Digital Remote-action Environment for Disabled persons: Automatic adaptation of the scrolling time to the user's characteristics and intentions

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SUMMARY

This article deals with a method of automatic adaptation of the scrolling time of the different actions proposed in a man/machine interface called "communicator". The EDITH project (for Environnement Digital de Téléactions pour Handicapés or Digital Remote-action Environment for Disabled persons), elaborated at the University of Metz, was used as a material support to define this method. It is only after the clinical evaluation of the EDITH system with a patient suffering amyotrophic lateral sclerosis that we realized an optimization of the temporal management on the control sensor enables to increase the use-performance of this type of interface.

INTRODUCTION

A recurrent problem of the use of communication technical mechanisms by deeply disabled persons is their variable watchfulness during the day : their tonus but also their enthusiasm can radically change over relatively short periods of time. Moreover their fluctuating attention explains for the largest part the rapidity or slowness, the efficiency or inefficiency, and the satisfaction or dissatisfaction of intentions they have using technical aids. The quality of a technical aid will therefore be appreciated partly according to the tolerance criterion of the mechanism to the user's general state fluctuations.

As far as we are concerned, the objective of this communication is to think about the adaptation modalities of an interactional telethesis (EDITH : Environnement Digital de Téléactions pour Handicapés or Digital Remote-action Environment for Disabled persons) to such variations. The EDITH system is a kind of communication interface which enables heavily disabled persons (aphasic and tetraplegic persons) to renew their interaction experience enabling them to influence their environment. It is in fact a kind of multifunctional communicator which enables to read, write, watch television, control a compact-disk player, give out pre-recorded sentences and inform the medical staff of a problem.

In this communication, we use the EDITH project as a material support to define:

- on the one hand, from the automatic/computer point of view, an analysis method of the performance disabled person/machine for the evaluation, the adaptation and the learning of these technical aids
- on the other hand, from the psychological point of view, the contents of the possible interactions, i.e. what the spastic user can do acting with a technical aid [1].

In a first part, we will present the system EDITH, then from the results obtained during the first clinical evaluation led for six months on a patient suffering amyotrophic lateral sclerosis, we will describe, in a second part the setting up of the automatic adaptation of a major component for these types of interface : the scrolling time control of the different actions proposed.

THE EDITH SYSTEM

The aim of our project is then to overcome the progressive interactional deficiency by conceiving a kind of "telethesis" which enables to develop emotional and functional comforts for a patient confronted to imminent death. It is a communication interface named EDITH whose design principles depend on the meaning, the understanding and the metaphorization of actions.

DESCRIPTION

EDITH - Digital Remote-action Environment for Disabled persons - is an electronic communication interface system which enables individuals suffering

very severe handicaps to go on communicating with their environment while their motor and oral resources are totally deficient.
On a technical level, the EDITH system is composed, on the one hand, of a multimedia software, adaptable and modular set up on a portable PC for reasons of convenience in a hospital environment and on the other hand of a an environment control box (picture 1). The PC-control box connection (Senic SX18 microcontrollor board) is made through the means of the series connection. The control box is equipped with a universal TV set remote control. It also offers the possibility of connecting additionally 8 on-off sensors and to control up to 8 outputs. One of the outputs is used to control alarm calls (call of the medical staff).

The EDITH system can therefore be defined as an interface for communication between a patient with the corresponding environment.

Currently the application is created to be used with a single control sensor. No matter what design technology (on-off sensor, breath sensor, emg sensor,...), it has simply to deliver a logic order : 0 or 1. The designation of an action on the EDITH system can be done like in the majority of software called « communicators ». In other words, the interface submits a menu of possible actions sequentially and the patient validates an option during the selection process. The engine selection of a specific function is performed to a large extent by the machine itself, and the patient only validates the current selection. The EDITH system controls the plan of action, the mistakes and the functions activating.

The user interacts with a single sensor which enables him/her to control an interface which itself controls three dimensions of the patient's environment (Figure 1):

- care control
- interpersonal relations
- cultural activities

The control of care requests is performed by two functions:

- call medical staff : the patient has the possibility of informing the medical staff about a specific problem or making a request (selecting the command activating the alarm call (bell, warning light) or the call button at bedside. The equipment should include a device monitoring proper operation of the application and activating the call in case of software problems and/or power cuts.
- the selection of pre-recorded sentences corresponding to requests for medical assistance. First the user has to select the geographical position of the place of the care to perform by designating this one thanks to a line/column crossing. A series of pre-recorded sentences corresponding to the area of the body showed appears on the screen under matrix form. The user has only to select via two clicks the appropriate sentence (for instance : "could you rub me some balm on my shoulders ?") . Care sentences are first sentences of action/state type ("it hurts me here", "please rub me here", ...) which are always valid whatever the area, then specific sentences to the body area selected are following such as "please put me some eye-drops",...

