

TECHNICAL RESULTS FROM MANUS USER TRIALS

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Abstract

Eight users have tried the Manus arm at the Department of Rehabilitation at Lund University Hospital. The user trials were carried out in close co-operation with Certec at Lund University.

After the trials one of the users, Ms Eva Gerdén, decided to buy a Manus arm, and she received her Manus arm in November 1998.

The main objective of the user trials was to find out how robot technology could support the early rehabilitation of people with spinal cord injuries. Another objective was to increase the knowledge of user needs and what make robots worth using.

This paper presents technical comments received during the user trials and from Ms Eva Gerdén. The results could be used for improvements to the Manus arm, to other wheelchair-mounted manipulators and to robots in general.

One of the most commented issues is the physical size of the Manus arm, preventing the user from driving the wheelchair close to a table or maneuvering the wheelchair through narrow passages.

Two of the users immediately stated that it was awkward to have the Manus arm mounted on the left side of the wheelchair, since they are right-handed.

Background

Certec at Lund University and the Department of Rehabilitation at Lund University Hospital have been co-operating within the field of rehabilitation robotics since 1993 when a RAID workstation was installed and evaluated.

In 1996 we received funding for creating a National Rehabilitation Robotic Center at the Department of Rehabilitation. A Manus arm [1, 2] (the first in Sweden) was purchased and user trials were carried out from May 1997 to May 1998. The main objective of the user trials was to find out how robot technology could support the early rehabilitation of people with spinal cord injuries.

After the trials, one of the users, Ms Eva Gerdén, decided to buy a Manus arm, and she received her Manus arm in November 1998. She is so far the only Manus end user in Sweden.

Another objective of the user trials was to increase the knowledge of user needs and what make robots worth using.

Certec's interest in theory and method is documented in "Certec's Core" [3].

Methods

Eight users have tried the Manus arm at the Department of Rehabilitation at Lund University Hospital. The user trials were carried out in close co-operation with Certec at Lund University.

Seven of the eight users have spinal cord injuries (C3-C6) and they had been injured 0.5-21 years at the time for the trials. One user has a spinal muscular atrophy since birth. The ages of the users were 22-51 years.

Approx. 15 patients and earlier patients at the Department of Rehabilitation were invited to the trials. Seven of them wanted to be part of the trials. The eighth user in the trials, Ms Eva Gerdén, was actively looking for robotic aids and was therefore invited to the trials.

The Manus arm was mounted on a Permobil Max90 wheelchair (fig 1) and the users had to move from their own wheelchairs to the Permobil wheelchair during the trials. Two joysticks were used for controlling the Manus arm and the wheelchair. Some users could use their hands to control the joysticks and some users used chin control.

Each user tried the Manus arm 3-4 hours per day for 1-2 days at the Department of Rehabilitation. Two of

the users asked to try the Manus arm at home for 2 hours, and so they did.



Fig 1. The Manus arm mounted on a Permobil Max90 wheelchair.

The users could choose which tasks to carry out, and at the end all users carried out the following drinking task:

- Open a kitchen cupboard,
- bring a glass to the table,
- close the cupboard,
- open a refrigerator,
- grasp a jug of water,
- pour water into the glass,
- return the jug to the refrigerator,
- close the door,
- insert a straw if necessary,
- drink the glass of water and
- return the glass to the table.

Other tasks carried out by the users:

- Take a book or a binder from a shelf and put it on a table or on their knees.
- Insert a video tape into a video cassette recorder and return the video tape to a table.
- Reach the environmental control unit from a shelf.
- Pick up things (e.g. a hand stick or a remote control) from the floor.
- Pick up a dropped magazine from a user's feet and put it back on his knees.
- Press door opening buttons and elevator buttons.
- Open the front door of a user's house.

During the trials, comments and suggestions from the users were written down and followed by a discussion. After the trials, a questionnaire was sent to the eight users.

More thorough discussions have been held with Ms Eva Gerdén after she decided to order a Manus arm. There has been a continuous dialogue with her about adaptations, modifications and suggestions for improvements as well as about the importance of independent living.

This paper presents technical comments received during the user trials and from Ms Eva Gerdén. The results could be used for improvements to the Manus arm, to other wheelchair-mounted manipulators and to robots in general.

