A More Efficient Man/Machine Interface: Fusion of the Interacting Telethesis and Smart Wheelchair Projects

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***Abstract* — This article presents a new and more efficient man/machine interface resulting from the fusion of two projects: the Smart Wheelchair project and the Interacting Telethesis project. This new interface allows a more natural control of the automatic motion capabilities of the smart wheelchair VAHM (Autonomous Vehicle for Motor Impaired People). Indeed, the pilot needs only to make his request (switch on the TV for example) without giving details about its location.**

The VAHM project aims to bring a piloting assistance for motor impaired people to powered wheelchairs using techniques coming from mobile robotics. It is possible to call upon local primitives like « wall following » or « automatic forward motion », or to plan an automatic trajectory.

The second project aims to realize a man/machine communication interface for people with motor impairments; interface defined as an « Interacting Telethesis » i.e. as a cognitive and/or valid motion resource(s) extension of the user. Therefore, the Interacting Telethesis allows disabled persons to be able to communicate (read, write, speak, listen, warn) with other people and to act on their environment (TV, music, etc.).

***Keywords*— mobile robots, powered wheelchairs, environmental control, man/machine interface, disabled persons.**

1. INTRODUCTION

The number of people who need mobility and/or communication assistance is regularly increasing as a result of a longer life expectancy on the one hand, and of an improvement in resuscitation techniques following perinatal or sports accidents on the other hand [1].

However, conventional electrical wheelchairs are not always sufficient to compensate for mobility disabilities: serious spasticity, excessively weak residual physical capacities (tetraplegia) exclude or hamper their use. In certain cases, a simple improvement of the standard joystick may be sufficient [2]. The use of other sensors instead of the joystick has often been described in publications [3] [4]. Parallel to this research, mechanical improvements to the wheelchairs may also facilitate its control [5]. An intelligent piloting assistance, indispensable in others cases, may also improve driving comfort, thus, reduce physical and nervous exertion for regular users of powered wheelchair [6].

Concerning the communication assistance, aids about disabilities are the most often designed to take care about one functionality [7][8]: writing and reading assistance, environmental control, voice synthesis, ... There are only few works addressing the integration of multiple functionality [9][10].

After a brief description of the two projects, we will see how the fusion of the man-machine interface allows optimizing the dialogue between the pilot and the smart wheelchair to obtain a simplified control of the automatic motion functionality.

2. BACKGROUND

2.1 THE VAHM PROJECT

Within the framework of the VAHM project (Autonomous Vehicle for Motor Impaired People), we aim to realize a modular system which would adapt to important levels of disability and a variety of situations (rehabilitation center, home, etc.).

The VAHM prototype (fig.1) is composed of a POWERPUSH electrical wheelchair. A computer (Pentium 166MHZ), connected to the wheelchair via a servo-motor card interface, manages low and high levels functionality and especially the man-machine

Figure 1: The VAHM robot

interface. Moreover, the wheelchair is equipped with a belt of 16 ultrasonic transductors. A 68HC11 board drives each sensor data processing. Dead-reckoning measures completely the system.

Thanks to a command sensor, the user pilots the robot via a graphic screen. The choice of the command sensor depends on the physical abilities of the user. From a functional point of view this sensor is either of proportional type (joystick, etc.) or an On/Off sensor (single switch, etc.).

To use the different functionality implemented on the wheelchair, the pilot communicates with the machine through a series of graphic screens.

Three main moving modes are available [11]:

- *The manual mode*: in this mode, the wheelchair control is not assisted. We find the usual working of a classical electrical wheelchair piloted with a proportional sensor (joystick) or a simple switch (On/Off switch).

- *The assisted manual mode*: in this mode, the pilot can choose «wall following» after having selected the left or right wall to follow. During a displacement along a wall, obstacles such as radiators or an opened door are taken into consideration by the wheelchair. The pilot can also choose an «automatic forward motion» and the wheelchair moves forward following the direction chosen by the user. If an obstacle appears it is automatically bypassed with a return as soon as possible to the initial direction.

- *The automatic mode*: in this mode, the environment is modeled by a discrete topological model [12]. Goal definition and choice of the final orientation may be done on the screen by selecting the destination semantically (« living room » and after «TV», «bedroom» and after « light », etc.). This restricts the number of authorized automatic motions but simplifies the man/machine conversation. Once the robot knows the destination, it plans and follows the path automatically by bypassing non-modeled obstacles on its way [13][14].

We have also developed a methodology to measure objectively and in real time, the performances of the man/machine system constituted of the automated wheelchair and its pilot. For this purpose, an evaluation criteria has been defined, representative of the person's physical and mental workload as well as of the machine's technical capacities [15]. The criteria defined above have been validated during tests in real situations carried out in a rehabilitation center with persons with motor disabilities [16]. The aim was essentially to validate the choices that contributed to the conception of the robotized wheelchair VAHM.

