A Social Robot as a Card Game Player

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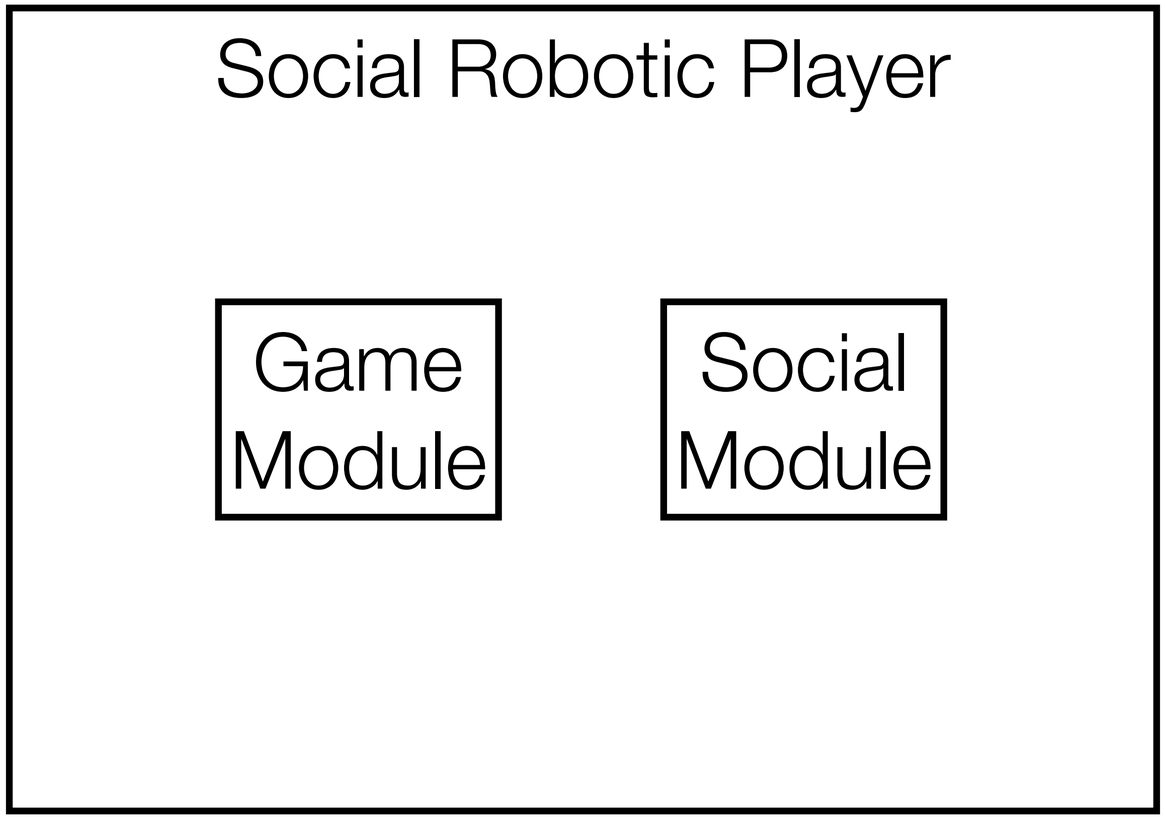
Goals

A social robotic player for a card game:

- Ability to play
- Perform social behaviours

The Sueca Card Game

- Portuguese trick-taking card gar
- 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

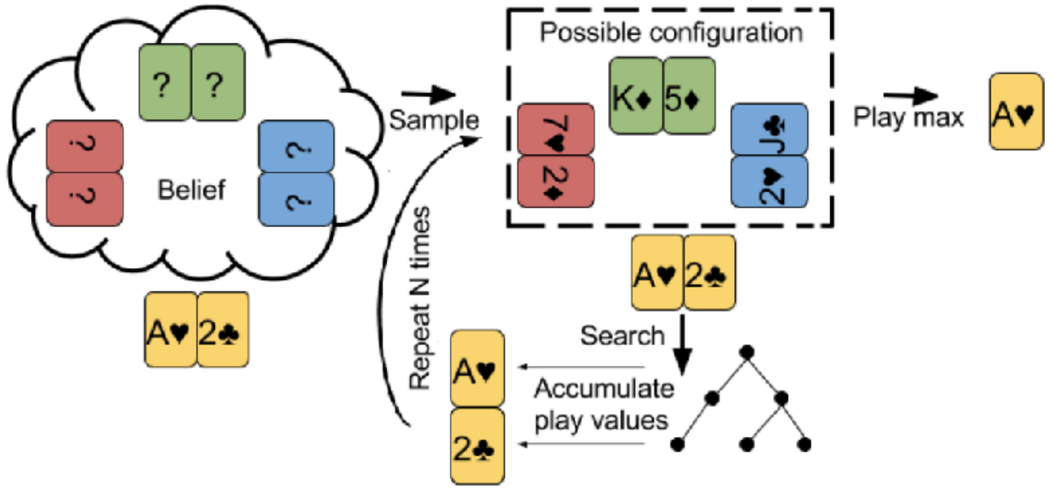
- Rule-based Player (RbP)

