Planning, Execution and Monitoring of Physical Rehabilitation Therapies with a Robotic Architecture

José Carlos González, José Carlos Pulido, Fernando Fernández y Cristina Suarez-Mejías

MIE 2015: Medical Informatics Europe
Overview

1. Introduction
2. Use Case Explanation
3. NAO Therapist Architecture
4. Evaluation
5. Conclusion and future work
Introduction
Focused Patients

- Children from 4 to 14 years old
  - Obstetric Brachial Plexus Palsy
  - Cerebral Palsy
- Causing upper limb disorders
- Rehabilitation helps to:
  - Recover upper limb mobility
  - Decrease muscle rigidity
  - Increase patient’s autonomy
    - Dressing
    - Eating

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Rehabilitation Procedure

Problems:
- Step A. Cumbersome task for therapists
- Step B. Repetitive exercises, loss of patient’s engagement
Towards Novel Therapy Methods

Using robots may improve patient’s engagement!
Our Goals

• Cognitive architecture to support and develop physical rehabilitation sessions with a humanoid robot:
  – Based on child-robot social interaction
  – Full autonomy without human intervention
  – Session monitoring and exercise validation
  – Adaptation to each patient’s difficulties
  – Automatic design of therapies
  – Generation of clinical reports
Use Case Explanation
What is a rehabilitation session with NAO like?

https://youtu.be/75xb39Q8QEg
NAOTherapist Architecture
NAOTherapist Architecture

- Includes **Artificial Intelligence** techniques
- Comprises three levels of Automated Planning
- Based on individual components
- Easily extensible and configurable
- Independent of the robotic platform
- Provides complete autonomy to the robot
Three Levels of Planning

**High-level planning**

- Therapy Designer
  - Therapy configuration
  - Planned sessions

**Medium-level planning**

- Decision Support
  - Anthropometric data
  - Actions

**Low-level planning**

- Robot Controller
  - NAO robot
  - Low-level Instructions
  - Kinect Sensor

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Evaluation
Evaluation

• First evaluation with **120 school children**

• Second evaluation with **3 pediatric patients** in the HUVR

• Evaluation points:
  – Social Interaction and presence of the robot
  – Children’s attitude and behavior
  – Active engagement and commitment
  – Performance of the patients
  – Usefulness of the prototype
### Categories of Video Analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Behavior</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotions</strong></td>
<td>Enjoyment, happiness</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Engagement, focus</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Anxiety, frustration</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Boredom, laziness</td>
<td>Artifact</td>
</tr>
<tr>
<td></td>
<td>Fear, displeasure</td>
<td>Artifact</td>
</tr>
<tr>
<td><strong>Intentionality</strong></td>
<td>Enthusiastic, energetic</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Proper</td>
<td>Playing</td>
</tr>
<tr>
<td></td>
<td>Lazy</td>
<td>Artifact</td>
</tr>
<tr>
<td></td>
<td>Does not train</td>
<td>Artifact</td>
</tr>
<tr>
<td><strong>Gaze</strong></td>
<td>Looks at the robot</td>
<td>Reciprocity</td>
</tr>
<tr>
<td></td>
<td>Looks at himself</td>
<td>Reciprocity</td>
</tr>
<tr>
<td></td>
<td>Looks at others</td>
<td>Artifact</td>
</tr>
<tr>
<td></td>
<td>Not involved</td>
<td>Artifact</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>Speaks and gestures to the robot</td>
<td>Reciprocity</td>
</tr>
<tr>
<td></td>
<td>Speaks or gestures to the robot</td>
<td>Reciprocity</td>
</tr>
<tr>
<td></td>
<td>Hears the robot</td>
<td>Reciprocity</td>
</tr>
<tr>
<td></td>
<td>Speaks to others</td>
<td>Artifact</td>
</tr>
</tbody>
</table>
Results of Video Analysis

50 videos of schoolchildren analyzed

- Reciprocity
- Artifact
- Playing

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Evaluation with Pediatric Patients

https://goo.gl/lBWKH4
Future works and initial conclusions

- The pilot with real patients will be performed in September in the VRUH. 20 patients will be training with THERAPIST during 3 months.

- The initial experiments indicate:
  - The combination of robotic platform with artificial intelligence will provide new ways for rehabilitation processes.
  - Time of professionals is optimized.
  - The interaction of users with NAO is fluent.
  - Children found pleasant the experience with NAO and involved during the rehabilitation session.
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Thank you for your attention!
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