2.2 THE INTERACTING TELETHESIS PROJECT

The aim of our project is to palliate the progressive interacting deficiency by designing a Telethesis compatible with the central cognitive process and/or the valid motion resource(s) [17].

The characteristics of the interactive Telethesis are first based on an empirical analysis of the need of a hospitalized person (attacked by Amyotrophic Lateral Sclerosis) during 6 months. Follows an iterative validation of various models obedient to the subject. The analysis closes with 240 hours of systematic recording of the operative mode of the subject (technical monitoring) that has allowed and will again allow to find new functionality and to optimize the interface ergonomic.

Concerning the interface control, all type of command sensors (breath sensor, On/Off switch, joystick, etc.) can be used. In that case, it is a on/off switch, since the subject has no other possibility. Only the validation of a pre-selected choice by permanent scanning of the functionality is realizable.

The material architecture is that of a multimedia PC equipped with a CD-ROM reader, portable for convenience reason in hospitable environment (fig. 2). The connection between the PC and the control case is made through the serial interface and the keyboard port. The control case is equipped with a 68HC11 microcontroller that manages a universal IR remote (TV control), the connection of a switch command and the management of the software (watchdog technical use) and hardware (power cut detection) security.

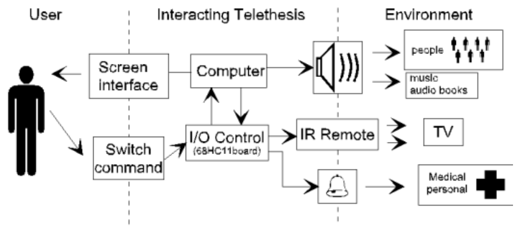

Figure 2: Synopsis of the Interacting Telethesis

At the moment, six functionality are implemented on the Interacting Telethesis project (fig. 3):

- Control of the medical alarm: bell warning the medical personal,
- Text publishing: reading text with integrated page mark and writing text with an online assistance of word prediction (based on 90,000 words),
- Television control: channel and volume control,
- CD-ROM reader control to listen to music and audio books,
- The use of pre-recorded sentences to communicate with the external world.

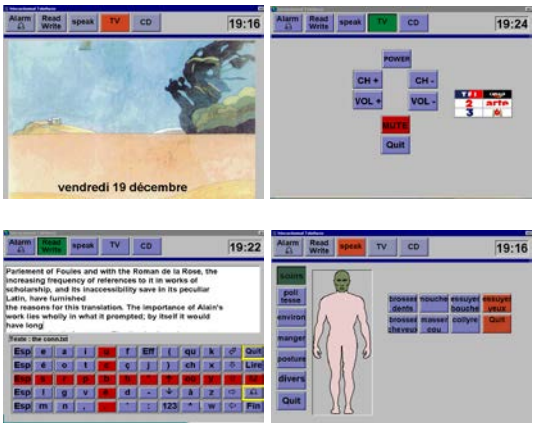

Figure 3: Some screen examples of the Telethesis man/machine interface

This way the user has the possibility to control some dimensions of his environment and can therefore in a certain way warn, read, write, listen and see.

The use of a notebook computer allows us to design a modular man/machine interface that take advantage of all the multimedia power according to the needs of the person. Therefore, all the functionalities are grouped in a single interface where the person uses them without computer knowledge.

Developed with only one subject, our aim is to enlarge the application field of the Telethesis. Such a device, due to its modularity, could be automatically adapted to different types of motor handicaps or to the elderly. Future investigations will have to demonstrate the feasibility and the validity of our approach.

3. MAN/MACHINE INTERFACE FUSION

3.1 MAN/MACHINE INTERFACE OF THE VAHM: MOTION CONTROL

Concerning the actual VAHM man-machine interface, the pilot has two methods to control the motion of the wheelchair (fig. 4). This interface allows from a main screen to use the motion possibilities implemented on the wheelchair:

- Manual control: the user can control manually its movements in the four directions (forward and backward motion, left and right turn) by selecting the appropriated icon during the scanning choice. A motion assistance can be associated (automatic obstacle avoidance) according to the needs of the person.
- Assisted manual or automatic control: the person can use a more or less complete assistance according to his location. When the person decides to use the automatic mode (X icon validation cf. fig. 4), if the wheelchair is in a modeled environment, the mode proposes to lead the embarked person into a pre-recorded destination (room, kitchen, etc.). If the wheelchair is not in a modeled environment the person uses the assisted manual mode by choosing to make a wall following or a forward automatic motion (obstacle avoidance in the direction given by the wheelchair orientation).

