A Cognitive Model of Interaction for Software Agents

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Cognitive modelling and Multi-Agent Systems (MAS)

Aim: analyzing, modelling and simulating human capabilities of planning and interaction

- Design systems able to well interact with human beings
- Benefit from the robustness of human communication and reasoning processes in MAS
Approach

Psychological experiment

Experimental protocols

Planning analysis
Planning model

Interaction analysis
Interaction model

Agent model: BDIggy

Design of MAS

Validation

Simulation
Agent architecture: BD Iggy

**Environmental Perception**

- Action
- Perception module
  - Memory
  - Beliefs

**Intentional Operation**

- Intention generator
  - Intentions
  - Desires
- Desire generator
  - Action
- Plan interpreter
  - Plans

**Communication Module**

- Communication module
  - Plans
  - Beliefs

**Executive Function**

- Execution module
  - Intentions

**Human Planning Module**

- Human planning module (Iggy2)
  - Beliefs
Cognitive modelling of human interaction

- Analysis of the e-mail corpus, from the psychological experiment:
  - at the utterance level
- List of pertinent performatives
- Performatives applied to mental states
  - at the discourse level
- Grouping together linked performatives into an *intervention*
- Represented by timed automata
  - discourse and utterance levels
- Semantics of the performatives
Modelling human interaction (1/5)
List of observed performatives

<table>
<thead>
<tr>
<th>Performatives</th>
<th>Speech act</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>directive</td>
<td>474 (42.97%)</td>
</tr>
<tr>
<td>reply</td>
<td>descriptive</td>
<td>437 (39.62%)</td>
</tr>
<tr>
<td>refine</td>
<td>directive</td>
<td>60 (5.44%)</td>
</tr>
<tr>
<td>thank</td>
<td>descriptive</td>
<td>30 (2.72%)</td>
</tr>
<tr>
<td>propose</td>
<td>commissive</td>
<td>29 (2.63%)</td>
</tr>
<tr>
<td>inform</td>
<td>descriptive</td>
<td>26 (2.36%)</td>
</tr>
<tr>
<td>cancel</td>
<td>directive</td>
<td>18 (1.63%)</td>
</tr>
<tr>
<td>acceptProposal</td>
<td>directive</td>
<td>10 (0.91%)</td>
</tr>
<tr>
<td>notUnderstood</td>
<td>descriptive</td>
<td>9 (0.82%)</td>
</tr>
<tr>
<td>refuseProposal</td>
<td>directive</td>
<td>3 (0.27%)</td>
</tr>
</tbody>
</table>
Utterance

Speech Act Theory : $F(P)$

$\rightarrow$ performative(mental state)

- directive(locutor’s desire) :
  air$\rightarrow$railway : query($pD(air \ pStage(Orleans \ Paris \ ? < 10h30 \ train \ ? \ ? \ false)))$

- descriptive(belief) :
  railway$\rightarrow$air : reply($pB(pStage(Orleans \ Paris \ 08h25 \ 09h30 \ train \ 1 \ 80 \ false)))$

- commissive(interlocutor’s desire) :
  railway$\rightarrow$air : propose($pD(air \ pStage(Orleans \ Paris \ ? \ ? \ ? \ ? \ train \ ? \ ? \ false)))$
Modelling human interaction (3/5)
Timed automata

- **Intervention**: series of utterances guided by the discourse goal
- Represented by timed automata
- Timed automata direct the agent:
  - to generate a message
  - to interpret a message
Modelling human interaction (4/5)
Example of a timed automaton
Modelling human interaction (5/5)
Semantics of performatives:

\[ \text{pMessage}(A_s, A_r, \text{query } pD(A_s, S)) \]

\[ \begin{align*}
&\frac{pD(A_s, S)}{
\frac{pD(A_s, S)}{
\frac{pMeans(S)}{
\frac{\neg pB(S)}{
\frac{\neg pB(\neg S)}{}}}}}}
\frac{Q_{\text{ini}}(s_2, s_4, s_7, s_8)}{\text{send(query)}}
\Rightarrow Q_{\text{ini}}(s_1)
\end{align*} \]

\[ \text{aUpdateTA}(M) \]

\[ \begin{align*}
&\frac{Q_{\text{int}}(s_1, s_2, s_4)}{\text{receive(query)}}
\Rightarrow Q_{\text{int}}(s_1)
\end{align*} \]

\[ \text{aAdd}(pB(pD(A_s, S))); \text{aUpdateTA}(M) \]
Conclusions...

- Cognitive model of human planning (Iggy2)
- **Cognitive model of human interaction:**
  - Performatives applied to mental states
  - Timed automata
  - Semantics of performatives
- Planning and interaction integrated in an homogeneous agent architecture (BDIggy)
- Implementing BDIggy
- Parametrizing our system
... and perspectives

- Implementing BDIggy
- Parametrizing our system
- Simulation
- Validating the cognitive models (Turing-like test)
That’s all folks...
Psychological experiment
Example of conversation

<table>
<thead>
<tr>
<th>Messages</th>
<th>Performatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have just learnt that it is possible to travel from Paris to Montpellier by train! Could you please give me some timetables?</td>
<td></td>
</tr>
</tbody>
</table>

| Yes, it's possible, there are 7 different departures from 8:12 until 18:28 (departure time). Are you interested in them? Could you be more precise on the time departure? Thanks. | + propose-information + query |

| Yes, from 10:15. | |

| Here is the first | |
| =========Time table========= | |
| Paris-Montpellier (train) | |
| Date: Tomorrow -- 1 person | |
| 10:30/14:39 - 590 F | |

| Now number 2, do you want any others? | |
| =========Time table========= | |
| Paris-Montpellier (train) | |
| Date: Tomorrow -- 1 person | |
| 12:06/16:21 - 590 F | |