Assistance System for Disabled People: A Robot Controlled by Blinking and Wireless Link

Lara del Val, María I. Jiménez, Alonso Alonso, Ramón de la Rosa, Alberto Izquierdo, and Albano Carrera

Departamento de Teoría de la Señal y Comunicaciones e Ingeniería Telemática, Universidad de Valladolid, España
lara.val@tel.uva.es

Abstract. Disabled people already profit from a lot of technical assistance that improves their quality of life. This article presents a system which will allow interaction between a physically disabled person and his environment. This system is controlled by voluntary muscular movements, particularly those of face muscles. These movements will be translated into machine-understandable instructions, and they will be sent by means of a wireless link to a mobile robot that will execute them. Robot includes a video camera, in order to show the user the environment of the route that the robot follows. This system gives a greater personal autonomy to people with reduced mobility.

Keywords: Assistance technology, blinking, disability, robot, wireless.

1 Introduction

One of the clearest attributes of human dignity refers to liberty. Liberty is the ability to choose among possibilities, to be accountable for one's action. Autonomy principle is closely related to this responsible liberty. People attach more and more importance to personal autonomy as the only way of treating disabled people fairly and equally.

Nowadays 9% people in the world have some disability [1]. They can be caused by several reasons, such as accidents, population ageing or congenital causes. Assistance or Rehabilitation Technology (AT or RT) arises in response to disability problem and the loss of personal autonomy, reaching into expanding disabled people abilities [2].

RT develops assistive robots, which are included in three groups: smart wheelchairs [3], telecare systems [4] and assistive robots over mobile platforms [5]. Most of these systems are controlled through traditional control methods: a joystick, a mouse or a keyboard. The problem arises with people who control only head movements. For these severe physically disabled people, there are systems that are controlled by voice [6], by brain waves [7], by head tilt [8], or even by electrooculography [9]. The disadvantage of these systems is their electrodes, which work out uncomfortable for some users, and their training work is long and complex [10]. Furthermore, most of these systems have a PC connecting the user and the device to be controlled. Development of a portable system, which controls mobile objects through stimuli, comes up with the purpose of remove this intermediate device. So the system could be easily carried

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and could be applied to countless daily life devices. Furthermore, hardware that comes into contact with the user is removed due to comfort reasons.

This paper proposes the design and implementation of an assistance prototype system for disabled people. This system will favor people with reduced mobility. It tries to promote and take advantage of movements that the patient preserves in order to execute those tasks that he cannot carry on by himself. The system tries to extend control and influence of this patients over their usual environment; this gives them greater autonomy and quality of life. Developed system consists of a robot whose movements are controlled by some voluntary action that the disabled person is able to execute. The system is very flexible and is included in pervasive computing thanks to the use of wireless links and to its modular structure. Like this, the designed prototype can be fitted to include more devices that could make human-environment interaction easier, such as a mechanical arm or a wheelchair.

2 System Objectives

Some principal system objectives are imposed, in order to establish the specifications over the design. First, this system must achieve generic objectives of assistance systems:

- Functionality: System must be useful for disabled people and must help them to make tasks that they cannot make on their own.
- Usability: System operation must be easy to learn and use.
- Comfort: System must be comfortable to use, in order to avoid user's rebound.
- Portability: The more portable the system is, the more easy to use it is and if the system has a stand-alone operation.
- Economy: Final product must have a moderate cost to be available to everyone that need it or want to use.
- User satisfaction.

Apart from these generic objectives, some specific objectives are pursued with this system:

- Providing severe disabled people with a means of interaction and environmental exploration is the final purpose of this system. The purpose of this system development is that severe disabled people will recover independence and liberty through interacting and exploring the environment by means of the limited gestures that they are still able to carry out. Some of these disabled people only keep mobility over the neck, or even only blinking capacity. That is the reason why the developed prototype has a human–machine interface (HMI) based on blinking detection.
- The system must be flexible to adapt itself to different disabilities by means of several user interfaces. So it could be used as a training system for the rehabilitation of disabled people. These users will be able to exercise the movements that they can execute, just like that changing the system input interface. Blinking detection interface could be changed for buttons or even for a manipulative arm. This objective is closely related with pervasive computing.

- The system must also be able of being employed as an entertainment system, mainly for disabled children. The possibility of interacting with the environment, which this system offers, is a key factor on the feasibility of the system acceptance as a game by disabled children. This system could also be use as a rehabilitation one. Play has an important role in children's development, a crucial vehicle to learn about themselves, the environment, and to develop social relationships.

