AFMASTER : AN INDUSTRIAL REHABILITATION WORKSTATION

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ABSTRACT

Experiment and evaluation show that robotized workstations are excellent tools to allow severely disabled people to get back to work. The modularity of such workstations provides to users a way to find a part of autonomy in their daily life (cooking, drinking or playing).

Up to now, there was no industrial workstation able to provide not only powerful functions but also robustness and reliability. Most of workstations were laboratory prototypes and, in spite of efforts of the developers, the reliability was the weak point of the system.

The French association APPROCHE has been working for many years to convince users, doctors and occupational therapists that robots are one of the best way to assist disabled people. In 1998, after two years of massive evaluation of the EPI-RAID workstations, APPROCHE asked to AFMA Robots, French manufacturer of industrial robots, to develop a new workstation. This AFMASTER workstation would be based on principles experimented by CEA on MASTER, RAID and EPI-RAID workstations but built with methods and quality of an industrial manufacturer.

The two first AFMASTER workstations will be operational in summer 1999. This paper presents the results of the evaluation of the EPI-RAID workstations and the design of the new AFMASTER ones.

INTRODUCTION

More open than the Handy 1 robot, easier to control than the Manus robot, the robotized fixed workstation should have found many applications for rehabilitation of disabled people.

Nevertheless, 15 years after the first MASTER prototype, this kind of robot is still less used than the robots of Rehab Robotics or Exact Dynamics.

While the DeVAR project was spreading his wings in USA [1], the RAID and EPI-RAID European projects brought the concept of MASTER to its maturity. But they were to steps left before an actual dissemination: a complete evaluation of such a workstation and a real industrialization to get a reliable and performing product.
The APPROCHE association, CEA and AFMA Robots have been getting together to take these decisive steps.

THE TEAM

The APPROCHE association

Founded in 1992, the French APPROCHE association gathers rehabilitation centers to promote the use of robotized systems for rehabilitation of disabled people. In 1995, APPROCHE bought 5 EPI-RAID workstations and 2 embedded arms MANUS. These robots have been evaluated by around 100 users in 10 French rehabilitation centers. This massive evaluation is partly described in this paper. After this fruitful experiment, APPROCHE wants that doctors become able to prescribe robots to patients as they prescribe electric wheelchair.

AFMA Robots

AFMA Robots is a 42 person company. It produces Cartesians manufacturing robots and performs engineering of robotized cells. Since 1980, AFMA has built more than 800 robots used in many industrial areas (automotive and aerospace industries). The competencies of AFMA Robots go from the mechanical design to the automate programming of multiple robot systems. Developing a new robotized workstation for rehabilitation is a new challenge for AFMA. The constraints of cost are far stronger for this application.

CEA

The French Atomic Energy commission has been involved in rehabilitation robotics for more than 20 years. In the 70s, CEA proposed to apply its knowledge in robotized manipulation to rehabilitation domain. For the Spartacus project and the very first Master project, CEA was the main designer and developer of the robotized system. Within the RAID and EPI-RAID projects, CEA associated to European rehabilitation centers improved the concept of workstation. CEA was the technical support of APPROCHE during the evaluation of the 5 workstations.

EVALUATION OF THE EPI-RAID WORKSTATION

The EPI-RAID Master workstation

The latest version of the Master Workstation (the EPI-RAID workstation) was based on a PC and transputer boards. Transputers were used for real time control of the arm. The Man-Machine Interface of the system used a graphical interface developed under Windows 3.1 [2].

Besides the robot and its controller, the workstation includes an environment control system (ECS).
The graphical man-machine interface can be configured to any kind of input device. Whatever the handicap of the user is, when he is able of controlling a single switch, he can access to all the functions provided by the workstation.

Fig. 1: the EPI-RAID Workstation

A programming language allows the station to be automatically controlled for complex or repetitive tasks involving the robot and the ECS.

A pneumatic tool changer allows to choose, according the task to perform, a universal gripper or a sheet of paper manipulator.

Method of evaluation

APPROCHE bought 5 workstation to be evaluated in 10 French rehabilitation centers. 91 users (65 men and 26 women) have evaluated the workstation [3].

For 86% of the users, the learning phase was short (2 day long). 90% of the evaluations lasted two weeks. Only one user has worked with the station 6 month long.

70 % of evaluations happened without any technical problem. Most of the failure came from the ECS. Computer and robotics failed less frequently.

Three domains of application were proposed for evaluation: vocational applications (inserting floppy disk in the PC, handling books or sheets, stapling sheets together...), daily life (handling glass or bottles, taking medicine, hanging phone...) and leisure (inserting video or audio tapes, handling CDs...).

