Involving Young Children in the Development of a Safe, Smart Paediatric Wheelchair

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ABSTRACT

Independent mobility is crucial for a growing child and its loss can severely impact cognitive, emotional and social development. Unfortunately, powered wheelchair provision for young children has been difficult due to safety concerns. But powered mobility need not be unsafe. Risks can be reduced through the use of robotic technology (e.g., obstacle avoidance) and we present a prototype *safe* smart paediatric wheelchair: the Assistive Robot Transport for Youngsters (ARTY). A core aspect of our work is that we aim to bring ARTY to the field and we discuss the challenges faced when trying to involve children in the development/testing of medical technology. We discuss one preliminary experiment designed as a "Hide-and-Seek" game as a short case study.

1. INTRODUCTION

In the UK alone, there are more than 50,000 disabled children who require mobility assistance [7]. Power mobility advocates consider mobility as "an essential component of a child's early intervention program" [2, 10]. However, powered wheelchair provision for young children remains a contentious issue. Nicholson and Bonsall's 2002 survey of 193 wheelchair services [11], showed that 51% of the respondents did not supply wheelchairs to children under 5 years. The top two reasons cited were safety of the child (36%) and safety of others (34%).

Safety is clearly an important factor, but for these children to lose independent mobility is a crucial set-back at a critical age. Mobility loss spawns a vicious cycle: the lack of mobility inhibits cognitive, emotional and social development, which in turn further limits personal independence [1, 9, 12]. Ultimately, this results in a severe long-term deterioration in a child's quality of life.

In our research, we aim to break this cycle by providing a key enabling technology: a *safe*, paediatric wheelchair we call the Assistive Robot Transport for Youngsters (ARTY) shown in Fig. 1. Contrary to traditional assumptions, powered mobility need *not* be unsafe (for the child or others). Rather, risks can be mitigated through the use of robotic technology and shared control systems [5, 13].

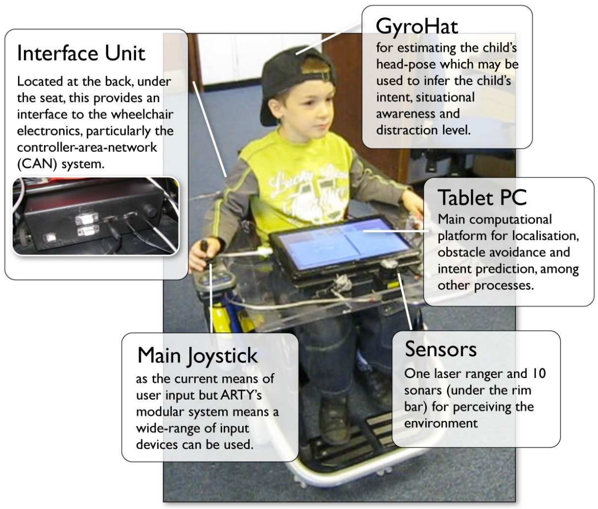

Figure 1: J, a 4-year old boy, using the Assistive Robot Transport for Youngsters (ARTY).

Delivered to end-users, safe powered mobility has the potential to improve social, emotional and intellectual behaviour [3] and drastically change lives. As such, a core aspect of our work is to bring ARTY into the field at an early design stage. Prior work has mostly focused on developing wheelchairs that work in tightly-controlled environments, but to be a relevant technology, assistive robots should be tested in *real-world environments* by *end-users* [6].

2. ASSISTIVE ROBOT TRANSPORT FOR YOUNGSTERS (ARTY)

In brief, ARTY is a children's powered wheelchair augmented with sensors (both IR and sonar-based) and a tablet PC as the main computational platform for localisation, obstacle avoidance, path-planning and intention prediction. Thanks to its modular design, ARTY accepts a wide range of input and sensor devices, important for catering to a wide range of disabilities. Also, ARTY continuously logs data from its sensors and input devices (such as our "GyroHat" that estimates the child's head-pose) and can provide therapists and researchers with badly-needed quantitative data.

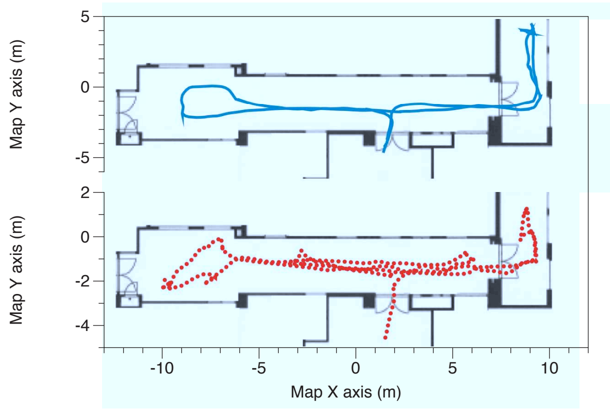

Figure 2: An adult's search path (blue-solid, top) compared to J's search path (red-dotted, bottom).

3. HRI GAMES WITH ARTY

Conducting studies with young children is not without its challenges. Unlike adult subjects, who tend to follow given instructions, children may wantonly disregard direction and have notoriously short attention spans. Furthermore, disabled young children have additional needs, e.g., the CALL Centre smart wheelchair [4] was not "a single entity" but multiple variants had to be designed (one for each user).

We posit that studies and/or rehabilitation exercises designed as games (e.g., in [4, 8]) are a promising way forward. In these experiments, the "fun-factor" – a design variable not usually considered in other settings – plays a more prominent role. For a preliminary experiment with the objective of gathering data on search patterns, we designed a "Hide-and-Seek" game to motivate children to look for hidden items (toys).

3.1 A Short Case Study: J

Our participant was J, a healthy four-year-old boy. Two earlier attempts with A and H, two girls aged three and two respectively, were not successful: A got bored after a single run of looking for the toy and H refused to sit in the wheelchair (she appeared intimidated by the many people in the experimental area – a busy research lab).

Based on the experienced gained from the previous attempts, we limited the number of people present to five (three experimenters, J and his father). We interviewed J's father beforehand to find out what J's favourite toys were ("Battlestrikers") and about J's general personality ("outgoing and active"). To make ARTY more attractive, we placed similar toys on ARTY's tray and changed the tablet's desktop image to match. To accommodate J's attention span, we planned side-activities to engage him when he was not using the wheelchair, e.g, playing with a Nao robot and the iCub humanoid. Local obstacle avoidance was used to prevent possible injuries from collisions.

We observed J rapidly learnt how to use the wheelchair – within a few minutes, he was able to navigate independently in both the practice and test zones. J played the "Hide-and-Seek" game twice. Both times, he was able to find the toy without difficulty. However, compared to adult participants (data gathered in prior experiments), J explored the territory in a less organised manner (Fig 2); he went-over the same part of the route several times and looked in the same box twice.

4. CONCLUSIONS

Our research goal is to bring safe, smart mobility to disabled children in real-world settings and we believe ARTY will play a significant role in making this a reality. We are currently working with medical professionals (doctors, therapists and researchers) at local children's hospital where we have performed a live demonstration. Future planned visits will help us better understand the needs of disabled children and caregivers, allowing us to further tailor ARTY and design better experiments. In the longer term, we expect that ARTY will allow young disabled children to move, play, explore and learn; activities that should be a part of every young child's life.

5. REFERENCES

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