3 System Structure

Figure 1 shows system general structure, on a functional level. The system is composed, mainly, of four blocks:

- The first subsystem is the user interface and is used to detect stimuli. It detects user's voluntary movements through a sensor; particularly, this article explains blinking detection sensor.
- This subsystem is the input interface of the second subsystem: the processing and transmission block. It interprets stimuli and sends them to the reception unit placed on the robot through a wireless link.
- This robot is the third subsystem. The reception unit adapts the stimuli to be understood by the robot, which moves according to them.
- Finally, this robot has a video camera that is added to its frontal side. This video camera transmits on UHF to the TV set that is placed in front of the disabled person. With this video camera, the user can watch the environment of the robot's route.

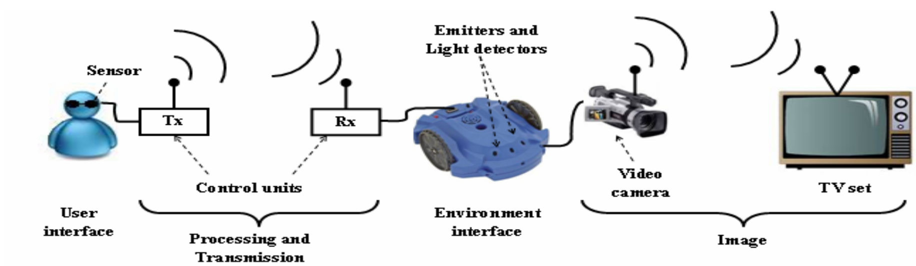

Fig. 1. System general structure, on a functional level

4 System Implementation

Once system structure and operation are defined, components of each system block have to be specified for each block task. Finally, the system is assembled. This stage takes into account that the system must have a reduced size and a friendly physical appearance, so circuits are hidden as much as possible.

Voluntary blinking is produced by a contraction of orbicularis muscle that surrounds the eye [11]. With this action, an ahead/behind movement comes about on eye external angle. This movement is the basis for blinking detection. Interface block achieved two tasks: getting the user order and fitting it for transmission. Produced signals could be simple or complex. The simple ones are generated through one action. There are three types of these simple signals: right eye blinking, left eye blinking and both eyes blinking. Complex signals are generated by means of two consecutive actions: right eye and then left eye blinking, or left eye and then right eye blinking. It is taken into account that second blinking must be within a predefined time interval. Table 1 shows these simple and complex actions, i.e., the relation between user blinking and corresponding robot movements.

Table 1. Relations between blinking, actions and instructions identification

Instruction ID	Blinking*	Action	Previous instruction
1	REB	Advance	Any
2	LEB	Move back	Any
3	REB»LEB	Turn right	Any
4	REB»LEB	Turn left	Any
5	REB+LEB	Stop	1,2,3 or 4
6	REB+LEB	Advance	5

*REB = right eye blink, LEB = left eye blink, » = consecutive stimuli, + = simultaneous stimuli.

Blinking reception block consists of glasses and optic sensors that are placed on the glasses arms, as can be observed on Figure 2. These optic sensors consist of an infrared emitter and a photodetector. Signal reception is based on measuring changes on light that comes from a source. Infrared emitter gives infrared light our towards eye external angle, where two different zones have been defined: a light/ahead zone and a dark/behind zone. These zones can also be observed on Figure 2. Light is reflected over one of the zones, depending on the eye is winked odder not.

(a) **(b)**

Fig. 2. Sensor positioning and reflection area definition: (a) Resting-state and (b) Blinking

The environment interface is a commercial robot, in order to avoid designing and making a specific robot. Like this, developing a low-cost and flexibly programmable solution is achieved, so that the system reaches a larger number of people.

The image block captures images through a video camera that is placed on the front part of the robot, as can be observed on Figure 3, and sends them through a UHF channel. Finally, these images are displayed on a TV set.

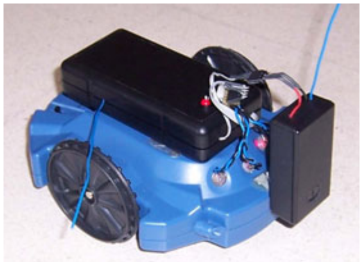

Fig. 3. Final robot appearance

5 System Performance Evaluation

In this section, the operational tests that have been carried out with our prototype are presented. Five people with no disabilities were asked to follow a use and learning protocol, which was developed to measure system usability and time that is necessary to control robot activity.

After testing the system, users were asked to answer a questionnaire, in order to assess their opinion regarding some system features. Their answers were coded according to a 5-level Likert scale (from -2 to 2), and are shown on Figure 4. All these features have positive evaluations. System response delay is the only feature that does not seem positive. Fortunately, these delays can be improved if the patient is trained enough in interface use.

