Internet based manipulator telepresence

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ABSTRACT

A wheelchair based manipulator MANUS for severely handicapped people is in use with over one hundred people in their homes. Assessment, telepresence, training and communication among users and between users and professionals are helpful in many phases of acquisition and use of such a manipulator. Services and technologies are developed in the EU supported project Commanus (remote diagnosis, remote optimisation, and remote control). Internet communications with both real and virtual real functions are described in this paper.

1. INTRODUCTION

The MANUS[1] manipulator is a technically advanced robotic manipulator designed to be mounted on a wheelchair and able to assist severely handicapped users in their daily tasks. An example of a Manus manipulator mounted on a wheelchair is shown in Figure 1. Today we witness the tendency that Rehabilitation Robotics (RR) is gaining slowly acceptance among the handicapped community and only a fraction is actually using the robotic manipulator devices in their daily lives. The main reason is the availability of alternative solutions such as smart homes, human carers and assistants to do tasks or services that could otherwise be performed by rehabilitation robots. Another factor that limits the use is the relatively unawareness of the potential users and rehabilitation advisors of the real capabilities of the robots if they are aware of their existence at all. Even when this awareness is present it is still difficult to decide whether or not to purchase the rehabilitation robot. The decision is mainly driven by the expected practical value of the rehabilitation robot, expressed in the increased hours of independence, the perceived utility and the estimated cost savings. Usually, this requires a time consuming assessment involving a rehabilitation robot, a rehabilitation advisor and service of the manufacturer of the rehabilitation robot. The potential user has to prove to be able to control the robotic device using a suitable human machine interface. Therefore, apart from choosing the right interface, the handicapped user has to train and reach a certain skill level even to be considered for purchasing these relatively expensive devices.

Another limiting factor is the high service level of these devices, which poses problems to the manufacturers as they are usually SMEs (small- to medium-size enterprises) with limited resources for service and support. This is also a cost increasing factor. Taking into account these aforementioned factors, the cost reimbursement organisations are not convinced of the benefits of these rehabilitation robots. In addition they may be less familiar with the advances in these new technologies and therefore reluctant in purchasing robotic devices.

Related to the above mentioned aspects is the fact that, so far, no effective infrastructure to reach the end users and potentially new users is available. Therefore, there is a strong need to have a better understanding of the user and the user needs and to have a well-established dissemination of information to show the cases with successful robotic rehabilitation solutions. In other words, we have to bring the Research and Development and the user community together to bring the benefits of RR into practice.

This paper describes an Internet based environment to operate a virtual or a real robotic manipulator in which the technology is totally transparent to the user. Internet based robotics systems are to some extent already as state of the art available (Leifer et al, 1997), though not for commercial RR systems.

We propose 'telepresence' as a means for teleassessment, teletraining, teleeducation, telediagnosis and telemaintenance. In this paper we will first introduce the global architecture of the system and discuss the 'tele'-aspects one by one.

[1] Exact Dynamics, Product Information URL: *http://home-1.worldonline.nl/~dynamics/*

Figure 1. *Manus manipulator mounted on a wheelchair.*

2. SYSTEM ARCHITECTURE

In Figure 2 a simplified schematic sketch of the system architecture is presented. The set-up is based on and inspired by the developments in RETIMO (Dreissen & van Woerden, 1999) and in the COMMANUS project.

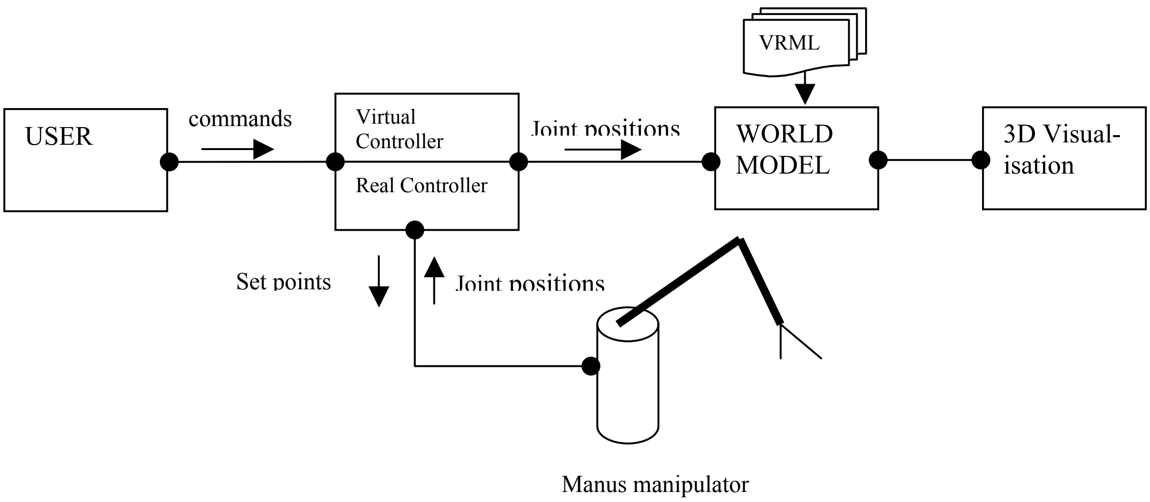

Figure 2. *Global architecture of the internet based manipulator telepresence environment.*

