AVEC: Power Assist Vehicle Enriching Communication using Intuitive Interface

Jaehoon Kim*
Dept. of Mechanical Eng.
Seoul National University, NAVER LABS
Seoul, Korea
poeq8283@snu.ac.kr

Minkyung Kim*
Dept. of Mechanical Eng.
KAIST, NAVER LABS
Daejeon, Korea
kmk7733@kaist.ac.kr

Hotae Lee*
Dept. of Mechanical Eng.
Seoul National University, NAVER LABS
Seoul, Korea
hotae319@snu.ac.kr

Keunwook Kim*
Dept. of Design / Communication
Seoul National University, NAVER LABS
Seoul, Korea
kwkim15@snu.ac.kr

Jungwook Moon*
Dept. of Mechanical Eng.
Seoul National University, NAVER LABS
Seoul, Korea
wjddnr623@snu.ac.kr

***Abstract*— We designed "AVEC", a wheelchair that helps an old caregiver intuitively manipulate with minimum force and interactively communicate with the passenger. AVEC has an interface using loadcell to recognize the caregiver's intention regardless of his or her hand position and two hub-motors to assist movement. We developed two prototypes and verified the utility of AVEC, which can be manipulated in a more intuitive way and enrich interaction between the passenger and the caregiver. Improving the current prototype to version3 will allow AVEC to enter our daily lives by improved interface and the system cooperating with the users.**

Keywords*— *Power assist wheelchair, Intuitive manipulation, Interaction design, Assistive technology

I. Introduction

In an aging society, importance of wheelchairs will increase as means of mobility. For elderly who have difficulty manipulating electric wheelchairs by themselves, caregivers need to push wheelchairs from behind. While most commercial wheelchairs are designed for passengers, there are few products focused on older caregivers. We developed a system also helpful to the caregivers.

There are many problems in conventional wheelchairs. First, controlling a manual wheelchair is a significant burden for older caregivers, especially on rough terrain and slopes. To address this, some electric wheelchairs [1, 2] have joystick or lever-type interfaces that enable users to operate behind the wheelchair. However, these products should be manipulated in a keen way corresponding to the walking pace. In addition, their unintuitive interfaces need training for the user to become proficient. After having experienced riding an electric wheelchair, we found that it was difficult and less intuitive for subtle manipulation with a joystick.

Second, it is difficult for caregivers to communicate with passengers. We conducted a field test to identify discomforts of manual wheelchairs by simulating a situation of a wheelchair passenger and a caregiver. Through the test, we found that it was hard for the wheelchair passenger to communicate with the caregiver, because both of them were facing the front. Also, role players seldom thought themselves as equal personals, as one was sitting in the wheelchair while the other was standing behind it.

Lastly, according to a survey the most uncomfortable aspect of electric wheelchairs was heavy weight[3]. Their bulky volume is also a major problem. To apply them into everyday lives, people must be able to handle them easily.

In order to solve the above problems, "AVEC", a novel wheelchair system, is designed to understand the caregivers' intentions and assist them with the force they lack. Also, it can improve the communication between caregivers and passengers while walking alongside the wheelchair.

II. Design Process

In order to build a focused problem space, we adopted 'Metodologia del Design' by Bruno Munari[4]. Also, to maximize understanding of the user, we conducted documentary research and drew an emotional user journey map according to the Human Centered Design guidelines[5]. Throughout the process, design goals were built upon the two frameworks. We have been developing multiple prototypes to accomplish the goals based on the iterative design process, and eventually get to the optimized solution. The goals we set are the following:

A. Intuitive power assist system

In order to solve difficulties in moving wheelchairs, we propose an intuitive power assist wheelchair system. The wheelchair adds force proportionally to the caregiver's input force. When caregivers push, pull and rotate this wheelchair, they would feel like operating a very light manual wheelchair no matter how heavy it actually is. In addition, generally it is easy to think of a joystick interface in terms of manipulating a powered wheelchair. Instead, we tried to make it more intuitive by using a handle-shaped interface. Therefore, this system assists the caregivers while they move naturally, as there is no need of conscious manipulation. The elderly with weak muscle strength and those who need time to learn complex interfaces can use this system without any training.

B. Interface that improves interaction between a caregiver and a passenger

While using a manual wheelchair, there was difficulty in communication between a caregiver and a passenger as the position of the handle makes it hard for them to face each other. AVEC interface solved this problem, enabling the users to communicate face to face. To deal with this, we decided to improve the shape of the interface. In order to help the caregiver manipulate the wheelchair right next to the passenger, we added an extension to the handle at a preferable angle. In this way, an old passenger with bad sense of hearing can communicate with a caregiver smoothly. This change is expected to help form a closer relationship.

