1. Background

- HRI for *socially assistive robotics* applications is a new, growing, and increasingly popular research area
- SAR is a multidisciplinary field at the frontier of many other fields including robotics, medicine, psychology, social sciences, neuroscience, and cognitive sciences
- SAR = providing assistance to human users mainly through *social* interaction, not physical contact
1. Motivation

- Have a customized therapy protocol
- Research Question:
  - How should the behavior and encouragement of the therapist robot be modeled and adapted as a function of the user's personality, preferences, and profile so as to improve his/her task performance?

[1. Motivation]

2. Interaction Design

HRI Information Processing Using the Personality Model of the User

[2. Interaction Design]
3. Robot Behavior Adaptation to User’s Personality and Preferences

- The robot behavior adaptation system optimizes the 3 main parameters:
  - interaction distance/proxemics
  - speed and amount of movement
  - verbal and para-verbal cues
  to adapt to the user’s personality and preferences and improve his/her task performance.

- The system monitors the user’s task performance and the time spent between exercises, and changes the robot’s behavior in order to maximize the user’s level of progress.

- We formulated the problem as *policy gradient reinforcement learning* (PGRL) and developed a learning algorithm.

- Summary of the PGRL algorithm:
  - parameterization of the behavior
  - approximation of the gradient of the reward function in the parameter space
  - moving towards a local optimum
5. Test-bed and Subject Pool

- Test-bed:

- Subject Pool:
  - 11 participants (6 male, 5 female)
  - 19-37 years old
  - 73% from robotics or technology-related departments (e.g., computer science, electrical engineering)

5. Experimental Design

- Duration: 15 minutes
- Task: moving pencils from one bin to another using non-dominant (weaker) limb
- Two Experiments:
  - Experiment 1: Robot Behavior Adaptation to User Personality-Based Therapy Style
  - Experiment 2: Robot Behavior Adaptation to User Preferences
- Learning Algorithm: activated only when the participant was performing below the set threshold
4. Experimental Design – Experiment 1

- **Experiment 1: Robot Behavior Adaptation to User Personality-Based Therapy Style**

  - Choice of therapy styles as a function of the user personality

    | Parameter | Extroverted | Introverted |
    |-----------|-------------|-------------|
    | Therapy Style | Id=1 | Id=2 | Id=3 | Id=4 |
    | Coach-like | Very Challenging | Stimulating | Encouragement-based |
    | Introverted | Id=1 | Id=2 | Id=3 | Id=4 |
    | Supportive | Educative | Comforting | Nurturing |

  - Choice of interaction distances and robot movement speed as a function of the user personality

    | Parameter | Extroverted | Introverted |
    |-----------|-------------|-------------|
    | Interaction Distance/Proxemics (m) | Id=1 | Id=2 | Id=3 | Id=1 | Id=2 | Id=3 |
    | Speed (m/s) | 0.1 | 0.2 | 0.3 | 0.1 | 0.15 | 0.2 |

4. Experimental Design – Experiment 2

- **Experiment 2: Robot Behavior Adaptation to User Preferences**

  - People are more influenced by certain voices and accents than others

  - Choice of therapist robot’s personality as expressed through English accent and voice gender as a function of the user preferences

    | Parameter | Id=1 | Id=2 | Id=3 | Id=4 |
    |-----------|------|------|------|------|
    | Therapist Robot’s Personality as Expressed through English Accent and Voice Gender | Female with accent | Male with accent | Male without accent | Female without accent |
5. Evaluation Methods

- Pre-study:
  - Eysenck Personality Inventory (EPI) Questionnaire

- Post-study:
  - Likert 7-point scale questionnaire:
    - The questions were designed to evaluate participants’ impressions about the robot’s therapy style and personality (e.g., “Did the robot succeed to adapt to your preferences?”)

5. Experimental Results

- Experiment 1

- Experiment 2

<table>
<thead>
<tr>
<th>Robot Therapy Style</th>
<th>Personality Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female with accent</td>
<td>Female without accent</td>
</tr>
<tr>
<td>Male without accent</td>
<td>Male with accent</td>
</tr>
<tr>
<td>Male with accent</td>
<td>Female with accent</td>
</tr>
</tbody>
</table>
5. Experimental Results

- A direct match between the values learned by the robot and the values given in the questionnaires by the participants was found.
- The robot adapted to both user’s personality and user’s preferences.

Exp1: Adaptation to User Therapy Style

Exp2: Adaptation to User Preferences

6. Conclusions and Future Work

- A behavior adaptation system using a reinforcement learning algorithm was presented.
- The adaptation system takes advantage of the user’s personality and the number of exercises performed.
- The robot adapts to deliver customized post-stroke rehabilitation therapy.

- Future work:
  - Validate the methodology with stroke-patients
  - Focus on physiological data to determine stress and frustration
Questions?