In this set-up the different building blocks are connected through the Internet as the means of communication whereas they may be at physically different locations. The user in Figure 2 can assume different roles. Typically, there are the handicapped user, the developer and the support and maintenance engineer, all using the same infrastructure. However for different types of use the blocks may be distributed differently over the real world. For example in remote assessment the handicapped user may control the real Manus manipulator through the Internet at a remote location relying only on a visual feedback.

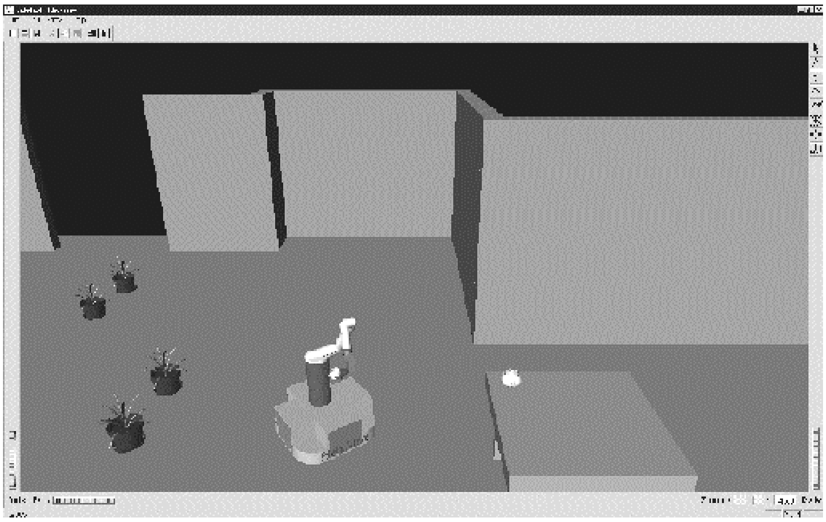

Figure 3. *A possible virtual world.*

The user chooses to use either the virtual controller or the real controller, which steers the real robotic device. In the world model different scenarios can be loaded which can range from complex scenes to mimic different real world situations to a simple scene with just a representation of the robot. The real world model is based on VRML file format, an emerging 3D-description standard, which is rich enough to ensure realistic visualisation as well as compact to facilitate responsive rendering through the Internet. An example of a virtual environment is shown in Figure 3. Currently, in the 3D-visualisation we use OpenInventor® as the 'glue' between the VRML input, the socket communication with the clients and the 3D rendering. This guarantees the developer a real-time performance and at the same time opens the way to generate VRML output.

3. TELEPRESENCE AND A VIRTUAL ENVIRONMENT

3.1. Virtual assessment

Users can perform first experiments over the Internet with a simulation environment like the one depicted in Figure 4.

With assistance over the net, either in text or by human speech, the disabled people can assess their ability to control simple movements. Moreover, they can mount the Manus manipulator in the virtual space on their own type of wheelchair and control Manus e.g. with a joystick.

3.2. (Tele)Training, Learning

A training and education module is under development, where a three-level training home is foreseen. The user environment consists of a control device connected to a web application (PC with Internet and access to the training site).

The training module consists of:

(a) A users home (later it may be the home of the disabled user) provided, at level 1, with only a Manus manipulator in the virtual space. In this environment the degrees of freedom of Manus can be controlled.

(b) At level 2 the manipulation of objects is trained in 2 ways. In the virtual space blocks (the well-known Kwee building blocks) can be mounted on top of each other either in a predefined or in a free setting.

(c) Use of the Manus manipulator in a virtual home is at the 3rd level. At this level the wheelchair with a Manus mounted on it can perform special tasks controlled by the user over the net. "Go from the living room to the kitchen. Open the door, drive trough the corridor. Open the kitchen door, go to the kitchen. Open the refrigerator, pick up a bottle of beer and return to the living room. Drink your beer."