The interpersonal relations enable the patient to interact with his/her relatives, family, friends. In this case, The EDITH system offers the possibility of having control on 2 functions:

- the selection of pre-recorded sentences corresponding to social phrases, the expression of an emotion or affection (for instance : "good bye, see you soon !", "you're getting on my nerves !", "love XXX"). The selection is made first by choosing among five types of sentences (politeness, environment, eating, position, others) then by selecting a sentence among the pre-recorded sentences matrix.
- written communication with the family, friends and the medical staff, with the assistance of an editor offering optimal character selection and a word proposal system after the first few characters have been input. This function supplements and enhances verbal communication. Tests will be completed by using the different methods which exist to fasten word capture via a single sensor control. They will enable to suit a method according to the person and his/her handicap [5].

The cultural activities are captured through three functions:

- Reading of texts stored on the computer hard disk : tracing the text, novel or work. The user has the possibility to open it, read it, move to the next or previous page, use a bookmark, leaving the text in a given state and going to this position.
- Controlling the TV set: controlling the basic commands (switching on and off, selecting channels, controlling the volume).
- Controlling a compact-disk player and listening to music or pre-recorded documents.

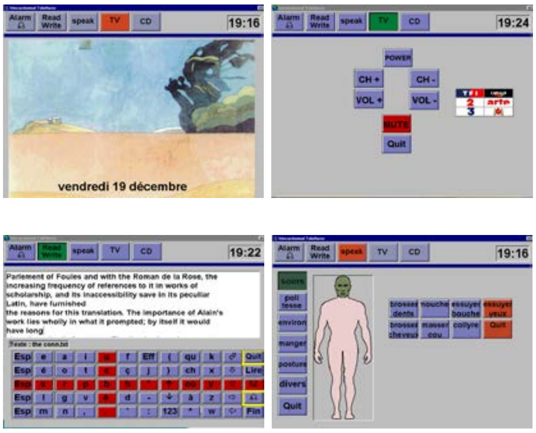


Figure 1: Some screen examples of EDITH interface

AUTOMATIC ADAPTATION OF THE SCROLLING TIME

After having introduced the EDITH system, we will now deal with the issue of the user's tolerance to a constant scrolling time. This issue consists in settling a process enabling to correct "on line" the scrolling cycle in order to maximize the user's selection comfort and to minimize the selection mistakes.

Context of the evaluation

Jacques, a biomedical engineer, developed an ALS when he was 56. During his hospitalization, the ALS was in a very advanced phase since the paralysis affected the four limbs and was to affect the mouth and the throat, leading to difficulties to talk and swallow. Jacques was thus very fast involved in this project. He used the EDITH system for over six months. The interface was set up at his bedside, at high level with an on-off sensor placed under his right forearm, next to the palm of his hand. The system was on permanently, round the clock. For two months, he agreed that all procedures be recorded (monitoring technique). Thus every thirty minutes, a specific file was updated with the recording of the time (day, hour, minute, second) and the type of action performed. These data were recorded by the computer.
These recordings enable at the same time quantitative analyses of "operating procedures" performed and qualitative analyses of the texts written by the patients [1].

Temporal discrepancy of the scrolling

The temporal analysis of the specific files (excluding the learning period of the mechanism) enabled us to enhance a discrepancy in the use of the EDITH system : some actions validations proposed by the system can be the result of a too late or anticipated action on the control sensor. This shows that the scrolling time value was not suitable enough to the patient's motor capacities during the permanent use of the system, even though the scrolling time of the EDITH system was particularly slow.
This discrepancy appeared when a series of contradictory actions followed in the specific files.
More formally when the actions are sequentially selectable during a scrolling time t_{def} (Figure 2), Jacques first selected the action$_i$, waited for the scrolling cycle to arrive on the action$_{i-1}$ and selected it then. Or he first selected the action$_i$ and right after the action$_{i+1}$. it is obvious that the discrepancy analysis is not valid for each type of this group of selections, it depends on the context of the actions proposed by the EDITH system. The relevance of their validities was greatly reinforced by the texts written by Jacques who wanted to be able to modify his scrolling time by himself.