Game Module

(2) Applying PIMC to the Sueca domain

Algorithm 1 PIMC search pseudo-code.

```
1: procedure PIMC(InfoSet I, int N)
2:     for all m ∈ Moves(I) do
3:         val[m] = 0
4:     for all i ∈ {1..N} do
5:         x = Sample(I)
6:         for all m ∈ Moves(I) do
7:             val[m] += PerfectInfoValue(x, m)
8:     return argmax_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

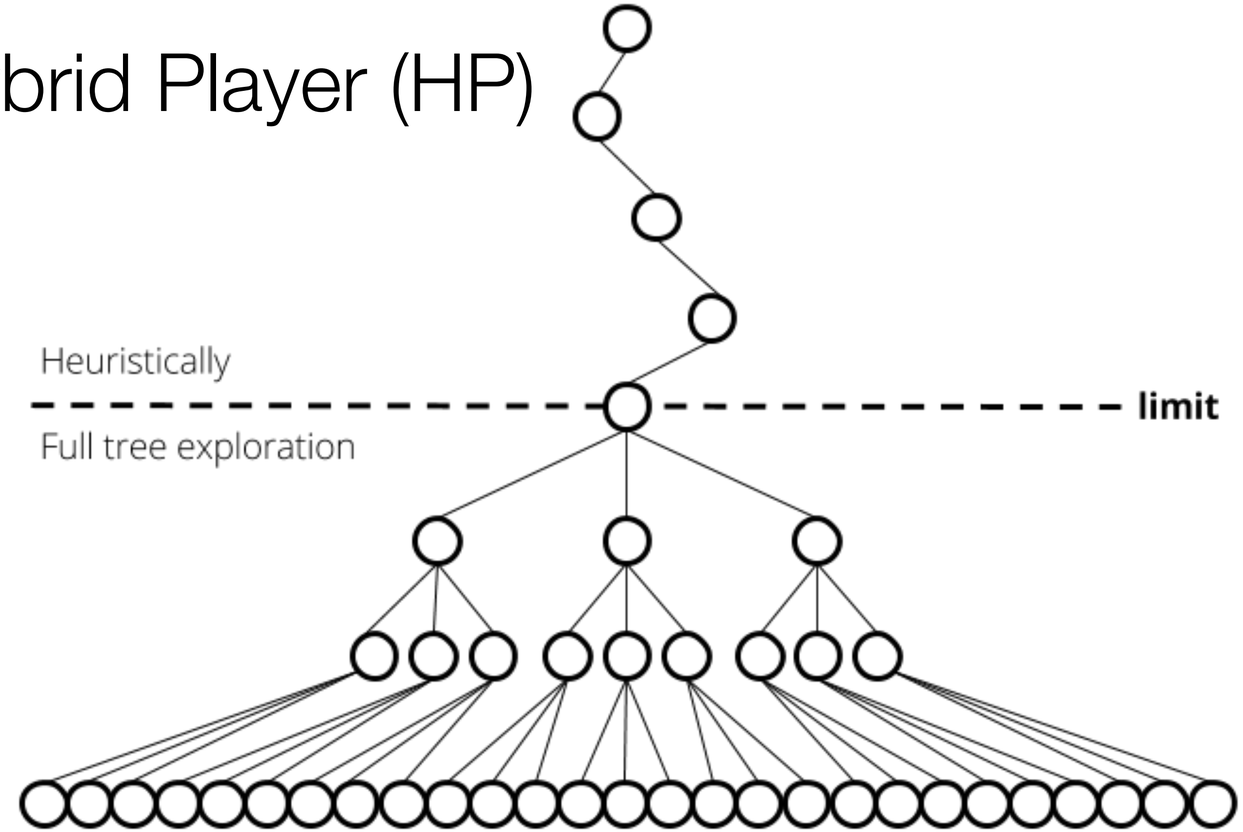
(2) Applying PIMC to the Sueca domain - **Search**