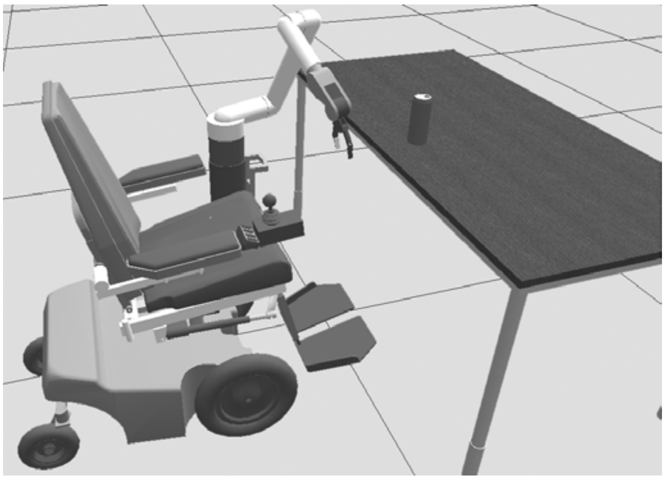

Figure 4. *A possible simulation scenario: working with a virtual manipulator.*

3.3. (Tele)Education

A Manus user and a professional assistive technology adviser are able to optimise functionality through communication with virtual reality and demonstrations in reality. Various users, communicating with each other can also perform this act.

3.4. (Tele)Diagnostic, Monitoring and Maintenance

By means of the Internet communication the user can be monitored and followed for health care purposes or to see whether service is required. It may also happen that the Manus is stuck in a certain position; in this case the embedded safety precautions, which prevent the user from damaging the Manus, make it impossible for the user to get it out of this position. In this particular situation, the support engineer remotely gets the current position and enters a lower control level to engage a safe trajectory to a correct position. Of course, the engineer may first practice a safe trajectory on a virtual robot to ensure a proper result. This procedure leads to a faster and less expensive maintenance and, for problems that can be solved via software, avoids the user to send the manipulator for service.

3.5. Virtual Development Environment

The virtual environment may help and boost research and development in new and efficient ways. First of all, the controller may be simulated and the effect of the new control can be visualised and validated in the virtual environment prior to testing it on the real robot.

Secondly, advanced controls such as an intelligent path planning algorithm for moving to a pre-defined position in a well-defined way from any point in the workspace can be developed off-line. Furthermore, the cost of development may be reduced as virtual robots are cost-effective solutions and several virtual robots can exist in parallel without extra costs.

Thirdly, a virtual developing environment opens the way to effectively integrate with other areas such as machine vision. Especially, a robotic device such as Manus with a substantial amount of backlash may benefit from feedback sensor equipment. This is essential if the Manus manipulator has to carry out tasks autonomously. One can envisage the Manus manipulator a task like "pick-up book", or "pick-up coffee cup". Semi-automating these tasks may enhance the usability and user-friendliness substantially.

4. FUTURE DEVELOPMENTS

4.1. RR Community

We foresee the development of a virtual rehabilitation robotics community. In this framework users can exchange recorded functionality, discuss best practices of control and exchanging self made operational modes like, for instance, a new drinking mode. Furthermore, in this community the interaction between users and professional will be essential and it will be encouraged, in order for the professionals to have a better understanding and view on required functionality.

4.2. Machine Vision Capabilities

One of our goals is to have Manus on a mobile base and carry out tasks autonomously. In order to do that, we are currently working on providing our system with machine vision capabilities. One or more cameras can be used for several and useful purposes.

A vision system in fact can be helpful for the navigation of the mobile base especially when working in an indoor environment. The robot may make use of natural or artificial landmarks present in the working space both for positioning itself and for target definition and path planning. From the manipulator point of view, which doesn't require help for positioning, a vision system is useful for helping the disabled user in tasks such as finding the object of interest, defining the best grasping point and speeding up the sequences of operations. An obstacle avoidance skill can improve performances both for navigation aspects with the mobile base and for safety aspects related to the manipulator.

From the point of view of the virtual environment development, a vision system is required for dealing with modified environments that have to be accurately rendered.

4.3. Improved Sensor System

New sensor systems will facilitate manipulation with Manus. An example is force/torque feedback sensors, which may help with complex tasks such as putting a cassette into a VCR. Experimentation with virtual sensors in the virtual environment will facilitate the design phase.

5. CONCLUSIONS

The assessment, training, learning, performance supervision, technical support and maintenance for rehabilitation robotic devices are difficult, expensive and insufficient supported for individual severe handicapped users. Since over one hundred Manus wheelchair mounted rehabilitation robots are now with users at their homes, the time is right for 'telepresence' as presented in this paper. We propose an infrastructure where the user, the developer and the support professional are brought together and may learn and benefit from each other. It is time to bring the benefits from Rehabilitation Robotics into practice. The Internet based manipulator telepresence environment will give a modest step forward in this direction.

6. REFERENCES

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