EC 601 – Project 1

Research into Assistive Robots for People with Motor Disabilities

Student Name: Piyusha Dongre

Submission Date: 18 September 2022

Table of Contents

Table of Figures

EC 601 – Project 1

Research into Assistive Robots for People with Motor Disabilities

Student Name: Piyusha Dongre

Submission Date: 18 September 2022

Introduction and Background

These days robots – complex devices that respond to the environment and perform without constant direction – are increasingly becoming a part of digital health. From exoskeletons and prosthetics to motion control and assisted surgeries, robots are part of innovations that can change lives for the better. Daily tasks can be particularly challenging for those with disabilities that limit how mobile they are. Mobile disability is the most common disability in the US, with 1 in 7 adults experiencing it in their lifetime *("CDC: 1 in 4 US Adults Live with a Disability | CDC Online Newsroom | CDC").*

These people can face significant obstacles in performing everyday tasks which can make it difficult for them to achieve independence and quality of life. Without assistive technology, people are often excluded, isolated, and locked indoors thereby affecting their self-esteem.

Assistive robots are very useful to people who have experienced spinal cord injury, cerebral palsy, rheumatoid arthritis, stroke, temporary impairment, amputation. They process sensory information to help people with motor disabilities perform daily actions such as exercise, eating, personal hygiene and grooming, housework, and many more. This paper focuses on the research into such robots that assist people with motor disabilities in performing routine tasks for daily life.

Effect on the society

The World Health Organization defines mental health as "a state of well-being" that allows a person to lead a fulfilling and productive life and contribute to society *("10 Facts on Mental Health")*. Assistive robots reduce the need for long-term caregivers and support services. It makes people who use it more independent with a control of their daily routine and life. Even though research is still being conducted, there is some evidence that they result in a positive mental wellbeing in those who use them. It also increases student's opportunities for education by supporting student's participation in learning experiences in a less restricted environment, social interaction, and potential for meaningful employment.

Literature Review

Some of the interesting assistive robot systems that are currently on the market consist of Obi the Feeding Robot, Panasonics Robotic Bed and Panasonic Hair-washing Robot. This section provides a detailed overview of each one.

EC 601 – Project 1

Research into Assistive Robots for People with Motor Disabilities

Student Name: Piyusha Dongre

Submission Date: 18 September 2022

1. OBI the Feeding Robot

Obi is a dining assistant that assists people with disabilities to feed themselves. It is designed for individuals with upper extremity strength and mobility limitations *("Meet Obi - MeetObi")*. Obi is controlled using customizable switches that allow the user to choose between four compartments of food and the pace at which they wish to eat.

Figure 1 - OBI Feeding Robot

Obi comes with reusable cutlery, is water resistant and has an anti-slip surface. It operates via two switches that instruct it to either deliver or scoop food. These switches can be operated by foot, elbow or any other way that works best for the user. It has a robotic arm for feeding which moves quietly in a smooth motion to avoid spills. As a result, users can carry on mealtime conversations or meetings peacefully. Obi is capable of collision detection. If something obstructs its path between the spoon and the mouth, Obi stops and waits for a direction via one of the switches. Additionally, Obi is as portable as a laptop – weighing only seven pounds – and can be carried anywhere from restaurants to back porch to a friend's house.

One of the customer reviews says "Obi has given me back the ability to feed myself and has helped me gain back ten pounds. This is the first time I've ever gained something since my diagnosis" *("Meet Obi - MeetObi")*. Thus, as mentioned in the third paragraph, Obi – an assistive robot – has given the user an increased sense of autonomy resulting in increased social interaction, meal enjoyment and well-being. However, Obi is quite expensive, costing around US$ 4,500.

2. Resyone Plus – Panasonic's Robotic Bed

There are a few devices in the market that transfer patients from a wheelchair onto a bed and vice versa. However, most of these need a middleman – a nurse or a family member and are quite slow. Panasonic's Robotic Bed – Resyone Plus – transforms directly into a wheelchair and

costs around US$ 10,500. A few years ago, it became the first to be certified ISO13482 compliant, the new global safety standard for service robots *("Panasonic's Robotic Bed/Wheelchair First to Earn Global Safety Certification")*. Resyone Plus works by splitting the mattress in half. One side stays firm in place while the other half transforms into a wheelchair. The person using it needs to shift a few inches to one side before switching the split mattress into a wheelchair.

