Participatory Design: Repositioning, Transferring, and Personal Care Robots

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ABSTRACT

In our ongoing survey, we examine the feedback of robotic aids that increases independence of persons with physical disabilities. Participants are asked to evaluate the perceived pros and cons of prototypes for repositioning, transferring, and personal care in video simulations. Using participatory design, our goal is to develop robotics aids by actively involving prospective consumers to achieve market success.

Keywords

robotics; repositioning; transferring; personal care

1. INTRODUCTION

Often, people with physical disabilities may require the support from caregivers, family, and friends to perform tasks, such as, feeding, toileting, ambulating, transferring, and other personal tasks. To increase independence with robotic repositioning, transferring, and personal care, we employ a participatory design approach to elicit feedback of prototypes from stakeholders taking an online survey to quickly evolve towards viable physical realization solutions.

2. BACKGROUND AND RELATED WORK

For adaptive hardware, subjects experienced comfortable and safe interactions when RIBA's robotic arms dynamically adjusted respecting their own trunk and thigh lengths for transferring [2]. In our own study of adaptive software, we found that preferred input modalities for robotic control were BCI, speech, and gestural interfaces [1]. Although user-centered approaches provide feedback in hardware and software, we seek to inform mechanical design requirements in the early stages.

3. CURRENT RESEARCH

Using participatory design, we conducted a 30-minute online, anonymous survey with several demographic questions and requested comments on prototypes. For fast demonstration, we used 3D video simulations. The following prototypes are in our survey.

Piano Mattress: an inflatable contoured mattress with air chambers that can be pressurized to be raised/lowered for mobility and repositioning in bed. Video URL: https://youtu.be/GfEsKwcvxdM.

Piano Lifter: a transfer system to accompany the Piano Mattress with five tines that fit in the deflated segments of the mattress and has two grippers. Video URL: https://youtu.be/27uVb7h4ZLY.

Figure 1 shows the Piano Mattress and Piano Lifter.

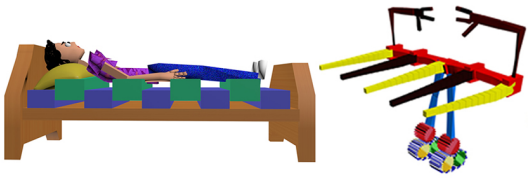

Figure 1: Piano Mattress with even air chambers raised (left) and Piano Lifter (right).

Wearable Sling: a motorized mobile base supporting nine separate slings for both right and left forearms, upper arms, thighs, lower legs, and trunk with head support for transferring. Video URL: https://youtu.be/oqzlCLctWhw.

Penta-Gripper: a transferring system with five grippers that can wrap around the limb/body to perform movement. Video URL: https://youtu.be/0xNNJ2o_N9A.

Figure 2 shows the Wearable Sling and Penta-Gripper.

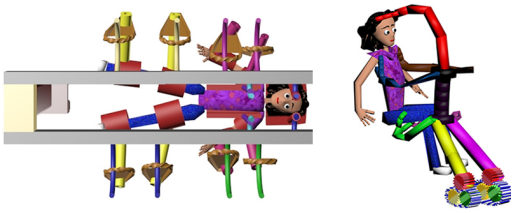

Figure 2: Wearable Sling in top view (left) and Penta-Gripper in side view (right).

Motorized Commode Chair: an electric commode wheelchair with a joystick and seat elevation, tilt, recline, brakes, and adjustable head support, armrests, and footrests. Video URL: https://youtu.be/U9-aF1sAMKY.

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Toilet Tongs: a toileting aid that supports head-trunk, retrieves toilet paper with motorized tongs, and has a bidet. Video URL: https://youtu.be/E9zr_zGv7JY.

Motorized Commode Chair and Toilet Tongs are shown in Figure 3.

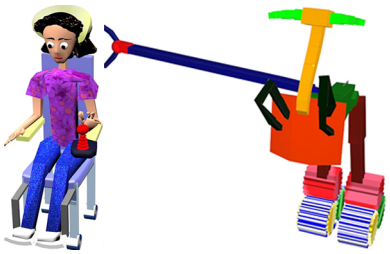

Figure 3: Motorized Commode Chair (left) and Toilet Tongs (right).