Results of evaluation

First, no situations were found where the disabled user could not use the system. Results of evaluation showed that the interest and the efficiency of the workstation is particularly appreciated for vocational tasks and leisure tasks.

Training was considered to be easy by 86% of the subjects. Access to the control station was considered to be well designed (75%), though 64% of the users felt that a second control station was necessary in order to separate the different functions (leisure, office, domestic), to have better visibility of each part of the
station, or to use the station in a recumbent position.

With respect to the operating modes, 84% considered the automatic mode interesting, while 80% judged the manual mode necessary on security and autonomy grounds, but felt that in practice it was too slow and too complex. The environmental control system was much appreciated (73%).

Other options gathered are: aesthetic judgement is varied (44% are appreciative, 16% do not like the system, and 40% have no opinion); 61% consider the system insufficiently reliable; 66% thought the organisation of the station to be functional, but in general the visibility was considered poor.

Estimations of the autonomy and time gain are reported in the table below.

<table>
<thead>
<tr>
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<th>Autonomy gain</th>
<th>Time gain</th>
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<tbody>
<tr>
<td>important</td>
<td>33%</td>
<td>17%</td>
</tr>
<tr>
<td>not important</td>
<td>62%</td>
<td>48%</td>
</tr>
<tr>
<td>none</td>
<td>5%</td>
<td>35%</td>
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</table>

A psychological study has been led during the technical evaluation[4][5]. It reveals that using this kind of assistance is interpreted by many users as giving up the hope of using again their own body. Of course, this feeling is painful. But the principle of programming tasks is very positive. The user has to think to what has to be done by the robot. He has to put his ideas together to explain the robot how to accomplish a task. For some users, the workstation was an opportunity to think again.

Last but not least, every one agreed to say that the cost of an EPI-RAID workstation (about $100,000) was an important obstacle to its real domestic application.

**THE NEW AFMASTER WORKSTATION**

**Objectives**

When APPROCHE asked AFMA Robots to develop a new fixed workstation for severely disabled people, it just asked for a reliable and cheaper EPI-RAID workstation. AFMA translated this request as a MTBF of 10,000 hours and a price of $50,000 for the new AFMASTER workstation.

**Mechanical design**

AFMA kept the design of a SCARA robot. This kinematics gives a wide enough work envelope fitting with the shelves the robot has to reach.

In opposition of the EPI-RAID workstation, the AFMASTER workstation does not include a horizontal rail to improve the working area. Several reasons explain this choice. The first one is an economical one: the less axis you have, cheaper
The interface of the EPI-RAID workstation has been preserved. The user can choose a task by selecting icons on the screen. An icon can represent a task or a set of tasks.

We assumed that the user is able to control a « mouse like » input device.

![Figure 2: Man-Machine interface of AFMASTER application](image)

A scanning facility is provided to assist the user for selection of the icon.

A sound blaster board and a modem are integrated to the PC. The user has an Internet connection, integrated phone and fax facilities.

The IBM Gold speech recognition unit allows the system to be controlled by the voice of the user. The workstation application is completely Windows 98 compatible. So this application is controllable by the speech recognition unit as easily as any other Windows 98 application.
One of the problems to solve was to use the same microphone for speech recognition unit and for phone and to have the same speakers for phone, speech synthesis and audio CD listening.

AFMA Robots has developed an ECS connected to the parallel port. This universal remote control can be programmed and used by a software running on the PC. This software can be used by the AFMASTER application.

Next steps

The first AFMASTER workstation will be delivered to APPROCHE in June 1999. APPROCHE will use this station in Kerpape to promote this new industrial product. APPROCHE will use this workstation to show to concerned people that this kind of product exists, is reliable and can assist the disabled in his daily life.

APPROCHE will buy ten of these new workstations within the two next years. These stations will be used for the same application in the other APPROCHE rehabilitation centers.

CONCLUSION

The good results of the evaluation of the EPI-RAID workstation helped the APPROCHE association to convince an industrial robot manufacturer, AFMA Robots to accept the challenge of building a reliable, cheap and performing robotized workstation for disabled people.

Thanks to the long experience of CEA, AFMA Robots designed and realized the new AFMASTER workstation in less than one year. The ten first models of this workstation will be used by APPROCHE in its rehabilitation centers to promote this industrial technical assisting device. We hope that, within two years, the eleventh AFMASTER workstation will move in a user’s home.

REFERENCES

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