Figure 2 - Resyone Plus Robotic Bed

Resyone Plus takes up less space as a single unit is equipped with multiple functions. As the bed becomes a wheelchair, both the caretaker and the person being transferred feel safer. It is estimated that Resyone Plus reduces the falls caused when transferring patients from bed to wheelchair by around 80% *("Panasonic's Robotic Bed/Wheelchair First to Earn Global Safety Certification")*. Physical and psychological burden of the caretakers can be reduced and may help them to stay in their jobs.

However, if a patient is immobile, they may not be able to move to the side of the bed that converts into a wheelchair on their own and still need assistance from a caretaker. Even though Reysone Plus poses a lot of advantages one of the drawbacks is that it does not give the user 100% autonomy in every case.

3. Panasonic Hair-washing Robot

Introduced in 2010, this hair washing robot claims to offer a degree of comfort that users cannot experience with human hands *(Hornyak and bio)*. The device includes a reclining chair, a mechanized sink, 2 robotic arms and 24 robotic fingers. To begin, it scans the user's head in 3D to understand the shape. It also helps the device to understand how much pressure is needed and where to clean. Each arm is equipped with three motors, each of which control the amount of pressure, the massage motions, and swing *(Boyle)*. The device then ejects shampoo where 8

of the fingers work the back of the user's neck while the rest massage and clean the scalp. Lastly, it applies conditioner and blow dries the user's hair.

Figure 3 - Panasonic Hair Washing Robot

It has been estimated that about 80% of elderly falls in the home occur in the bathroom *("Safety for Seniors: Preventing Falls in the Bathroom: Belvedere Health Services")*. Along with being useful for mobility restricted users this robotic device will also be a boon to the elderly community and their families. The machine was placed in one of the hair studios in Japan for getting feedback from trials. The reviews seemed to be quite good. However, after all as these robots are manually programmed machines. One should always be mindful that one miscalibration can cause accidents.

Open-Source Research

OpenBionics is an opensource initiative that focuses on development of affordable, lightweight, modular, adaptive robotic and bionic devices that can be easily reproduced using off-the-shelf materials *("OPENBIONICS – Open-Source Robotic and Bionic Devices.")*. Body Powered Exoskeleton Glove and Robot Hands are two of their open-source projects that were interesting to read about.

1. Body Powered Exoskeleton Glove

The application of this glove is for restoring mobility of people that suffer from paralysis or stroke. This project offers a compact, affordable, and lightweight alternative to heavy and expensive devices in the market that providing grasping capabilities for the user.

EC 601 – Project 1

Research into Assistive Robots for People with Motor Disabilities

Student Name: Piyusha Dongre

Submission Date: 18 September 2022

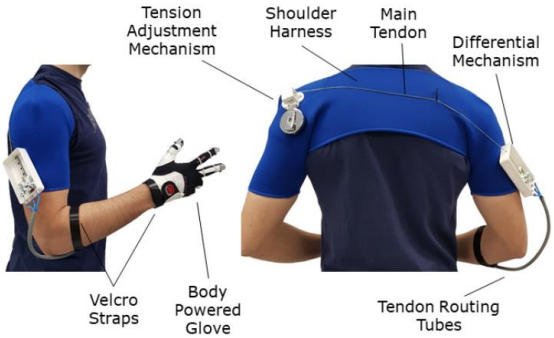

Figure 4 - Body-powered Exoskeleton Glove

As seen in Figure 5, the device consists of four different parts – the differential module, the soft glove, the tendon tensioning and adjustment mechanism and the harness *("OPENBIONICS – Open-Source Robotic and Bionic Devices.")*. This glove works on the mechanism that transmits forces from the shoulders to the fingers through a tendon routing system. The harness makes the device fit comfortably and keeps the shoulders aligned. This glove is simple and straightforward, and users can use it without intense training. It can be adjusted to all body types as the size of the harness and the glove depends on the user's height and weight. However, the execution of tasks upon wearing this glove takes longer due to the longer body compensation motions that are required to actuate the glove *("OPENBIONICS – Open-Source Robotic and Bionic Devices.")*.

The GitHub repository for this project includes all the designs, electronics, software, and bill of materials required to replicate the glove device. According to the sources, the prototype costs less than US$100 and weighs less than 400g.

