Towards a Communication System for People with Athetoid Cerebral Palsy

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Abstract. Communication is an important act in the development and empowerment of human beings. Through language, humans communicate their needs, desires, moods... Unfortunately, many physical and mental disabilities deprive some people of such communication means. Nowadays various Augmentative and Alternative Communication (AAC) systems exist in order to help people with disabilities. Virtual keyboards are the most common AAC systems for physical disabilities. Concerning mental disability, there are tools based on pictograms. This paper is divided into two parts. First, we put forward a critical review of various AAC systems with a focus on users with athetoid cerebral palsy. Second, the paper presents work in progress concerning a communication system for such users.

Keywords: Communication; mobility; cerebral palsy (CP); slurred speech; communication aid; COMMOB.

1 Introduction

« *Communication is an act so natural that many people forget its importance. Without communication, we are lonely beings in a completely disordered world. Emotions cannot be expressed and therefore there would be no relationship between humans* ». At first sight, this observation may seem totally impractical and straight out of a science fiction book. In reality, the statement came from an anonymous person with cerebral palsy and in so doing speaks for a large category of the population living in a world apart. It underscores the fact that for many people with intellectual or physical disabilities, it is extremely challenging to communicate verbally – but also often through a system [15, 16] – for example, when having to formulate correct sentences. The challenge is even greater for those affected with athetoid cerebral palsy [9]. In addition to experiencing major difficulties in making gestures (e.g. inability to use a keyboard), these people find it difficult to pronounce words when producing correct sentences. This is because the verbal utterances are deformed due to dysarthria [14].

Many people want to express a lot of things, but they are unable to do so. People with athetoid cerebral palsy (CP) also have problems with manual gestures due to involuntary movements due to neurons damaged from lack of oxygen at birth. These neurons continue to send electrical impulses to the muscles to dysfunctional arms and legs, thus causing involuntary movements with high amplitudes [9]. In this context, we propose the COMMOB system software to facilitate everyday communicational activities with systems and other people. The system cannot be directly transferred to other disabilities because of the specific needs of athetoid CP users.

The article begins with a state of the art about different categories of communication systems for people with cerebral palsy. Different communication needs of such people (considered in this paper as users) are accordingly presented. Then, our current work on the COMMOB communication system is explained. The article concludes with a discussion and research perspectives.

2 Related work

In [7], a critical study of various means of communication, more or less easily exploitable by users with athetoid CP, was conducted. It identified four categories of communication aids: virtual keyboards, physical aids, speech recognition system, brain-computer interface. (Please note that optical motion tracking is not considered in this study, because it is not possible due to the uncontrolled movements of the people with cerebral palsy). In what follows, we briefly present some virtual keyboards and assistive communication systems that seem potentially interesting for users with cerebral palsy. These systems were chosen in relation to their level of use in the field of disabilities. The first category of communication aids are virtual keyboards such as:

- **K-Thot optimized** [1]: This has four letters per key. The letters are grouped by occurrence frequency in French. For example, the letter "q" is on the same key as the letter "u". This process reduces the distance traveled by the pointer (mouse), and consequently, it reduces physical effort and reduces user fatigue.
- **HandiGlyph** [3]: This aid has three ambiguous keys and a command key. A regular scanning focus rotates past the four keys. Each ambiguous key corresponds to a family of letters that share a similarity of form (diagonal stroke, curve, straight line). The expected word is deduced by a linguistic predictor like for all the ambiguous keyboards.
- **KEYGLASS** (http://keyglass.free.fr/): This system proposes the most probable letters on four semi-transparent keys around the last key pressed. For example, if the user presses the letter "b", letters "e, a, u, o" will appear around the "b" key. This process reduces the distance traveled by the mouse and therefore makes text input faster.
- **Chewing Word** [5]: This keyboard combines several methods to accelerate the input. First, moving the most probable letters closer to the last key pressed. Secondly, the predicted word appears in a bubble just above the last key pressed.
- **Sibylle** [10]: The system consists of a virtual keyboard comprising a set of subkeypads that allows the entering of characters or full words. The cursor succes-

sively highlights each key of the active keypad that can then be selected by a single-switch selection process. It also has sophisticated letter and word prediction components which dynamically calculate the most appropriate letters or words for a given context. This method can reduce more than 50% the number of key presses.

