A Walking Aid Integrated in a Semi-Autonomous Robot Shopping Cart

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***Abstract*—Challenged and/or elderly people experiencing limited mobility impairment may want to get support for walking. In public, e.g., in a supermarket, they may want to get this support without it being immediately visible. Therefore, we integrated walking aid functionality into a robot shopping cart. It can support a customer to lean on the cart while the walking pace is controlled to follow a user-determined setting. More precisely, the user of the cart can get walking assistance by holding specifically designed handle bars supporting both arms. This construction is fully integrated in a prototypical robot designed as a shopping cart.**

Keywords—Walking aid; semi-autonomous robot shopping cart.

I. Introduction

Especially in an aging society, more and more (partial) challenges arise. Primarily elderly people often experience challenges with walking. As long as they can walk, however, they typically prefer some kind of walking assistance over a wheel chair. In public, they may even want to hide their challenge and to get such support without it being immediately visible. The latter requirement is hard to fulfill with a dedicated walking aid.

We developed a (prototypical) robot serving as a shopping cart and, from the very outset, we planned to integrate a walking aid. When someone would use such a robot shopping cart, this very robot can serve both the usual shopping purposes and as a walking aid. Its motor power lets it drive to desired goods and help move loaded goods, and at the same time provide walking assistance. In addition to the mode with the walking aid, the robot cart has a steering mode, an autonomous mode and semi-autonomous modes for guiding a user to certain products and for following the user. Unless the robot is in the walking aid mode, its handle bars are in a locked position.

This shopping cart is a companion robot designed to perform services in a complex and cluttered dynamic environment, a supermarket, shared by humans and other robots. To share such an environment with humans and to cooperate with them requires certain communication abilities from the robot. Even our prototypical implementation for research purposes can handle multimodal input through a touch screen, speech input and a barcode reader [3], as well as output through a graphical user interface and speech output [2]. It can even reinforce multimodal output through a motion cue [6]. The primary services that we implemented in the prototype are management of a shopping list and guiding a user to the products from the shopping list.

The remainder of this paper is organized in the following manner. First, we explain the design and implementation of this walking aid. Then we present an exploratory study with it. Finally, we discuss related work.

II. Walking Aid Design and Implementation

We designed the cart to provide walking assistance for users with special needs. In particular, it provides physical support for walking, via an add-on ergonomically designed for such users. Another main goal was to particularly support those who want to hide their challenge while shopping in a supermarket.

Taking existing designs for non-robot walking aids into consideration, the idea was to use a construction supporting both arms with handle bars positioned at waist-height and equipped with buttons for user control. However, no adjustments in width and height were intended, in order to keep the design and the first-time usage simple. The buttons can be pressed easily while holding the handle bars for being physically supported. Due to safety reasons, two (yellow) bumper rings enclose the outer cart shape for detecting collisions. These bumpers limit the leg-moving space, i.e., a walking aid add-on inside the bumpers has safety-related advantages but is ergonomically inapplicable.

Therefore, the handle bars of our walking aid are swivel-mounted on the cart (see a design sketch in Figure 1 with body proportions). Figure 2 shows the implemented walking aid in its locked position. Whenever the walking aid is to be used, the handle bars can be swiveled out of their vertical spring-locked position. Figure 5 shows this position of the implemented walking aid when in use for steering the robot. The swivel-out event is detected by two micro switches to enable an automatic mode change of the cart.

Each of the two bars ends is equipped with two pushbuttons for controlling speed and orientation of the cart. Two of these buttons can be seen in Figure 2. The walking aid control through all four buttons is illustrated in Figure 3.

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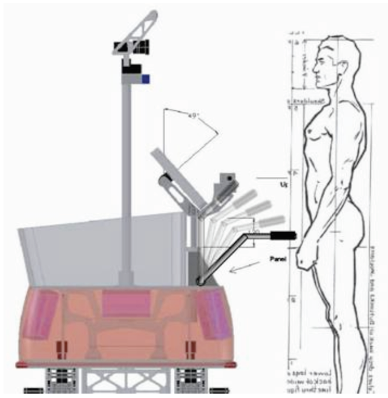

Figure 1. Swivel-mounted handle bars for our cart walking aid related to body proportions.

Figure 2. Implementation of the walking aid — locked position.

However, there is no step-less speed control, and compared to the autonomous modes of the cart, maximum speed and acceleration are reduced for better controllability.

III. Exploratory Study

We have explored how a robotic shopping cart apart from its main function of carrying goods and guiding to locations in the store, could have a second function as a walking aid. In order to conduct a formative evaluation of the walking aid, we carried out a small user study where we let two users drive the robot (as shown in Figure 5), who where untrained on the walking aid. As the prototype is motorized and in an early stage, we did not involve people with actual walking impairments as users of the system for safety reasons.

A. Setup and task

The participants were introduced to the notion of a walking aid. They were also shown how to operate the robot using the buttons on the handles, both with the illustration shown in Figure 3 and by letting them try it out on their own. Using a think-aloud protocol, the participants reported which one of the functionalities they attempted to use.

After that, they had to perform the tasks depicted in Figure 4. The first task was to drive *forward* in a slalom course to a point located in the map (see Point 1). Once at Point 1, they were instructed to drive *backward* to Point 2. This slalom course contains the typical maneuvers one would perform with such a shopping cart. The grey boxes shown in the figure are empty cartons with a dimension of about $60 \times 60 \times 60$cm. The participants were instructed that they should not touch the boxes with the robot.

After they had performed these tasks, the participants received a subjective questionnaire and filled it out.