2. Robot Hands

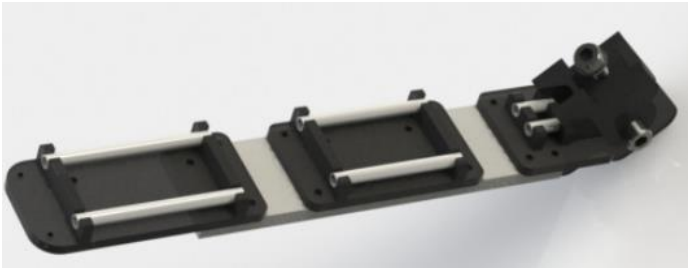

Figure 6 - Structure of Robot Finger

It can be seen from Figure 5 that the elastomer materials appear at the lower part of the robot finger, while the low friction times that are used for tendon routing appear at the upper part of

the finger together with the rigid phalanges *("Robot Hands – OPENBIONICS")*. The robot hand consists of low-cost off-the-shelf materials that can be used to replicate the design.

The GitHub repository for this project includes all the designs, electronics, and software required to replicate the glove device. According to the sources, the prototype costs less than US$100 and weighs less than 200g.

Conclusion

Use of assistive robots can prove beneficial for people with motor disabilities. However, the main issues faced by such devices is safety, cost, and ease of usage. There are a few open-source platforms that allow replication of assistive technologies at an affordable price; however, such platforms are not very common. In addition, roboticists are trying to figure out how to make assistive devices work by developing new interfaces that enable the control of complex robots using a single-mouse and nothing else.

In conclusion, despite such great innovations in the realm of assistive robotics however, there is still much potential for further advancements to alleviate the burdens faced by those with physical disabilities, and it is certainly worthy of rigorous exploration.

References

1. "CDC: 1 in 4 US Adults Live with a Disability | CDC Online Newsroom | CDC." *CDC: 1 in 4 US Adults Live with a Disability | CDC Online Newsroom | CDC*, 16 Aug. 2018, www.cdc.gov/media/releases/2018/p0816-disability.html#:~:text=The%20most%20common%20disability%20type,%E2%80%9D%20said%20Coleen%20Boyle%2C%20Ph. Accessed 14 Sept. 2022.
2. "10 Facts on Mental Health." *10 Facts on Mental Health*, 8 July 2022, www.who.int/news-room/facts-in-pictures/detail/mental-health.
3. "Meet Obi - MeetObi." *MeetObi*, 23 Aug. 2022, https://meetobi.com/meet-obi/. Accessed 14 Sept. 2022.
4. "Panasonic's Robotic Bed/Wheelchair First to Earn Global Safety Certification." *New Atlas*, 15 Apr. 2014, https://newatlas.com/panasonic-resyone-robot-bed-wheelchair-iso13482/31656. Accessed 16 Sept. 2022.
5. Hornyak, Tim, and See full bio. "Panasonic Shampoo Robot Hits the Salon - CNET." *CNET*, 30 Apr. 2012, www.cnet.com/culture/panasonic-shampoo-robot-hits-the-salon. Accessed 15 Sept. 2022.

EC 601 – Project 1

Research into Assistive Robots for People with Motor Disabilities

Student Name: Piyusha Dongre

Submission Date: 18 September 2022

6. Boyle, Rebecca. "Headlines From 2020: Newest Hairwasher-Z Robot Recalled After Tragic Beheadings." *Popular Science*, 25 Sept. 2010, www.popsci.com/technology/article/2010-09/panasonic-recalls-newest-hairwasher-z-after-16th-decapitation. Accessed 14 Sept. 2022.
7. "Safety for Seniors: Preventing Falls in the Bathroom :: Belvedere Health Services." *Safety for Seniors: Preventing Falls in the Bathroom :: Belvedere Health Services*, https://belvederehealthservices.com/belvedere-home-care/blog/safety-seniors-preventing-falls-bathroom#:~:text=Recent%20studies%20have%20shown%20that,home%20occur%20in%20the%20bathroom. Accessed 16 Sept. 2022.
8. "OPENBIONICS – Open-Source Robotic and Bionic Devices." *OPENBIONICS – Open-Source Robotic and Bionic Devices.*, https://openbionics.org/ Accessed 16 Sept. 2022.
9. Chen, T. L., et al. "Robots for Humanity: Using Assistive Robotics to Empower People with Disabilities." *IEEE Robotics & Automation Magazine*, vol. 20, no. 1, Institute of Electrical and Electronics Engineers (IEEE), Mar. 2013, pp. 30–39. *Crossref*, https://doi.org/10.1109/mra.2012.2229950.
10. Editorial. "Top 5 Assistive Robots for People with Disabilities." *RoboticsBiz*, 25 Apr. 2020, https://roboticsbiz.com/top-5-assistive-robots-for-people-with-disabilities/
11. "Robot Hands – OPENBIONICS." *Robot Hands – OPENBIONICS*, https://openbionics.org/robothands/. Accessed 17 Sept. 2022.