- **UKO-II** (http://wiki.cogain.info/index.php/UKO-II): This contains all the letters on only 4 keys. To enter a letter, the user indicates the number of the key where the desired letter is situated. Then it enters the letter rank in the selected key. This process reduces moving the mouse over a large number of keys.
- **K-hermes** [6]: This is an ambiguous multitap keyboard with several letters per key. The user presses the desired key n times to select the letter of rank n. For example, if the first key is for letters "a", "b", "c", to enter the letter "b", the user must press the key twice. In addition, in order to speed up the input, the keyboard offers word prediction.

A lot of work on virtual keyboards for mobile devices is also available in [11]. In general, virtual keyboards allow you to enter text, while requiring a significant physical effort over a long period, despite the many optimizations features described above. To summarize, virtual keyboards are not well equipped to enter a long text for people with athetoid CP. To improve virtual keyboards, the predictions of words need to be more efficient by reducing the number of movements during input.

The second category concerns physical communication aids:

- **Joystick EdgeWrite** [17]: This system allows text input through the movements of a power wheelchair joystick. The user forms the letter by moving the joystick along the physical edges and into the corners of a square bounding the input area.
- **Entering row / column with two buttons** [2]: This virtual keyboard has a cursor that highlights a key at the crossing of a line and a column. The user has two physical buttons, one for changing the line, the other for changing the column. After a certain period, the highlighted key is selected.
- **Guide finger** [8]: This consists of a plastic plate with holes to access the keys on a physical keyboard. This system avoids pressing multiple keys at the same time.

These physical aids have the drawback that they must be used since childhood to be very effective. If the user has not used this kind of equipment when his/her brain still had a significant plasticity, it can be difficult, if not impossible, to use the Guide finger as an adult [4].

The third category includes speech recognition systems, where a voice recognition approach attempts to adapt recognition systems for people with dysarthria [14]. These systems seek to standardize as much as possible the voice of disabled people. However, the error rate remains sufficiently significant for voice recognition not to be considered as very efficient.

The fourth category concerns Brain-Computer Interfaces (BCI) [18]: such interfaces aim at controlling a computer by using brain activities detected by electrodes placed in a helmet. This allows to single actions only (such as a keypress) by means of a scanning system. It requires high concentration [12] and is not usable for the moment on a mobile device because it requires too much resources and heavy equipment. Moreover, this system has a high error rate (80% [12]).

In short, these different categories of AAC systems are not satisfactory for users with athetoid CP. A new type of system is thus envisaged in the section that follows.

3 Needs analysis and specification of the COMMOB system

The name of system is a combination of two words: *COMmunication* and *MOBility* because COMMOB is an assistive communication system for use at home or on the go. The well-known concept of pictogram is at the basis of this communication system. Pictograms are used to accelerate the production of sentences, by proposing, whenever possible, a set of context sensitive pictograms. For example, if the user is in a railway station, the program offers symbols only related to the location, or if the user selects the symbol "I would like to drink", the program offers only symbols denoting drinks. The user can also use a predictive virtual keyboard (see section 2) to enter words not represented by pictograms (for example names of railway stations). The keyboard is also context sensitive. It can propose words according to the interaction context that can be characterized through various sensors of the system. For example, the location of the user will be retrieved by the GPS chip, the sound volume will be recovered by the microphone, ...

The complexity of the problem lies in the possibility of access and to express a maximum of words or sentences through the pictograms for the user to enter minimum words. There is a strong link between the virtual keyboard and the module managing the pictograms. A set of predefined dialogues is proposed so that the user does not have to enter all the words. The user also has the possibility to prepare future dialogue in advance before using the system. These two features are intended to speed up text input, so to make the dialogue more fluid. Other modules may be added in order to extend the basic functionalities. For example, a speech synthesizer to read sentences produced. In the case of a CP user who is a computer scientist, a module exists to help him or her program by accelerating the entry code. The system provides the user with a set of software components (bricks), each specialized with a specific feature (such as GUI design) and represented by pictograms so that he or she can assemble the software.