- MinMax algorithm
  - Costly in early plays of the game
  - Cannot met the time constraint of 2 seconds!

Game Module

(3) Enhancing considering our requirements

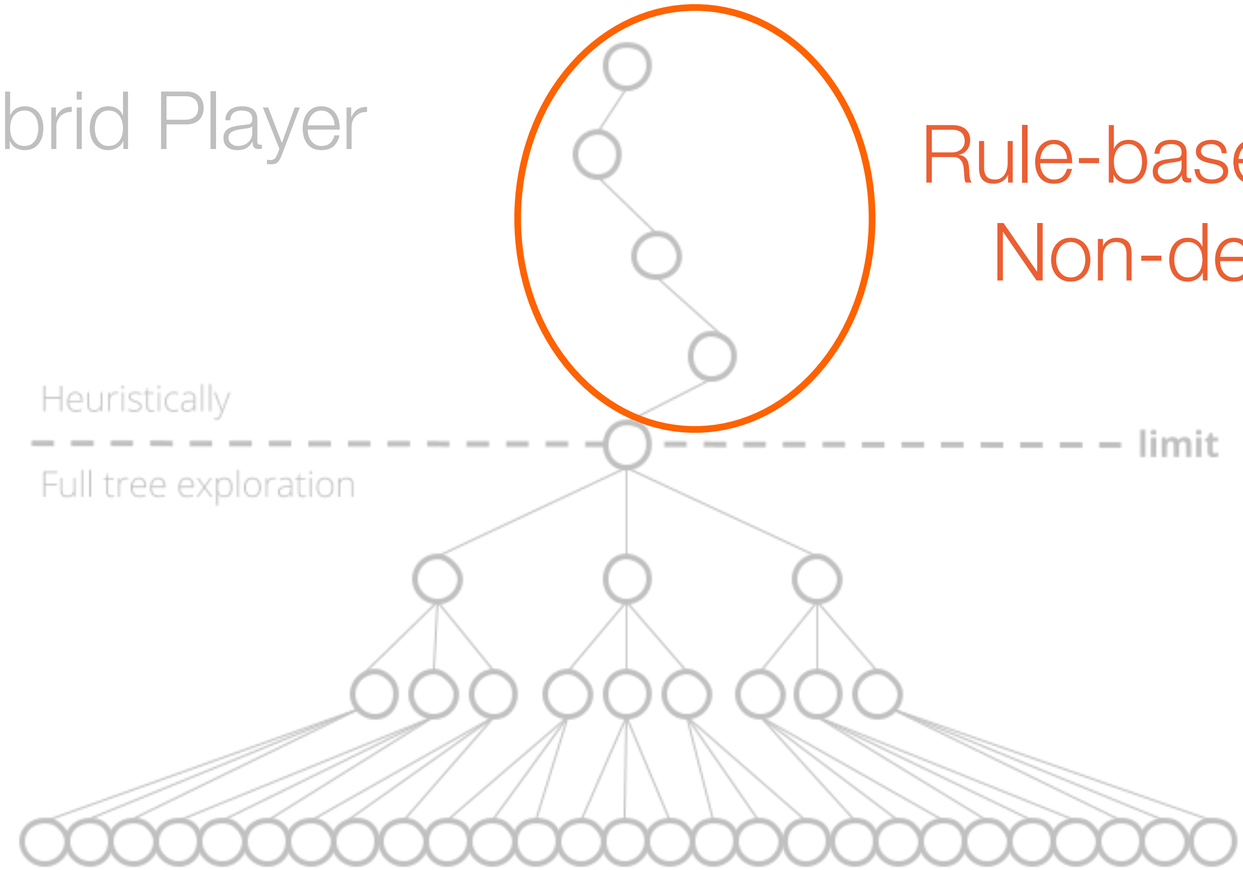
- Hybrid Player (HP)



Game Module

(3) Enhancing considering our requirements

- Hybrid Player

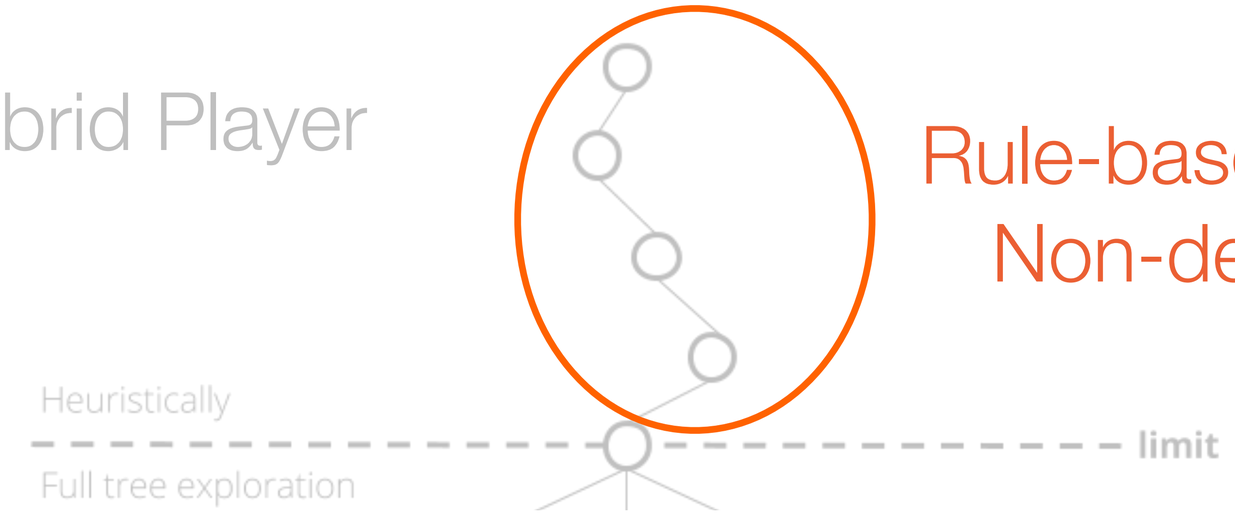


Rule-based procedure
Non-deterministic!

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

	N = 1	N = 5	N = 10