---

*All authors contributed to this work equally.

Fig. 1. Manipulating AVEC behind it(left) and alongside it(right)

Fig. 2. Prototype 1(left) and Prototype 2(right)

C. *Light weight and foldable structure*

For wheelchairs to be used in everyday life, they need to be more accessible to the user. For example, when we have to keep a wheelchair in a certain space such as the trunk of a car, a foldable and compact structure is preferable. Also, reducing the weight of the wheelchair is necessary to transport it easily. These two goals will make a wheelchair more user-friendly.

III. PROTOTYPE DEVELOPEMENT

Based on main goals derived from our design process, we have developed two prototypes. Both of them mainly consist of a recognition part based on loadcell interface as Fig.1 and a driving part based on two BLDC motors. The loadcell interface on the steering handle can recognize the intention of the caregiver's behavior by measuring the amount of force applied from the caregiver's hands. The system controls the BLDC motors to assist the force of the caregiver in proportion to the force applied. It can help the caregiver carry the wheelchair with minimum force. Also, the wheelchair automatically stops when the caregiver releases his or her hold. Prototype 1 mainly focused on practical utility while prototype 2 more focuses on the first goal, intuitive power assist function, by building the system from scratch. Finally, prototype 3 will be downsized for better application in our daily lives.

A. *Prototype 1*

- System Configuration – In prototype 1, we modified the existing manual wheelchair for fast production but with much similar appearance to the wheelchairs originally used. We replaced the existing wheel with BLDC hub motor and added the loadcell interface into the original handle. Moreover, we developed a specialized handle to allow the caregiver walk alongside it while moving the wheelchair. An LED strip on the handle shows the state of the wheelchair whether it is operating or coming to a stop. Prototype1 improves usability of the caregivers in a more intuitive way.
- Field Test – The usability of prototype 1 was evaluated by five professional caregivers for the elderly by comparing prototype 1 from the manual wheelchair after using both products. The result showed that the power assist function relieved the burden of caregivers. Also walking side by side, they could interact with the passenger more comfortably.

B. *Prototype 2*

- System Configuration – We developed the whole wheelchair system which concentrates on intuitive driving performance. The basic frame was made of aluminum profile and designed to flexibly test many conditions, such as the suspension and the wheel size for better quality of the ride. To keep the manipulation intuitive in various environments such as on a slope, we used IMU sensors to estimate the state of the wheelchair and assist appropriate force. Gain tuning for the brake system and enhancement of the assistance function were also applied to improve driving performance to become more intuitive.

C. *Prototype 3*

We are planning to develop prototype 3 to improve visual feedback and make our daily lives more comfortable. Prototype 3 includes a handle with touch sensors, which recognize the location of the caregiver's hand. Through this recognition and better LEDs, we can display information with more clarity. Furthermore, downsizing and applying the folding mechanism will help the wheelchair to be better used in people's daily lives.

IV. CONCLUSION

As society ages, the needs of caregivers and wheelchair passengers are changing. However, conventional manual wheelchairs are insufficient to meet their needs. Thus, we developed a new wheelchair to achieve three design goals derived from existing issues and successfully proved them through field tests. An intuitive power assist system improved the interaction between a caregiver and a wheelchair. Also, an extended interface improved communication between caregivers and passengers. Lastly, a lightweighted foldable structure will make the wheelchair more accessible in our daily lives.

ACKNOWLEDGMENT

This project was supported by NAVER LABS Autonomous Machine group.

REFERENCES

[1] EZ Lite Cruiser, Caregiver (rear) joystick mount. URL https://www.ezlitecruiser.com/collections/customize-your-ez-lite-cruiser/products/ez-lite-cruiser-caregiver-joystick-mount.

[2] AATGB Ltd., V-Max. URL https://www.aatgb.com/v-max---v-max-4.html.

[3] J. Lee et al., "An investigation of caretakers needs for changes in electric wheelchairs ", *Journal of Rehabilitation Welfare Engineering & Assistive Technology*, Korea, vol. 10, pp. 177–184, August 2016. (in Korean).

[4] Munari, Bruno. Da cosa nasce cosa. Bari, Laterza, 1981.

[5] IDEO.org, The Field Guide to Human-Centered Design. San Francisco, IDEO, 2015.