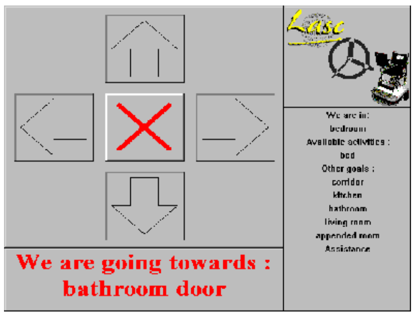

Figure 4: Actual VAHM man/machine interface

Therefore, to trigger an action, the person must first designate the location action before it can use the environmental control module.

3.2 FUSION FOR A MORE EFFICIENT MAN/MACHINE INTERFACE

The fusion of the man/machine interface of the VAHM project with the interface of the Interacting Telethesis project allows the user to pilot automatically his VAHM wheelchair with only two commands. We call this request a « metaphorical command » since it will directly generate the realization of the action requested by the pilot (for example: TV icon followed by the power icon validation - cf. first screen example of figure 3).

The man-machine interface of the VAHM project is not any more mobility oriented. This new interface uses the ergonomic of the Interacting Telethesis by proposing in priority the communication assistance with the physical and social environment that is statistically the most used. An icon dedicated to the mobility is added to be able to use the manual mode or the assisted manual mode (figure 5).

Figure 5: New Man - Machine Interface

With regard to the use of the automatic mode, the request by the pilot of a « metaphorical command » generates automatically a wheelchair motion if necessary. The man/machine interface module analyzes the request and uses the planning module by giving him automatically the goal point.

This analysis of the request is realized by using inference rules based on the actual localization of the wheelchair and on the type of the request, as for example:

IF *validate action* **IS** *TV ON* **THEN**
IF *wheelchair localization* **is not right for** *TV* **control THEN**
proposes an automatic motion to the *TV* **and realize** *TV ON*

Because of the cooperative command architecture of the VAHM project, the implantation of the new man-machine interface and the I/O interface is considerably simplified since all the software modules communicate with each other and are independent [18].

This modification of the use of the automatic mode simplifies and optimizes the utilization of the VAHM wheelchair:

- The person does not need any more to designate the location request: minimization of the man/machine dialogue (important for the pilot's physical workload),
- The wheelchair capacities are more exploited since its position is known in the environment at every moment: exploitation of the localization module in order to decide automatically a motion,
- The man/machine cooperation is optimized: the wheelchair analyzes the « action oriented » request of the pilot helping him to realize the action more rapidly.

This implies that the automatic mode is no longer used to go everywhere in the environment as we can do it with a designation of a geometrical type on an architectural plan. To do this, the pilot has to use the functionality of the manual or assisted manual mode. The use of the automatic mode becomes then completely transparent for the embarked person.

4. CONCLUSION

In this paper we have described the modification of the man/machine interface of the VAHM project that comes from the fusion with the Interacting Telethesis project. The main idea of this fusion is to optimize the cooperation between the disabled person and the wheelchair in order to make better use of its automatic motion capacities.

To implant efficient motion capacities on an electrical wheelchair based on mobile robotics techniques is not enough for the person to forget her handicap. Whatever their sophistication degrees may be, if the control of these functionality is too complicated, the pilot will not use them. It is necessary therefore that the cooperation between man and machine is the most optimized so that the pilot can naturally control functionality which are not natural.

With the different researches in the laboratory and the clinic test in the rehabilitation center, we have been able to improve the specifications of the VAHM project. This show us that the implantation of an automatic mode (development and improving: modeling, planning, localization, etc.) is only conceivable if it is easy to use. The analysis of the use of the automatic mode shows us its use essentially to bring the person to execute what he wants to do. The request has generally a well precise aim and a well-defined position in its evolution environment.

With this new man/machine interface the pilot can control its wheelchair by thinking only to transmit the desired request without having to detail it.

The future works, besides the improvement of the different algorithms implanted in the system, and the complete implantation of the new interface are moving toward a more elaborated use of the monitoring technique (online recording of the data flow between man and machine). The purpose being to analyze in real time the request of the user so that the system adapts automatically to them [19].

6. ACKNOWLEDGMENT

Authors hold to salute the memory of Sir LAMAZIERE J., Biomedical Engineer, and its courage to confront sickness and to commit in this Interacting Telethesis project where he has played a central role. Authors thank also the Jeanne Garnier medical house to allow them to continue our research. We thank also the « Association Française contre la Myophatie » (A.F.M.) that sustains financially the project VAHM, as well as the POWERPUSH Company that provided us with an electrical wheelchair for the technological transfer of our prototype.

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