M = 1	58,8 ± 26,8 47,3%	61,2 ± 26,6 52,4%	61,4 ± 26,2 54,2%
M = 5	59,4 ± 26,5 50,3%	62,8 ± 25,8 55,8%	62,3 ± 25,6 54,6%
M = 10	61,4 ± 25,7 52,9%	63,1 ± 25,5 56%	63,2 ± 25,9 57%

Game Module

{M = 10, N = 5} with **M x N = 50**

VS

{M = 5, N = 10} with **M x N = 50**

=

Increasing M instead achieves better scores

+ reduces computational time!

	N = 1	N = 5	N = 10
M = 1	58,8 ± 26,8 47,3%	61,2 ± 26,6 52,4%	61,4 ± 26,2 54,2%
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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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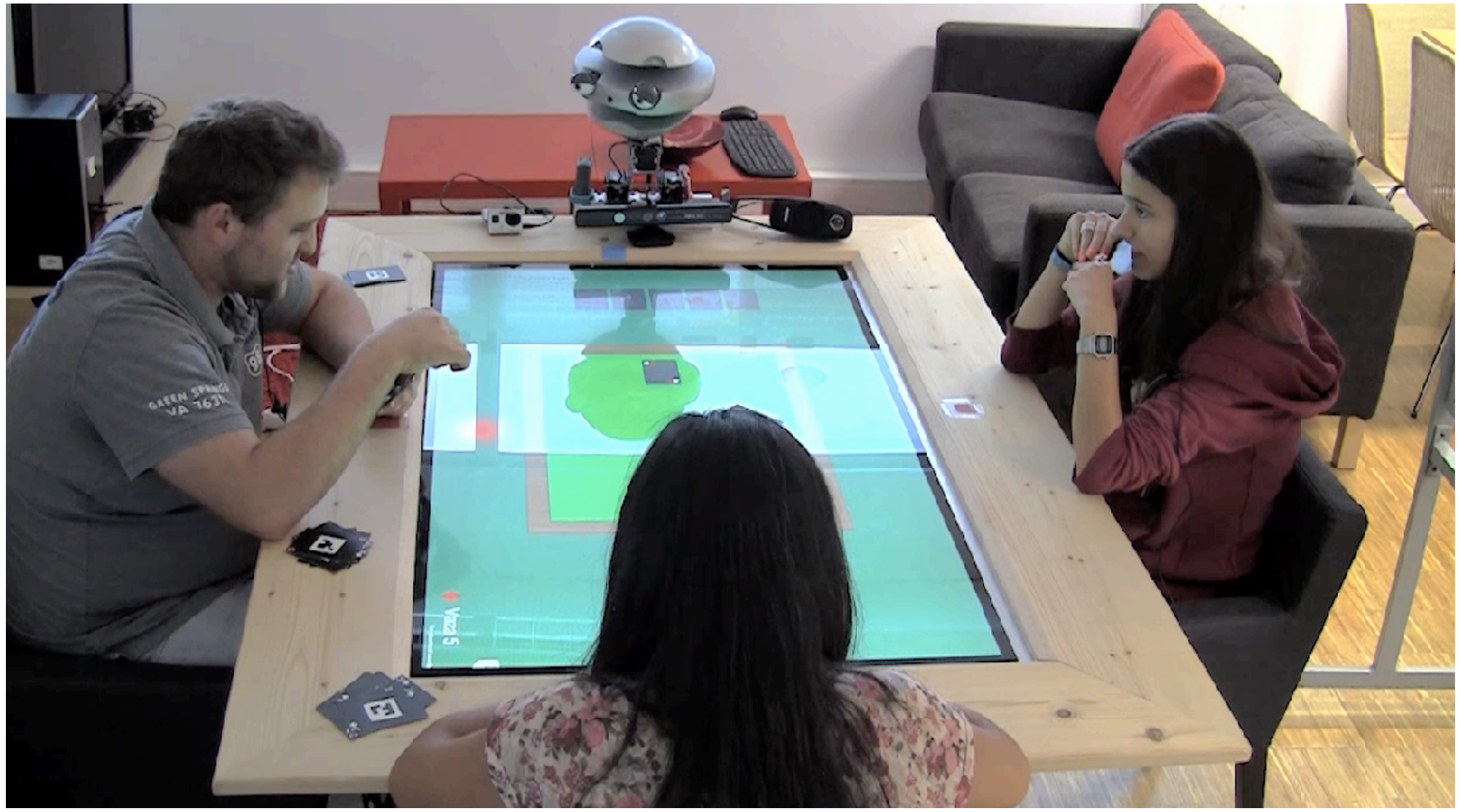
Evaluation

- User study
  - Emys robot
  - 60 participants (10 females; M_{age}=24,31±3,85)

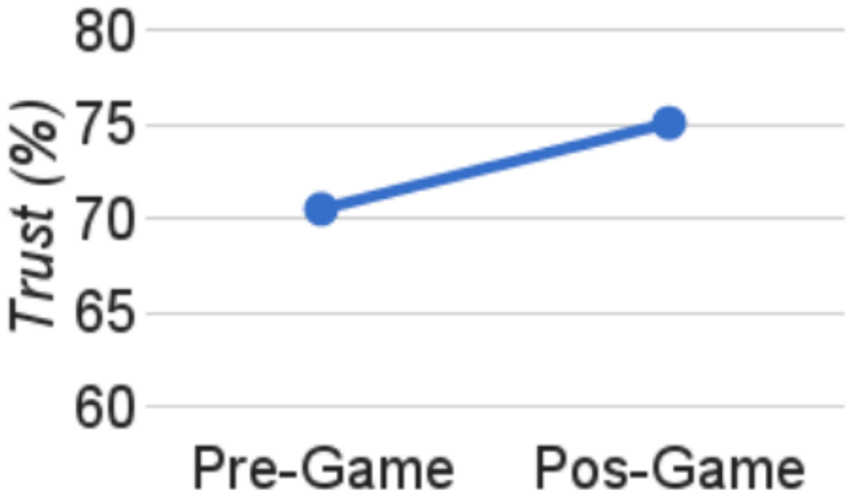


Evaluation

- 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)



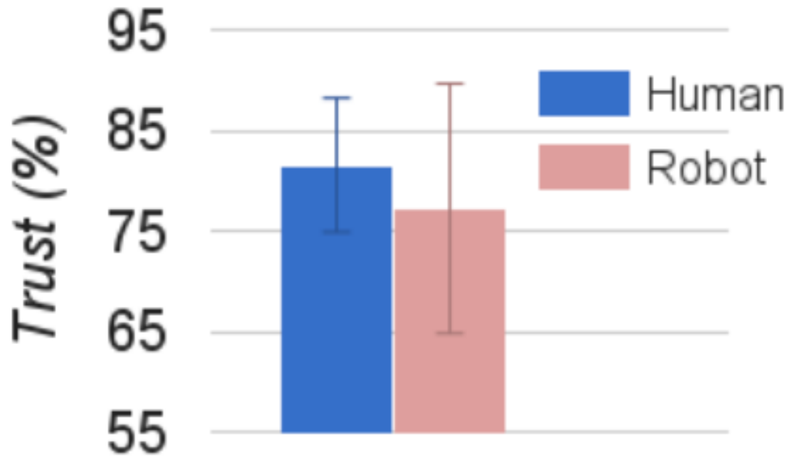
Evaluation

- 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!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