Social Robots and Human-Robot Interaction
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Lecture 11. Teamwork, Collaboration and Conflict with Social Robots
Scenarios we are interested..
Scenarios we are interested in...

Build Social Intelligence

“Interactions between humans and robots are inherently present in all of robotics”

Focus on the Interaction
Scenarios we are interested in...

So... how can we build collaborative interactions to support teamwork??

“Interactions between humans and robots are inherently present in all of robotics”

Focus on the Interaction
Cooperation
Summary

• Collaboration
• Mechanisms for collaboration
• Conflict in Teams
• Cases studied
On Collaboration

Collaboration: is considered an arrangement in which two or more parties (which may or may not have any previous relationship) work jointly towards a common goal.
Teams

Team (def): a small number of partners (often with complementary skills) who are committed to a **common goal** and performance for which they hold themselves **mutually accountable**.

We can have human-robot teams where the partners are humans and robots, committed to reach a common goal through collaboration.
Mixed Human-Robot Teams

In human-robot teams, people and robots collaborate on tasks, sharing the same physical workspace and manipulating the same objects.
How to achieve a good collaboration

- To achieve a **common goal**, and performance, partners in a team need a **common plan** for all involved.

- The common plan has associated actions from the individual team members and “**joint actions**”.
Goal Directed joint action

Figure 1. Goal-directed joint action. Rather than imitating the other’s actions (a), people must sometimes perform complementary actions (b) to reach a common goal. Drawing by Ellie Langenhuizen.
Collaboration with Joint Action

Mechanisms for collaborative joint actions:

- **Joint intention** (the formulation of intentions knowing the intentions of others)
- **Action planning** (the mechanisms by which the members of the team build a plan that is to be executed by all— a “joint plan”)
- **Action execution** (the execution of the actions taking into account the other’s actions)
Mechanisms for Joint Actions

- Joint Intention
- Action Planning
- Action Execution
Joint Intentions

In order to achieve such “joint intentions” team members need to know the intentions of the other team members and what they are doing.

• Bratman’s notion of joint intention is viewed as:
  – not only as a persistent commitment of the team to a shared goal,
  – but also implies a commitment on part of all its members to a mutual belief about the state of the goal.
Joint Intention

That is: teammates are committed to inform the team when they reach the conclusion that a goal is achievable, impossible, or irrelevant.
Intention Recognition

For successful collaboration the creation of the joint intention structure there are a set of elements needed in the robot:

– To estimate this intention of the others (intention recognition).

– Intentions may be communicated by the others (including the human) in an explicit or implicit manner.
Intention Communication

Different modalities to communicate intention:

- Speech
- Gestures and Motion
- Action itself
- Haptic signals
- Physiological signals

Fig. 2. Main ways of communicating intentions. Implicit communication is marked in grey.
Mechanisms for Joint Actions

Joint Intention

Action Planning

Action Execution
Building Collaborative Plans

When two or more partners have established a joint intention, they need to create a plan for their actions which will depend on the other’s actions.

To have a collaborative plan for an action, a group of agents must have:

1. mutual belief of a (partial) recipe
2. (a) individual intentions that the action be done
   (b) individual intentions that collaborators succeed in doing the (identified) constituent subactions
3. individual or collaborative plans for the subactions

Fig. 1. Key components of collaborative plans.
Planning with others!

• In planning we define a problem as a set of states with a set of possible associated actions. These actions may cause a transition from one state to another.
  – The goal of planning is to find the sequence of actions that lead to a certain state in the world.
  – Yet, when we have more than one agent, and some of these agents are humans and others robots, the planning is a difficult process
Types of Planning

- **Decision theoretic planning**: defines goal achievement through maximizing reward. Decision theoretic planning uses sequential decision models to decide on a sequence of actions to take in a series of states, rather than a one-time decision. There are sequential decision models that represent uncertainty, time-dependence, history dependence, and partial observability.