Results of the questionnaire

Seven of eight users answered a questionnaire:

- Only one user wanted to have a Manus arm as it looks and works today. The other users thought it was too large, too heavy and too difficult to control.
- However, four users would like a Manus arm if it was improved. The following improvements were mentioned: It should be mounted on the back of the wheelchair. It should be possible to use the wheelchair joystick to control the Manus arm. It should be smaller, lighter, easier to use and have more reach. It should be possible to lift heavier things.
- Five users would like to try the Manus arm again, if it was improved.
- Speed: Three users think it is too slow. Three users think it is OK.
- Strength: Four users think it is too weak. Three users think it is OK.
- The most difficult thing when using the Manus arm: Too many "commands" for a small adjustment. Too many functions to keep in mind in the beginning. Using the joystick.

Comments and suggestions received from the users

Size and position

One of the most commented issues is the physical size and position of the Manus arm, preventing the user from driving the wheelchair close to a table or maneuvering the wheelchair through narrow passages.

Furthermore, the view from the wheelchair is limited when the Manus arm is mounted, and even more limited when folded out.

Two of the users immediately stated that it was awkward to have the Manus arm mounted on the left side of the wheelchair, since they are right-handed (even if they have not used their right hands for many years).

Modify the fold out and fold in procedures, so they don't require so much space. Turn the base all the way to the user's legs before folding out the upper and lower arms just in front of the user.

Weight

The Manus arm is mounted above one of the front wheels, which makes wheelchairs with small front steering wheels difficult to steer. It is also harder to drive the wheelchair up a sidewalk curb.

Reach, payload and grasping force

More reach to the floor. In general, the reach is too short. The maximum payload is too low to manipulate a 1 kg pot without problems. The position of the gripper relative the center of gravity of the object to be grasped causes high torque. It should be possible to see how hard the gripper is holding an object.

Detect the weight of a grasped object (e.g. a milk package) to be able to know how much I can tilt it before the milk is at the edge of the package. It is

frustrating to find out that the package is almost empty, when you have been very, very careful during the pouring movements.

Gripper fingers

A gripper with three fingers might be more useful and might be more rigid than the two-finger gripper. The fingers of the gripper should be a little thinner, narrower and rounded to be able to grasp small things 45 degrees from vertical.

Joystick, keypad and their menus

It is very difficult for the user to use two joysticks (one for the wheelchair and one for the Manus arm). A joystick switch box for the Permobil wheelchair is not yet available. The Manus display should be integrated with the wheelchair display.

The Manus joystick can rotate around itself. This is a problem when you need to have a Y-shaped adaptation on the joystick on which you can put your hand. If you lift the hand from this Y-shaped adaptation, it is difficult to put the hand back.

Sometimes it is not good to have the movement of the Z-axis and the open/close movement in the same joystick menu. When you control the joystick with your chin and move the arm in the Z direction, it is hard to prevent the gripper from opening by mistake (and dropping an object). However, when you can control the joystick without problems, it is very

good to have these movements in the same menu.

The two menu alternatives “Away” and “Closer” should be added to the keypad drink menu. This is good if you have to grasp a glass close to the table, to prevent the fingers of the gripper from pushing against your lips. The speed of the “Stop drinking” movement should be faster than the “start drinking” movement.

New movements

Small and large circular movements should be introduced, to be able to stir sugar in a cup of coffee or to stir food on the stove.

Short movements with high acceleration would make it possible to push food (e.g. meat balls) around in the fry-pan.

Discussion & Conclusion

The mounting position of the Manus arm unnecessarily limits the number of potential users. People with spinal cord injuries at the levels C5-C6 will hardly accept a Manus arm, which stops them from driving very close to a table. This is necessary to be able to use their limited arm/hand functions.

A solution where the Manus arm temporarily could be moved back along the side of the wheelchair is desirable. It should still be possible to use the Manus arm from this position. An arm mounted on the back of the wheelchair would be a better solution in this perspective, since the wheelchair

would be narrower without the arm on the side.

The results of the user trials indicate that integration of the wheelchair and the robot arm is the key to success for wheelchair mounted manipulators. If wheelchair manufacturers could have their wheelchairs prepared and approved for mounting robot arms, the enormous amount of work for each adaptation could be reduced and the user would have an optimum solution. The robot might then be worth using.

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