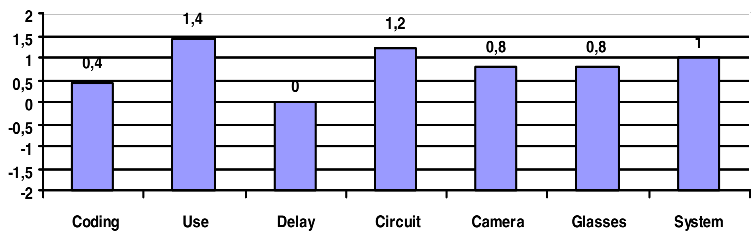

Fig. 4. Average users' evaluation

6 Conclusions

This is an easy to use system for people that have reduced mobility, but are able to execute voluntary actions with their facial muscles, particularly those related with blinking. This system can also be used by people that need support on their interaction with the environment, because they are immobilized, for example, in bed.

This system has different uses, such as trainer of communication capabilities that disabled people have. These capabilities can be used to manipulate a wheelchair, a robotic arm or even a computer mouse with the same interface. This use allows them to watch some home areas where they cannot move due to their physical disabilities.

Our system can also be used as a communication means to allow disabled people to demand medical assistance to their carers.

The system is very inexpensive and is within reach of any disabled person. The cost of elements that are part of the system does not exceed 200$, without including the TV set. At present, a new version of this system is being developed. It has a wireless TV set, in order to improve system performance, being able to send captured images to several TV sets: to the disable person's one and to the carer's one.

In any case, its ease of installation, handling and its use without a PC make this system being suitable for people with no technical education. Some system functions can be programmed, such as transmitting certain sounds or certain light signals. These changes can be done because the robot is very flexible and easy to be programmed.

References

1. Disabled Peoples' International, Strategic plan (2005), `http://www.dpi.org`
2. Association for the Advancement of Assistive Technology in Europe, AAATE. A 2003 View on Technology and Disability, (2003), `http://www.aaate.net`
3. Mihailidis, A., Elinas, P., Boger, J., Hoey, J.: An intelligent powered wheelchair to enable mobility of cognitively impared older adults: An Anticollision System. IEEE Trans. on Neural Systems and Rehabilitation Engineering 15(1), 136–143 (2007)
4. Cortés, U., Annicchiarico, A., Vázquez-Salceda, J., Urdiales, C., Cañamero, L., López, M., Sánchez-Marrè, M., Caltaginore, C.: Asistive technologies for the disabled and for the new generation of senior citizens: The e-Tools architecture. AiCommunications. The European Journal on Artificial Inteligence 16(3), 193–207 (2003)
5. Volosyak, I., Kouzmitcheva, O., Ristic, D., Gräser, A.: Improvement of Visual Perceptual Capabilities by Feedback Structures for Robotic System FRIEND. IEEE Transactions on Systems, Man and Cybernetics-Part C: Applications and Reviews 35(1), 66–74 (2005)
6. Simpson, R., Levine, S.: Voice control of a Powered Wheelchair. IEEE Transaction on Rehabilitation Engineering 10(2), 122–125 (2002)
7. McFarland, D.J., McCane, L.M., Wolpaw, J.R.: EEG-Based communication and control short-therm role of feedback. IEEE Transactions on Rehabilitation Engineering 6(1), 7–11 (1998)
8. Chen, Y.: Application of tilt sensors in human-computer mouse interface for people with disabilities. IEEE Transactions on Neural Systems and Rehabilitation Engineering 9(3), 289–294 (2001)
9. Barea, R., Boquete, L., Mazo, M., López, E.: System for Assisted Mobility Using Eye Movements Based on Electrooculography. IEEE Transaction on Rehabilitation Engineering 10(4), 209–218 (2002)
10. Wolpaw, J.R., Birbaumer, N., Heetderks, W.J., Mcfarlands, D.J., Peckham, P.H., Schalk, G., Donchin, E., Quatrano, L.A., Robinson, C.J., Vaughan, T.M.: Brain-computer interface technology: a review of the first international meeting. IEEE Transactions on Rehabilitation Engineering 8(2), 164–174 (2000)
11. Berardelli, A., Cruccu, G., Kimura, J., Ongerboer de Visser, B.W., Valls-Sole, J.: The orbicularis oculi reflexes. The International Federation of Clinical Neurophysiology. Electroencephalogr. Clin. Neurophysiol. Suppl. 52, 249–253 (1999)