

Design of a Wheelchair Mounted Robot

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Abstract

A prototype wheelchair mounted robot has been designed using a systematic design methodology which included regular consultation with wheelchair users (the "volunteers"). During evaluation of the Wessex Robot (a portable, trolley mounted robotic manipulator) with disabled users, it became clear that, in certain circumstances, a wheelchair mounted robot would be more useful to a severely disabled person. A survey amongst volunteers has been carried out and interaction with a proportion of these volunteers has led to the design of a prototype suitable for further development. Where appropriate the design of the prototype is based upon the Wessex Robot.

Background

The Wessex Robot comprises a manipulator mounted upon a wheeled trolley which may be moved about by a helper. The robot has a single switch input and a LCD display provides a scanning menu system.

This system is appropriate for users who are not moving around a lot in their homes. Where a user can move around

unaided, in their home a wheelchair mounted robot may be more appropriate. If the wheelchair is powered the necessity of providing a separate power source is obviated.

Objectives

The long term objective is to design and build a working wheelchair mounted robot suitable for long term evaluation by volunteers. This device will use the same design of manipulator as that developed for the Wessex Robot (the "manipulator"). A new vertical actuator, appropriate user input device/s (probably a modular system), a new end effector and wheelchair mountings will be designed and built. New software and new electronic hardware will also be required.

This paper describes the work leading to the design of the first prototype device.

Initial Survey

Twenty eight questionnaires were completed by volunteers (ten questionnaires were completed by people with muscular dystrophy, six by people with spinal injury, four by people with cerebral palsy, four by

people with multiple sclerosis, and four by people with other disabilities).

The completed questionnaires gave an indication of the group of people most interested in a wheelchair mounted robot, the nature of disabilities that the robot would have to accommodate e.g. involuntary movements, the person's daily reliance upon a carer, the type of wheelchair presently used, the type of input devices that they were accustomed to using, and so on.

Following analysis of the completed questionnaires four people were interviewed in their own homes to ascertain a more complete picture of their requirements. These four people represented four different disability groups: cerebral palsy; muscular dystrophy; spinal cord injury; and multiple sclerosis.

Design Concepts

On completion of the initial survey the information gathered from the volunteers was used to guide the conceptual design work. The emphasis was on safety, non-interference with the use, accessibility, and mobility of the wheelchair, the ability to perform priority tasks, robustness, reliability, keeping the costs down, and aesthetics.

The manipulator can only operate in a horizontal plane. Vertical translation must be provided by an additional

system which must not move the manipulator out of a horizontal plane during use. Various designs were considered and eventually these were reduced to three concepts, one which mounted upon the front of the wheelchair, one which mounted upon the side, and one which mounted upon the rear of the wheelchair (Fig. 1).

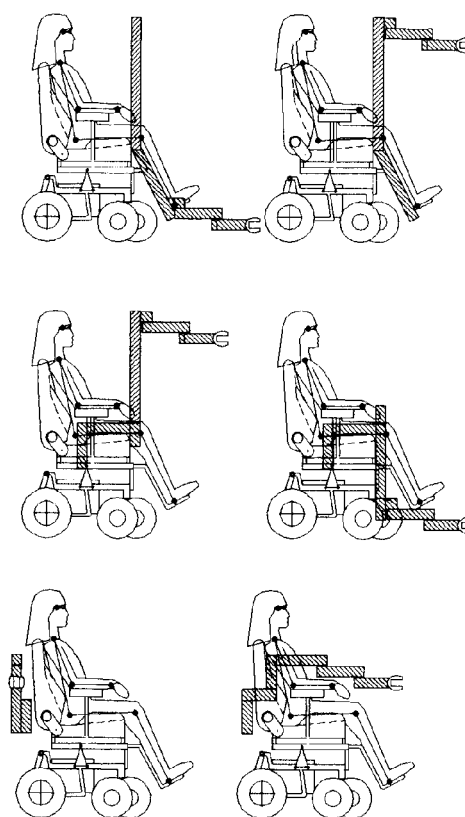


Fig. 1 Initial concepts

Five volunteers, chosen to represent different disability groups and different age groups were sent a description of the concepts together with drawings, and a

questionnaire exploring issues affecting the manner in which the robot arm should be mounted. Four people completed and returned the questionnaires.

After analysis of the responses it was decided to explore a simplified version of the concept which mounted the robot upon the side of the wheelchair.

The design to be explored further comprised a tall, simple, aluminium mast (the "mast") with a square cross section cantilevered off a pivot attached to the wheelchair below the level of the seat. The mast provided a linear bearing for the manipulator to run on.

During use of the robot it was proposed that the mast would be positioned at the front of the wheelchair and, when no longer required, that the robot be swung out-of-the-way to the rear of the wheelchair. It was hoped that this would enable users to make unimpeded transfers in and out of their wheelchairs, and enable carers to help correct the user's posture without enhancing the possibility of injury to the carer or to the wheelchair user.

If the mast obstructed access to a table or desk, it was proposed to allow the cantilever to swing slightly out to one side, thereby allowing access but still maintaining the use of the robot. Finding means of preventing the robot from destabilising the wheelchair was

considered to be an important issue and it was planned to investigate this further after user evaluation.

Telescoping and folding masts were considered but rejected on the basis that they were complex, heavy, and relatively expensive, in favour of a simple permanently extended mast. Whether or not a permanently extended mast would be acceptable to the volunteers became a key question in the research that followed.

Prototype Design

The prototype (Fig. 2) comprises a tall, slender aluminium mast with a square-cross section and a specially designed linear bearing which allows a mock-up of the manipulator to be moved and positioned at any height. The mast is cantilevered at one end of an aluminium box section. The box section pivots about a small stand designed to sit close to a volunteer's wheelchair.

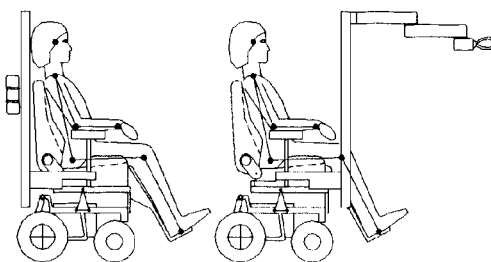


Fig. 2 Prototype concept

Three volunteers from different disability groups were chosen to give

their opinion on the proposed design. The interviews were all carried out in the homes of the volunteers save for one interview which was carried out at a residential home whilst the volunteer was in respite care. By placing the prototype's stand next to a volunteer's wheelchair, each volunteer could get an idea of what it might be like to have the robot more permanently attached to their wheelchair.

Response to the design varied greatly, two of the volunteers felt that they could tolerate the shape and size of the proposed design. The third volunteer did not like the design at all and said it made her "...feel like a robot".

The volunteers made a number of suggestions e.g. reduce the amount of room required by the robot when being swung around to the back of the wheelchair, ensure that the mast can be (very) easily detached and re-attached to the wheelchair etc.

Conclusion

The present prototype design looks promising but it is only at the very beginning of a long iterative design and re-design process. The regular input of the volunteers is crucial even though it can be time consuming. It not only helps prevent expensive mistakes being made but it also provides an insight into the psychological factors which will

ultimately affect the success of the design.

Future Work

Work has already begun on the design of the new prototype and the electronic hardware which will be incorporated within it. In addition to evaluation by volunteers the prototype design will also be mechanically tested from strength, reasonable life, and general robustness. Design work on the new end effector will begin shortly.

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