- **Partial-order planning** approaches by solving sub problems independently with sub plans, which in the end are combined. Partial-order planning in reality is a search in the plan space (rather than in the space of the world states) and first suitable plans are found for single sub problems. Linearization of actions happens in the end allowing for a higher flexibility.
Joint Plan

- fill the glass
  - get glass
    - hand-1: reach, grasp, move
    - hand-2: move, stop, tilt
  - position bottle
    - move, stop, adjust, steady
  - pour it
For a group $GR$ to have a Full SharedPlan (FSP) to do a complex action $A_\alpha$ requires that:

- $GR$ mutually believe that each member agent intends that the group do $A_\alpha$.
- $GR$ mutually believe that they have a full recipe for doing $A_\alpha$.
- Each action in that recipe be fully resolved.

A basic action $A_\beta$ is *fully resolved* if:

- Some agent $G_\beta$ in $GR$ intends to do $A_\beta$.
- $GR$ mutually believe that $G_\beta$ intends to do $A_\beta$ and is able to do $A_\beta$.
- $GR$ mutually believe that each member agent intends that $G_\beta$ be able to execute $A_\beta$.

Similarly, a complex action $A_\kappa$ is *fully resolved* if:

- Some subgroup $GR_\kappa$ in $GR$ have a full plan to do $A_\kappa$.
- $GR$ mutually believe that $GR_\kappa$ has a full plan to do $A_\kappa$ and is able to do $A_\kappa$.
- $GR$ mutually believe that each member agent intends that $GR_\kappa$ be able to execute $A_\kappa$.

*Figure 4. Informal Definition of a Full SharedPlan (FSP).*
Another central feature is the establishment and maintenance of common ground:

**Def (Clark):** "the sum of [...] mutual, common, or joint knowledge, beliefs, or suppositions".

Common ground is necessary with respect to the objects of the task, the task state, and the internal states of the team members.
Joint attention for creating Common Ground

Joint attention: knowing what others perceive (and don’t perceive)

Studies on joint attention suggest that the ability to direct one’s attention to where an interaction partner is attending provides a basic mechanism for sharing representations of objects and events [6,7].

Thus, joint attention creates a kind of ‘perceptual common ground’ in joint action, linking two minds to the same actualities.
Mechanisms for Joint Actions

- Joint Intention
- Action Planning
- Action Execution
A not collaborative robot...
Example for an industrial setting
Teamwork with robots

• Robots as members of a team, can have different roles:
  – Partner
  – Mediator
  – Conflict mediator
A case studied: Using Robots to Moderate Team Conflict:

Study to examine a robot’s effectiveness at regulating emotions in a team-based problem-solving task.

- Focus on the effect of regulating emotions on perceived team conflict.

- Teams are prone to conflict of two types: relationship and task conflict
Conflict in Teams

Task Conflict exists when there are “disagreements among group members about the content of the tasks being performed, including differences in viewpoints, ideas, and opinions”
H2a: More conflict (relationship and task) will be perceived in a team when a team member introduces a negative trigger that contains a personal attack vs. being only task oriented.

H2b: Less conflict (relationship and task) will be perceived in the team when a robot repairs negative triggers, especially triggers that contain personal attacks vs. being only task oriented.
Experiment

- Experiment: a 2 (negative trigger: task only vs. task plus personal attack) x 2 (repair: yes vs. no) between-subjects experiment (N = 114 individuals, 57 teams)
- Studied the effects of a robot repairing negative triggers on team affect, conflict, perceptions of team members’ contributions, and team performance during a problem-solving task.
Negative Triggers that lead to conflict in teams

A negative trigger manipulation, was done with a carefully trained confederate delivered negative triggers during the task. Depending on the experimental condition, the confederate issued two triggers:

– primarily directed at the task (task) or
– primarily directed at a team member (personal).

The triggers were developed with the confederate through numerous iterations.