Figure 1 represents the needs of users with athetoid CP concerning oral and written communication. Each module of COMMOB meets a specific need of the disabled person. These needs are grouped into themes (for example, "On the street" regroups communication needs of a disabled person in such a context). Obviously, some needs may be present several times in different bubbles. However, we chose to put only the most representative bubble so as not to overload Figure 1.

The COMMOB system is currently in a prototyping phase. It is written in Java under MS Windows 7 that allows an easy finding of already developed modules which can be reused or adapted. The tablet used is a HP Slate. It provides an 8.9 inch touchscreen (23 cm). The size of the tablet computer allows its installation on a wheelchair to be used everywhere. It has a USB port that connects an infrared system to control the cursor with a joystick installed on the wheelchair.

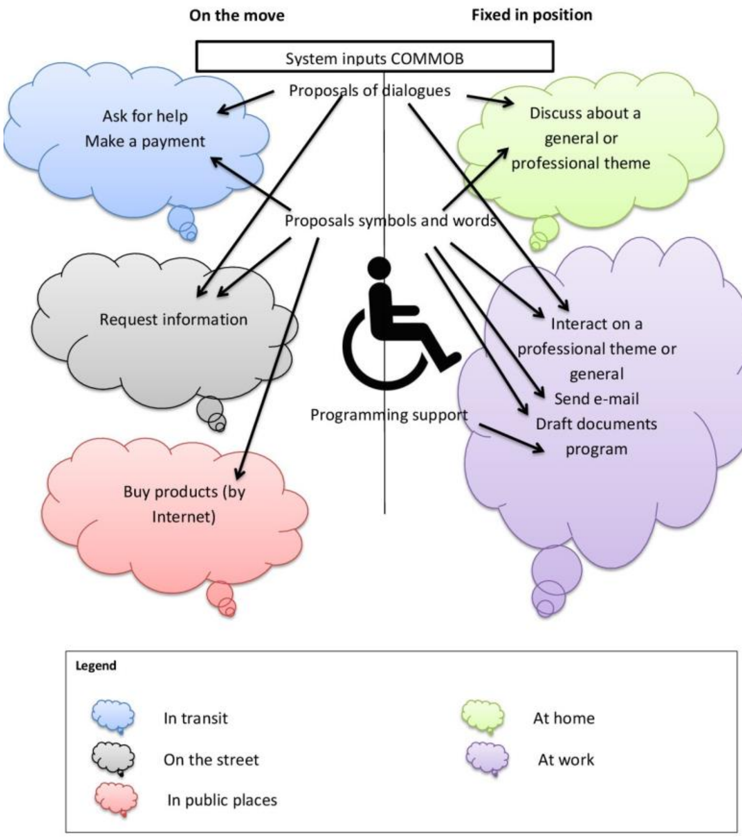

Fig 1. Potential contributions of COMMOB.

Figure 2 shows an example of formulating sentences from pictograms associated with words; for complementary text entry, the use of a virtual keyboard is necessary. Indeed, some words cannot be represented by pictograms, such as the names of railway stations. The user must complete the dots using the virtual keyboard, in this case clavicom NG (http://code.google.com/p/clavicom/). This keyboard provides the user with a set of predicted words to accelerate the entry.

The device, based on joystick and touch pad, is embarked directly on the wheelchair. Figure 3 illustrates the following situations: in an office (a), in a public place (b), outside (c). The user moves the mouse pointer with the wheelchair joystick. The connection is made through the electronic unit, which is located above the left handle (c). Information flows in the infrared beam. The validation is done through a button next to the joystick (d).

This method (pictograms + virtual keyboard) allows the user to enter words that cannot be readily represented by pictogram(s).