B. Results

Both participants managed to learn driving the robot using the given interface, and they also succeeded with the driving task. Further studies, however, are necessary to figure out if this electro-mechanical interface is helpful and easy to learn for the elderly and (partially) challenged people as well. Since only two people took part in the study, it makes little sense to provide quantitative data. There were some open questions where the participant expressed their opinions:

- *“[I] would like the direction button on the other hand”*
- *“a bigger turning radius would be better for handicapped people”*
- *“The global behavior is easy to understand even if a few tries are needed to learn the commands”*
- *“[It’s] easier to learn by using than by reading instructions.”*

The construction was considered stable and pleasant to grasp, and its handling and use easy to learn. Interestingly, just trying it out was considered more effective than the instructions through the illustration in Figure 3. Still, the placement of buttons should be studied further.

IV. Related Work

Most of the related research activities focus solely on the walking function. They implemented their support for walking as a primary, single function, either by assisting with the driving using the handle as input (see [1], [11]) or by assisting visually impaired users to a location using a physical interface modeled after the leashes of guide dogs. The user grabs the handle and follows the robot (see [8], [9]).

Graf et al. [5] designed and implemented a semi-autonomous walking aid platform for elderly and handicapped people. These authors have people in mind that use

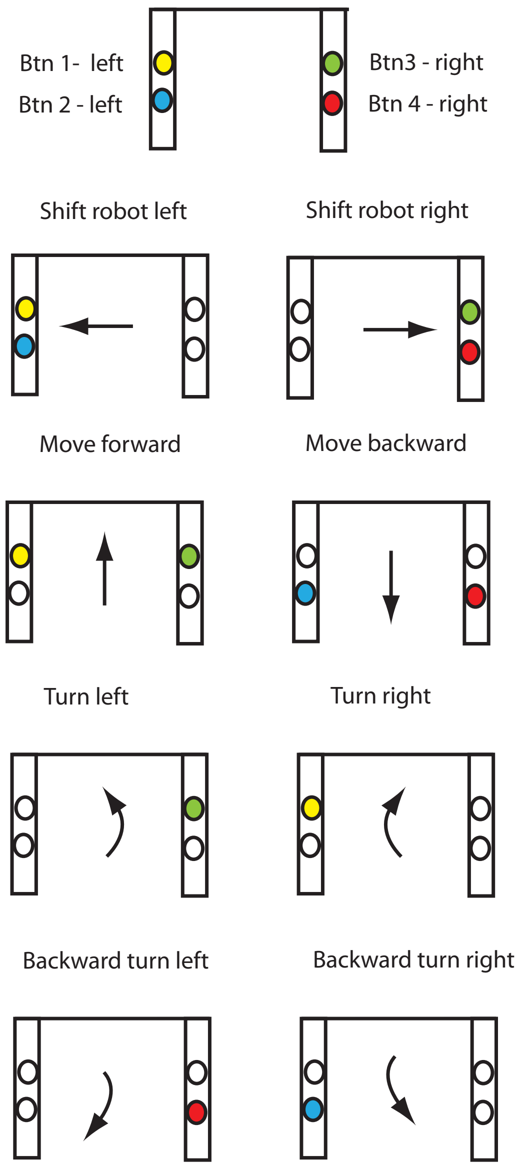

Figure 3. Walking aid control through the four buttons.

this platform day-by-day, thus getting used to it. While this walking aid is used mainly at home, we focus on a populated domain like a supermarket, where people typically do not have much time to learn a user interface. Moreover, we focus on slightly impaired users who are, in principle, able to walk on their own, but might require some help when maneuvering a shopping cart filled with a lot of goods, and would like to hide their walking problems.

Addressing the same problem of keeping the elderly and handicapped independent, previous research by Lee et al. [10] and Annicchiarico et al. [1] presents personal assistive mobility devices for elderly people with walking

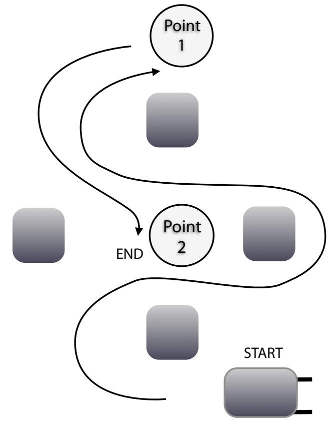

Figure 4. The map showing the task that was used for the pilot study.

impairments. However, their focus is on users requiring a "pure" walking support. Our work does not fit well for those that who have more severe problems when using a shopping cart in a supermarket.

Kanda et al. [7] presented an affective guide robot in a shopping environment. This robot supports people to navigate through a shopping mall and provides information about products via a speech interface for input and output. Even though our service robot shares the same domain with this service robot, their work does not have any functionality to help people with a walking impairment.

Glas et al. [4] introduce a guiding and helping robot called RoboPal. It is designed to operate in the domain of everyday life, acting as a guide or helping people with daily errands in real-world environments. The authors studied nonverbal cues of RoboPal associated with leading and following behavior of the robot. However, due to its morphology, RoboPal is a communication robot only and not intended to physically support the elderly or disabled in the course of maneuvering goods in a shopping cart.

V. Conclusion

We designed and built a walking aid that is prototypically integrated in a semi-autonomous robot shopping cart. Through building it and a small exploratory study, we gained first insights and showed the principal feasibility of such an approach. After the safety issues will have been solved satisfactorily, studies and experiments with people having partial challenges with walking can be a next step for further development of such an integrated walking aid.

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Figure 5. The walking aid in use.

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