)
Game Module

(3) Enhancing considering our requirements
- Hybrid Player

Rule-based procedure
Non-deterministic!
Game Module

(3) Enhancing considering our requirements
- Hybrid Player

Rule-based procedure
Non-deterministic!

Should the Hybrid Player compute more often each sampled distribution?
Game Module

N - number of sampled distributions
M - number of computed game trees for each sampled distribution
N x M - total number of computed game trees

Average points and winning rate of HP+RbP VS 2RbP in 1000 independent games

<table>
<thead>
<tr>
<th></th>
<th>N = 1</th>
<th>N = 5</th>
<th>N = 10</th>
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<tbody>
<tr>
<td>M = 1</td>
<td>58.8 ± 26.8, 47.3%</td>
<td>61.2 ± 26.6, 52.4%</td>
<td>61.4 ± 26.2, 54.2%</td>
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<tr>
<td>M = 5</td>
<td>59.4 ± 26.5, 50.3%</td>
<td>62.8 ± 25.8, 55.8%</td>
<td>62.3 ± 25.6, 54.6%</td>
</tr>
<tr>
<td>M = 10</td>
<td>61.4 ± 25.7, 52.9%</td>
<td>63.1 ± 25.5, 56%</td>
<td>63.2 ± 25.9, 57%</td>
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Game Module

\{M = 10, N = 5\} with \(M \times N = 50\)

VS

\{M = 5, N = 10\} with \(M \times N = 50\)

= 

Increasing \(M\) instead achieves better scores
+ reduces computational time!

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          | 54,6%  |
| M = 10   | 61,4 ± 25,7
          | 52,9%  | 63,1 ± 25,5
          | 56%    | 63,2 ± 25,9
          | 57%    |
# Game Module

Winner!

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Social Module

- User-centred study to analyse how (and when) people behave during a game
- Set of verbal utterances
- Game state triggering behaviours
- People react emotionally

➡ We used FAtiMA emotional agent architecture
Social Module

- We define a set of appraisal rules according to the goal of “winning the game”

  ➡ Produces adequate emotions as a result of game events (e.g. gloating, resentment, happy for, pity)

Play(player, move, trick score of the agent)

Play(P2,10,21) -> Happy for P2 (partner)

Play(P3,11,14) -> Gloat over P3 (opponent)

Play(P3,10,-14) -> Resentment at P3 (opponent)
Building a social robot as a game companion in a card game

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New Zealand
Evaluation

- User study
  - Emys robot
  - 60 participants
    (10 females; $M_{age}=24.31 \pm 3.85$)
Evaluation

- User study

- Winning rate (objective measure)

- Human-Robot Trust Questionnaire towards partner before and after playing (subjective measure)
Evaluation

- Pre- and post-levels of trust were significantly different (Mixed ANOVA, \( p = 0.03 \))
Evaluation

- Pre- and post-levels of trust according to the partner type (human or robot) were not significantly different (Mixed ANOVA, p = 0.65)

➡ The variation of trust was not different between participants that had a human or robotic partner
Evaluation

- Post-levels of trust according to the partner type (human or robot) were significantly different (Welch test, $p < 0.01$)
Evaluation

- Robot team achieved a winning rate of 60%
- The RbP and human players from the user study had similar performances
Conclusions

- High trust levels towards the robot
- However… people trust more on the human partners
- Trust is complex construct
- Accomplished the goals
Thank you!