Table 1 – Negative Triggers (Personal & Task)

<table>
<thead>
<tr>
<th>Negative Triggers</th>
<th>Delivery</th>
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</thead>
<tbody>
<tr>
<td>Personal Attacks</td>
<td></td>
</tr>
<tr>
<td>1. “You’re stupid, lets not use this one. Use this.”</td>
<td>2-3min</td>
</tr>
<tr>
<td>2. “That’s not right, you are not very good at this.</td>
<td>5-6min</td>
</tr>
<tr>
<td>Use this.”</td>
<td></td>
</tr>
<tr>
<td>[Directed at a team member. Condescending]</td>
<td></td>
</tr>
<tr>
<td>Task-Directed</td>
<td></td>
</tr>
<tr>
<td>1. “Lets not use this one. Use this.”</td>
<td>2-3min</td>
</tr>
<tr>
<td>2. “The one isn’t right. Use this”</td>
<td>5-6min</td>
</tr>
<tr>
<td>[Directed at the task. frustrated, tense]</td>
<td></td>
</tr>
</tbody>
</table>
Repairing conflict in a team with a robot

After each negative trigger, the robot delivered either one of two repair comments (repair) or one of two comments that were unrelated to the trigger and intended to be neutral (no-repair).

Repairs identified the negative trigger as inappropriate and then added a normative statement to stay positive.

<table>
<thead>
<tr>
<th>Spoken Repair</th>
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</thead>
<tbody>
<tr>
<td>Repair Comment</td>
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<tr>
<td>1. “Whoa, man, that was inappropriate. Let’s stay positive.”</td>
</tr>
<tr>
<td>2. “Dude, what the heck! Let’s stay positive.”</td>
</tr>
<tr>
<td>No-Repair Comment</td>
</tr>
<tr>
<td>1. “Defusing bombs is difficult.”</td>
</tr>
<tr>
<td>2. “There are many possible combinations.”</td>
</tr>
</tbody>
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Measures

• **Affect** was measured using a three-item scale comprised of participants’ ratings of valence on the 9-point Self-Assessment Manikin scale and of how much they felt surprised and excited ($\alpha = .63$).

• **Perception of conflict** in the group was measured by averaging Jehn’s widely used and validated scales of task and relationship conflict at the team level. Perception of task conflict was measured by asking participants questions such as “How frequently did you have disagreements within your team about the task you were working on?” ($\alpha = .86$). Perceptions of personal conflict were measured by asking participants questions such as “How much relationship tension was there in the team?” ($\alpha = .85$).

• **Perceived confederate contribution** was measured by asking each participant to rate on a 100-point sliding scale to what degree each of the other participants and the robot contributed to the team.

• **Team performance** on the bomb defusal task was measured by counting the number of moves the team made within 10 minutes as well as by counting number of correctly identified wires in the best configuration the team made during the 10 minutes.
Video
Results

Perceived relationship conflict was significantly higher when the robot repaired personal attacks ($M = 3.09$, $SD = .99$) than when it did not repair them ($M = 2.04$, $SD = .88$). However when the same repair utterances followed a task violation, perceptions of relationship conflict were about the same for repair ($M = 1.82$, $SD = 0.68$) and no repair ($M = 2.01$, $SD = 0.73$).
When confronted with a task violation, teams on average reported experiencing more positive affect when the violation was not repaired ($M = 0.44$, $SD = 1.34$) than when it was repaired by the robot ($M = -0.32$, $SD = 1.18$). However when confronted with a personal violation, teams reported feeling better when the robot attempted to repair the violation ($M = 0.30$, $SD = 1.41$) than when it did not ($M = -0.48$, $SD = 0.98$).
Results

The hypotheses was that team members would feel more positively toward the contribution of team members who make personal attacks when a robot repaired that attack. At the team level, ANOVA results show there was only a marginally significant main effect for repair type on perception of the confederate, $F(1, 49) = 3.00, p = .09$, partial $\eta^2 = .06$, with teams reporting that the confederate contributed more to the team when the robot intervened with a repair ($M = 28.8, SD = 21.4$) as compared with when it didn’t ($M = 23.0, SD = 14.9$).
Discussion