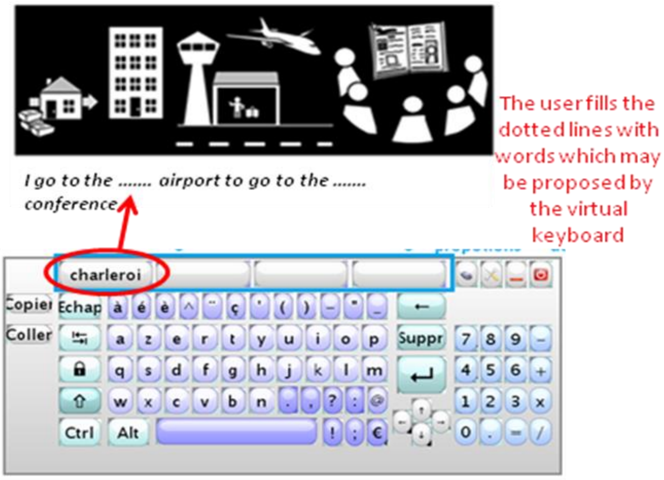

Fig 2. Example of formulation of a sentence from words and pictograms

Fig 3. Embarked COMMOB system, used in different situations.

Figure 4 shows a screenshot of the GUI module for formulating sentences with pictograms. The user selects symbols from the tree to the right of the Figure.

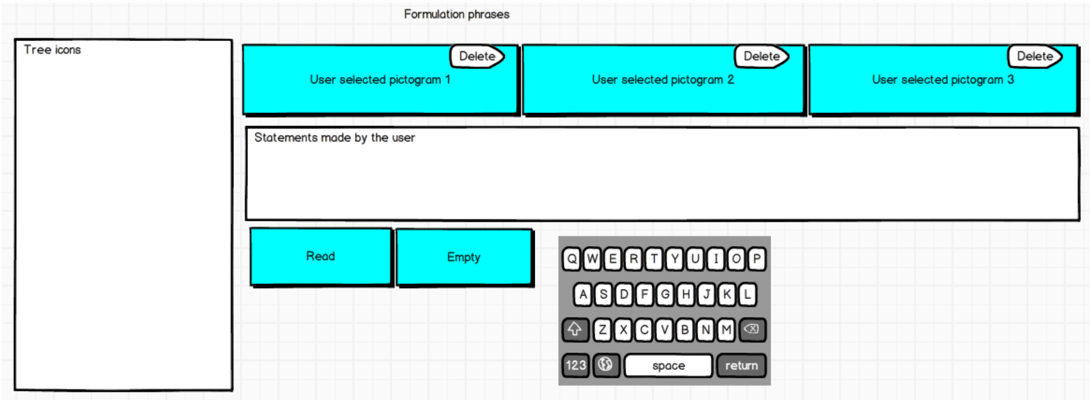

Fig 4. Screenshot of an example of sentence generation.

4 Discussion and future work

In this paper, AAC systems for users with athetoid CP have been envisaged. These communication systems are grouped in different categories which all have their advantages and disadvantages. We believe that in mobile contexts, the virtual keyboard (available and controllable with a joystick installed on a wheelchair) is a tool well suited for text input. Accordingly, our future perspectives take the form of an integrated communication support within the scope of the doctoral thesis of the first author. It aims to help people with athetoid CP who have difficulty communicating with systems and humans in various situations (at home, in mobility...). To do this, we chosen to use pictograms to accelerate the input of sentences, which are supplemented by a virtual keyboard (for the names of cities, for example).

To sum up, the main features of our system are: the use of (1) pictograms in order to speed up the text input; and (2) context-sensitive prediction. A prototype is under development (the system is currently composed of different mock-ups). Our aim is to finish a functional prototype and to conduct user testing as soon as possible. These tests will be based on a scenario with several activities (on the move or not, using pictograms or not). Results will be analyzed in terms of error rate, number of pictograms selected, number of entered words, using standard metrics of the domain (KSPC, ksr ...) [11].

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