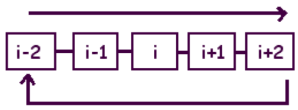
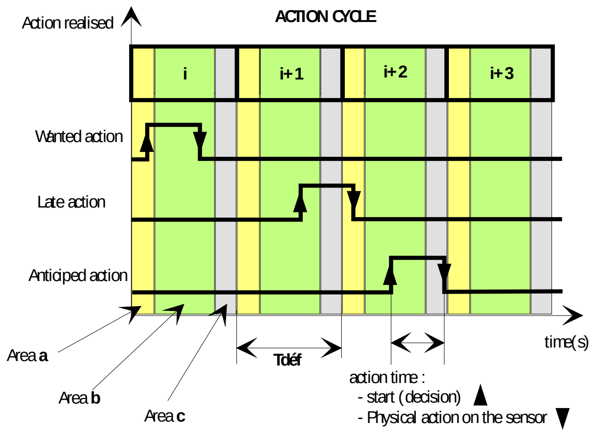


Figure 2 : Cycle of action scrolling time

Perspective of an automatic adaptation

The user has to wait for the sequential scrolling of the actions to enable that his movement be selectable to be able to validate it by using the control sensor. In agreement with the MHP model [3] which divides an action in three parts : perception time, motor time and cognitive time, the discrepancy is the result of the fact that for a disabled person, the motor time is significant and delays in the time the performance of the action wanted. The chronometer, thereafter, shows the validation discrepancy. For instance, for a late action, when the action wanted is selectable, the addition of the three types of time, which can be from 0.5 second to 6 seconds depending on the handicap, sees to it that the action on the control sensor will be taken into account when the next action will be validable. The action performed will not be the one wanted, which will lead to a loss of time and to stress… As far as the anticipated action is concerned, the person who knows his/her motor time will release his/her order on the control sensor too early and will select the previous action, whereas the sequential scrolling was about to change of state (i.e. going to the next action).

We can see that during the scrolling time t_{def} during which the action is selectable, there are three areas **a**, **b**, **c**. The meaning of the wished action differs depending on the fact that the action of the control sensor comes in one of them:



- area **a**: The action wanted by the patient was the previous action. The scrolling time was a priori too fast.
- area **b**: The action wanted is the one selected. The scrolling time is suitable.
- area **c**: The action wanted by the patient was the next one. The scrolling time was a priori too slow.

An automatic adaptation of the scrolling time can thus be considered according to the number of times a validation discrepancy is noticed. We can correct the validation mistake in an obvious way for the user by validating, on the one hand, the action wished and not the action asked, and on the other hand by correcting the scrolling time which must be increased or decreased depending on the are chosen (**a** or **c**). The size of the areas are first calculated empirically in comparison with the scrolling time t_{def}. The purpose is thus to correct immediately the patient's selections and to elaborate in a way a "do what I mean" system, and thus to focus not on the action selected but on the user's likely intentions. According to the specific files analysis, the size of the **a** area should begin at 10% of the scrolling time and it would be of 5% for the **c** area. Currently a search is in progress using fuzzy logic to make the **a**, **b**, **c** areas and t_{def} vary on line. It appeared that there were more discrepancies of late actions mostly after having used the EDITH system non-stop. In fact, we realized that the late or anticipated actions mainly depend on the action of action in progress. For instance when writing a text discrepancies are rather anticipated. This comes from a deep concentration and a will to go faster than the machine to write the text. Fastening methods do exist so much on the level of the scrolling control (linear, matrix, line/column or column/line, dichotomic,…) [7] as the word ending prediction [2] [4] [6], but they do not take an on-line change of the scrolling time into account.

CONCLUSION

In this article, we introduced the EDITH system which currently enables a disabled person to : call for help, write and/or read texts, speak using pre-recorded sentences, control television and/or a CD player. One of the optimization criteria of a man/machine system for severe disabled people needs a constant search of an efficiency-rapidity/effort ratio considering the difficulty of the task to perform (for instance, writing texts, choosing among a great sample of pre-recorded sentences,…). A first clinical evaluation of the use of the EDITH system enables us to develop an on-line method of adaptation of the scrolling time. This method can be used with all kinds of interfaces so-called "communicators" with which the user has only one control sensor giving a logical command (0 or 1). It is obvious to the method used according to the type of the actions cycle proposed by the system. As for Jacques, we did not have the time to clinically verify this adaptation. It is being implemented in the latest version of the EDITH system in order to lead a wide clinical evaluation in which several associations for disabled persons will participate.

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