RoboticToothbrush: a oral hygiene system with a head supporter and three grippers each for water supply for rinsing, a toothbrush, and a spit cup, as shown in Figure 4. Video URL: https://youtu.be/t9rYUetF2Tc.

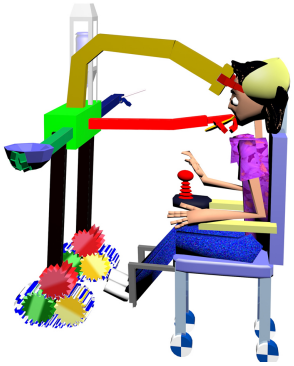

Figure 4: RoboticToothbrush brushing teeth.

Universal Gripper (UniGripper): an aid with a head supporter and a robotic arm for feeding, wiping the mouth, combing hair, and fine motor activities, as shown in Figure 5. Video URL: https://youtu.be/7zK3J1hMvRE.

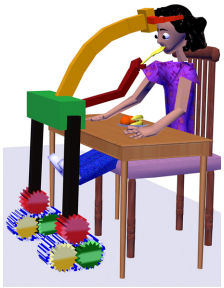

Figure 5: UniGripper feeding the user.

3.1 Preliminary Results

We recruited participants by emailing organizations such as Cure SMA and the Muscular Dystrophy Association, and posting messages to topical online forums. We are targeting 200–300 survey responses to increase higher statistical accuracy from voluntary participants that must be 18 years or older.The study was reviewed and approved by the UMBC Institutional Review Board (IRB). The survey can be accessed here:http://www.csee.umbc.edu/~kavi1/survey.html.

The survey covered four major topics to collect demographic information, current practices of repositioning and transferring, perceived pros and cons of our eight prototypes, and future perspective on assistive robots. We structured the survey with close ended questions with multiple-choice and ratings for quantitative data and open-ended questions to identify opinions of prototypes for qualitative data.

Currently, we have 151 survey responses. One of the questions on our survey is, *"Have you or your loved one ever been in a situation that no one was nearby to help for repositioning when needed?"* As of now, responses indicate that 60.3% of the participants or their loved one have experienced a situation that no one was nearby to provide repositioning assistance when needed and 39.7% of them did not share that experience.

Most notably, our Piano Mattress prototype was highly favored by 98 participants (64.9%) and and the remaining 53 participants (35.1%) were not interested. These preliminary results are very promising for our research. By enhancing the lives of persons with physical disabilities, their family members, and their caregivers, the field of assistive robotics will rapidly advance.

3.2 Conclusion and Remaining Work

Our results will be very helpful to the research community that may provide useful insights to create a suitable mechanical design configuration for impacting the existing challenges of individuals with physical disabilities. The perceptions and expectations of the target population about assistive robots are vital to shaping the design and development of assistive technologies to have higher rates of user acceptance and utility.

Overall, the survey responses have shaped the ongoing development of our robotic prototype devices by identifying attractive alternative design solutions. Our goal is to perform in-depth text mining and sentiment analysis on our open-ended questions. These results will soon be published in an upcoming workshop, journal, or conference.

4. REFERENCES

[1] K. Krishnaswamy, R. Kuber, and T. Oates. Developing a limb repositioning robotic interface for persons with severe physical disabilities. *Universal Access in the Information Society*, 15(4):609–627, 2016.

[2] M. Sun, H. Nakashima, S. Hirano, K. Matsuo, M. Ding, C. Jiang, T. Mukai, and G. Qin. Adaptive user-centered design for safety and comfort of physical human nursing: Care robot interaction. In *Proceedings of the 4th International Conference on Digital Human Modeling and Applications in Health, Safety, Ergonomics, and Risk Management: Healthcare and Safety of the Environment and Transport - Volume Part I*, DHM'13, pages 365–372, Berlin, Heidelberg, 2013. Springer-Verlag.