EMYS: a social robot that plays “Sueca”
Motivation

Complexity
Motivation

Can an artificial player be social?
Motivation

A social robot that plays Sueca

Why?

Well known by the elderly

AI for Sueca

Social behaviours
Card games

Solving hidden information games

Monte Carlo Methods

Nash equilibrium

Belief distributions

PIMC  ISMCTS  IIMC
Motivation

Related Work

Card games

HRI in games

AI

Social player

User studies

Conclusions
HRI in games

EMYS, the Risk player

- Topology of speeches
- Relevance value of a move
- Power of a player
- Simulation of roles
- Luck perception

iCat, the chess tutor

- Children tutor
- Careful advices
- Long-term interactions
HRI in games

There is a gap in companion robots for older adults without serious health problems
PIMC concept

Belief

Sample

Possible configuration

Search

Accumulate play values

Repeat N times

Play

max

A

2

A

2

K

5

7

2

J

2

A

2

A
Algorithm 1 PIMC search algorithm

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:       $val[m] += \text{PerfInfoValue}(x, m)$
8: return $\arg\max_m \{val[m]\}$
Information set
- Deck
- Suits per player
AI

- Min Max
  - αβ pruning
  - Depth limit
  - Ordering heuristic
  - Transposition table
  - Equivalent states removal

Possible configuration

Sample

Search

Accumulate play values

Play max

K♦ 5♦
7♥ 2♦
A♥ 2♣
Benchmark: Rule-based Player

<table>
<thead>
<tr>
<th></th>
<th>FGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2RB vs 2RB</td>
<td>50.4%</td>
</tr>
<tr>
<td>1RB 1Rand vs 2Rand</td>
<td>53.4%</td>
</tr>
<tr>
<td>2RB vs 2Rand</td>
<td>62.9%</td>
</tr>
</tbody>
</table>

Team impact!
Low FGR? Why?

Luck? Which initial features affect results?

Linear regression (features $\rightarrow$ team final points)

- Team aces number
- Team sevens number
- Team trumps number

poor predictors, however significant!

Hard, medium and easy initial conditions for the team
Implementing PIMC...
Parametrizing...

**Trick Player**
- Utility func.: $u_1$
- Depth limit: 1 trick

**Deep-1 Player**
- Utility func.: $u_1$
- Depth limit depends on the tree size

**Deep-2 Player**
- Utility func.: $u_2$
- Depth limit depends on the tree size

\[
\begin{align*}
    u_1 = \begin{cases} 
        \text{teamPoints}, & \text{teamPoints} \geq \text{opponentTeamPoints} \\ 
        -\text{opponentTeamPoints}, & \text{teamPoints} < \text{opponentTeamPoints}
    \end{cases}, \quad u_2 = \begin{cases} 
        2, & \text{teamPoints} > 90 \\ 
        1, & \text{teamPoints} > 60 \\ 
        0.1, & \text{teamPoints} > 30 \\ 
        -2, & \text{opponentTeamPoints} > 90 \\ 
        -1, & \text{opponentTeamPoints} > 60 \\ 
        -0.1, & \text{opponentTeamPoints} > 30
    \end{cases}
\end{align*}
\]
### Most significant rate

<table>
<thead>
<tr>
<th>Favourable Games Rate (%)</th>
<th>Hard Games</th>
<th>Medium Games</th>
<th>Easy Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trick Player</td>
<td>3.7</td>
<td>53.3</td>
<td>95</td>
</tr>
<tr>
<td>Deep-1 Player</td>
<td>0</td>
<td>59.4</td>
<td>100</td>
</tr>
<tr>
<td>Deep-2 Player</td>
<td>0</td>
<td>58.9</td>
<td>100</td>
</tr>
</tbody>
</table>
User centred-studies

4 participants from a day-home care institution playing Sueca

Relevant Game Situation
Shuffling
Cutting
Dealing
Receiving cards
Choosing the next play
Playing a card
Playing a trump card
Winning the trick
Winning the game
Losing the trick
Losing the game

