In-Situ Design and Development of a Socially Assistive Robot for Paediatric Rehabilitation

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Introduction

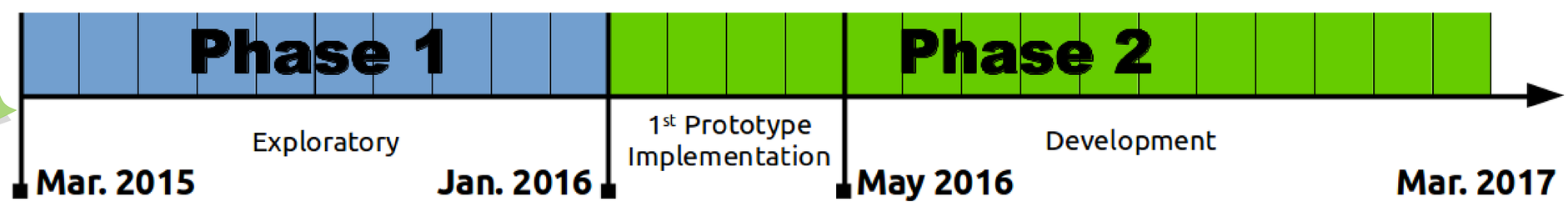
Socially Assistive Robots (SAR) show great potential for boosting therapeutic outcomes in children undergoing intensive rehabilitation. In partnership with a busy paediatric rehabilitation clinic, we are developing and evaluating software to adapt NAO as a therapeutic aid for paediatric rehabilitation. Unlike previous work, we are focussed specifically on the needs of clinical deployment. In particular, NAO leads therapy sessions for children with physical disabilities, such as cerebral palsy, undergoing intensive rehabilitation. We aim to increase exercise compliance and maintain emotional wellbeing, particularly when therapists are not in attendance.

Design Approach

Phase 1 (Exploration): Has two key objectives: determination of SAR roles and requirements through rapid prototyping and mock-ups (via *Wizard-of-Oz* control); and establishing the legitimacy and acceptance of the technology with stakeholders. Activities are conducted predominantly on-site, over the course of frequent unstructured visits. Data is gathered through investigator observation and unstructured consultation with patients/parents, therapists and doctors.

Phase 2 (Formative Evaluation and Development): Focusses on deployment and iterative development of the SAR. A stand-alone minimum viable SAR prototype (based on Phase 1 findings) is developed and deployed in patient sessions. Robot performance data is gathered during sessions, and patient/therapist/parent perceptions of trust, usefulness and therapeutic benefits are gathered via semi-structured interviews at the completion of each session.

Over 30 patients engaged with NAO during Phase 1



NAO has led 14 rehab sessions with 9 patients during Phase 2

Roles (from Phase 1)

Demonstrator: NAO demonstrates exercises at the beginning of each set, and provides verbal instructions.

Motivator: NAO provides verbal encouragement at the beginning, during, and at the end of each prescribed exercise. Entertainment through music, dancing and joke telling are also offered upon completion of exercise sets.

Companion: NAO is a co-participant during the session, joining in and providing empathetic statements to acknowledge the child's progress.

Derived Requirements (from Phase 1 and 2)

Configurability: Therapists must be able to pre-load rehabilitation exercises, number of repetitions, etc.

Stability: To minimise failure, demonstration exercises must utilise joint poses and movements that remain within conservatively defined operating limits.

Adaptability: To ensure the therapeutic assistance is aligned with the patient's presenting needs, the SAR should adapt to patient mood and progress, allowing in-session adjustment of activity settings (eg, repetitions, speed and sequence order).

Integration: The SAR must be easily set up, portable and operable by carers without specialised training.

Interaction: Basic interaction with the SAR should be supported for both carer and patient throughout the session. This will support Adaptability, Responsiveness, and maintain patient engagement.

Responsiveness: The SAR should recognise the patient's mood and progress, and respond appropriately.

Stand-alone: The SAR should be operable without technicians, *Wizard-of-Oz* or additional hardware.

Robustness and Endurance: The system should operate continuously. Unforeseen interruptions such as falls, or unintended user interactions should be restorable.

Socially Assistive Robot Roles in Action

NAO **demonstrates** a "bridge" to the patient

NAO **accompanies** the patient during the Sit-to-Stand exercise

NAO **motivates** the patient during the Toy Relay game

Design Process Evaluation

- Frequent (weekly) hospital visits and **in-situ development** have been **key** to the **high volume of patient interactions** driving the SAR development
- The **direct inclusion of therapists** in the co-design of the system has been a **key** component in **building trust and ownership** of the resulting SAR prototype
- Requires **large time investment** of a small development team
- Promotes design transparency, but **exposes system deficits** to the end users

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