Verbal and nonverbal behaviours
EMYS: the Sueca player
EMYS: the Sueca player

<table>
<thead>
<tr>
<th>Relevant Game Situation</th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Greeting</td>
<td>Win</td>
<td>Single Win</td>
<td>Single Lost</td>
<td>Self</td>
<td>Self</td>
</tr>
<tr>
<td>Lost</td>
<td>Double Win</td>
<td>Double Lost</td>
<td>Team</td>
<td>Other Cheat</td>
<td>Other Cheat</td>
</tr>
<tr>
<td>Draw</td>
<td>Quad Win</td>
<td>Quad Lost</td>
<td>Opponent</td>
<td>Other Cheat</td>
<td>Opponent</td>
</tr>
<tr>
<td>Team Cheat</td>
<td>Draw</td>
<td>Draw</td>
<td>Opponent Zero</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Cheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Play</td>
<td>Playing</td>
<td>Shuffle</td>
<td>Cut</td>
<td>Deal</td>
<td>Next Player</td>
</tr>
<tr>
<td>Self Happy</td>
<td>New Trick</td>
<td>Self</td>
<td>Self</td>
<td>Self</td>
<td>Team</td>
</tr>
<tr>
<td>Happy For</td>
<td>Following</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
<td>Opponent</td>
</tr>
<tr>
<td>Gloating</td>
<td>Not Following</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Resentment</td>
<td>Cut</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Pitty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitty</td>
<td></td>
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</tr>
</tbody>
</table>

28
Human-like behaviours:

- speech frequency
- emotional state (FAtiMA)
  - posture
  - subcategory of some utterances
- competitive to the opponent
- encouraging to the partner
User studies

60 participants

(1) Pre-questionnaire
  ● PANAS
  ● Human-Robot Trust

(2) Playing with EMYS

(3) Pos-questionnaire
  ● PANAS
  ● Human-Robot Trust
  ● Networked Minds
User studies

- Trust in the partner
- Social Presence of the partner
- Affect felt
Are there changes in trust after the experience of interacting with the Sueca partner? [Mixed ANOVA test]

**Answer:**

- **time** → **Trust** (p=0.03)
- [time, partner] → Trust (p=0.65)
User studies

Trust

Are the trust levels influenced by the partner (robot or human)? [Welch test]

Answer:
partner $\rightarrow$ Trust ($p=2 \times 10^{-6}$)
User studies

Trust

Are the trust levels influenced by the game results? [Two-way ANOVA test]

Answer:

- game result $\rightarrow$ Trust ($p=0.065$)
- [game result, partner] $\rightarrow$ Trust ($p=0.507$)
User studies

Social Presence

Is the social presence influenced by the Sueca partner (robot or human)? [One-way ANOVA test]

**Note:** Networked Minds Questionnaire has 6 dimensions

**Answer:**

- partner $\not\rightarrow$ co-presence ($p=0.217$)
- partner $\not\rightarrow$ attentional allocation ($p=0.965$)
- partner $\not\rightarrow$ perceived message understanding ($p=0.777$)
- partner $\rightarrow$ perceived affective understanding ($p=0.007$)
- partner $\rightarrow$ perceived emotional interdependence ($p=0.046$)
- partner $\not\rightarrow$ perceived behavioural interdependence ($p=0.406$)
User studies

Affect

Are there changes in positive/negative affect after interacting with the Sueca partner? [Mixed ANOVA test]

Answer:

- time $\rightarrow$ positive affect ($p=0.008$)
- [time, partner] $\nrightarrow$ positive affect ($p=0.488$)
- time $\nrightarrow$ negative affect ($p=0.267$)
- [time, partner] $\nrightarrow$ negative affect ($p=0.184$)
User studies

The robot team won 12 and drawn 1 sessions out of 20

60%  5%

FGR: 65%
Conclusions

2 main contributions

AI for Sueca

Social robotic player

Can beat the rule-based players

- Social presence can be comparable to human partners
- Trust levels towards robot partner are lower than towards human partners
- Positive affect increased after the experience
Future Work

Technical improvements:
- to create a heuristic for the utility function
- machine learning from collected games to infer a current world approximation
- to improve the linear regression of the final points
- transposition table as LFU or LRU
- to generate games of different initial conditions
- to explore other emotions of FAtiMA
- to avoid redundancy of utterances during the session

HRI next steps:
- expand the scenario for an older audience
Thank you!