FTC 2016 - Future Technologies Conference 2016
6-7 December 2016 | San Francisco, United States

Adaptable Virtual Keyboard and Mouse for People with Special Needs

Alexandre Henzen
Graduate Program in Electrical and Computer Engineering
Federal University of Technology
Curitiba, Brazil

Percy Nohama
Graduate Program in Electrical and Computer Engineering
Federal University of Technology
Curitiba, Brazil

***Abstract*—Assistive technologies are helping people without speech or functional writing to communicate through alternative methods and devices. The area of study that covers these technologies is called alternative communication. The goal of this paper is to present a new solution that allows people with special needs to use all the features of the keyboard and mouse via sensors connected to a user's body part in which it maintains motor control. The application developed constitutes a keyboard and mouse emulator, configurable and adaptable, which was named ETM (Emulator Keyboard and Mouse). The software captures trigger's signals connected to the USB (Universal Serial Bus), through the adaptation of the contacts of the buttons of a joystick. By means of a command processor and a key layout tailored to user needs, it sends keyboard and mouse commands for any Windows application. Tests conducted with cerebral palsy in the project participants schools and volunteers with amyotrophic lateral sclerosis, have shown satisfactory results. With the adaptation of sensors and programs developed, it optimized communication and user learning, minimized motor limitations due to neurological diseases, and it has expanded his accessibility and digital and social inclusion.**

Keywords—Virtual Keyboard; Virtual Mouse; Disabled People; Alternative Communication

I. INTRODUCTION

Communication requires the ability to transmit information through different codes and systems controlled by general rules, so that the user can interact with others and be integrated in his social community. By means of speech associated with gestures, facial and body expressions, one person interacts with other individuals, communities and cultures, forming social bonds, thus characterizing the human condition [1].

The scientific area of assistive technology which specifically collaborates to the expansion of communication skills is named Alternative and Augmentative Communication (AAC). AAC helps persons without speech or writing ability to communicate with others [2].

As a result of such communication limitations imposed to people with disabilities, both written and oral methods and alternative communication systems are required [3].

Sensorial, cognitive or motor disabilities may compromise all or part of human communication skills, which can be complemented with a support system and Alternative Augmentative Communication (AAC). These alternative mechanisms are less efficient than the natural ones, with significantly lower typing speeds [4]; however, in many cases, they may be the unique alternative for those with reduced mobility to access the computer and to communicate with the world.

One of the existing systems to solve this problem involves the emulation of keyboard and mouse [5].

In order to solve this demand, we developed a keyboard and a mouse's emulator software associated to low-cost sensors, adequately to assist a large portion of the population with some kind of physical disability that have impaired their communication abilities.

So the goal of this paper is to present ETM, a different approach from other CAA solutions by its enormous adaptability to assist the users in their specific individuality, by means of the customization features that will be described and discussed along this paper.

II. METHODS

ETM was originally developed to assist people with cerebral palsy [6]. Due to its adaptability to different types of situations, its use may be expanded to different types of disabilities such as quadriplegia due to spinal cord injury or amyotrophic lateral sclerosis, and hemiplegia due to cerebral vascular accident, for instance. The software has undergone several advances since its first version.

Originally, an electronic circuit was connected to the mouse and keyboard inputs of the computer. To generate a more affordable solution, the hardware was replaced by sensors (and associated softwares) directly connected to computer device inputs such as USB (Universal Serial Board) and the Serial Port (RS232) [7].

The program acquires signals from sensors connected to the computer inputs, turning on the keyboard and mouse actions, allowing the user to use all features of the keyboard and mouse. These sensors are attached to the wheelchair or the user's body. For instance, to control the program, the handicapped user who moves only the head will press an on/off key coupled to the back of his wheelchair. With the head movement, a signal is sent to the computer to run a command indicated on the virtual keyboard or on the pointer of the virtual mouse displayed on the screen.

Figure 1 shows the application architecture. The program consists internally of a layout's manager, responsible for the visual part of the virtual keyboards, a script processor for

978-1-5090-4171-8/16/$31.00 ©2016 IEEE

processing chained commands, one device manager to acquire signals from the sensors and the command processor that is the core part, responsible for emulation of keyboard and mouse. Emulation means to declare to the operating system to type characters as if received from the keyboard and to click or move the cursor as if received from the mouse.

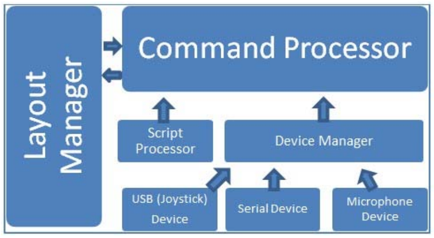

Fig. 1. ETM internal architecture

The layout will stay always on-top with respect to the other windows, so the user will never lose it from his sight. Any other page can be read or written to as is the case for the conventional mouse or keyboard user.

A. *Input Devices*

The layer responsible for obtaining the signals from the sensors was developed to require a minimum of hardware.

The possible input sensor devices are:

USB Joystick: currently, it is the most widely used input device due to its simplicity, ease of acquisition and low-cost.

One advantage of Joysticks is that they use the HID protocol (Human Interface Device) [6], which is an universal connection, requiring no additional driver installation, which makes it compatible with the majority of the operating systems on the market. When connected to the USB port, ETM recognizes the command buttons, and one can set them individually for each type of action.

Serial Port: Although it is obsolete, the serial port is present in many desktop computers. It is very common to find older computers on schools, often the result of donation. USB or RS232C Serial Ports are very suitable to be transformed on ON/OFF sensors, just connecting two wires to DTR pin (Data Terminal Ready) and CTS (Clear to Send). By software, the user can poll (test) the condition of CTS and state whether the contact is made or not. The same may be done for some other pins.

Microphone: The microphone's role as sensor is to acquire any sound that indicates a command to be executed. When the software receives a noise signal picked up by the microphone, this signal is filtered and converted into a digital pulse, which is recognized by ETM indicating that an action should be executed.

Camera: The camera feature was developed with the goal of acquiring the blink of the eye and turn it into an action. This sensor was not efficient due to calibration difficulties. This feature can be improved and was replaced by and optical sensor, which is more efficient.

Keyboard: the computer keyboard may be used as a sensor. ETM disables all functions of the keys making them all work like a single button that can be pressed finding any limb of the body. For example, a keyboard can be set at a back of the wheelchair and be activated through the head movement. It is not recommended because this forbids the use of smart layouts, based on the so called "sendkeys".

III. Results

One of the ETM's advantages is the creation of layouts with customizable keyboard keys. Unlike a computer user who uses conventional keyboards where the layout complies with industry standards such as the QWERTY arrangement, a user with special needs using virtual keyboard often wants to change the key layout for better ergonomics, and even exclusion of some key strokes.

The software features a layout editor where one can create the layouts of keyboards, such as in Figure 2. For each layout it is assigned a name. It can be loaded when ETM is running through a menu.

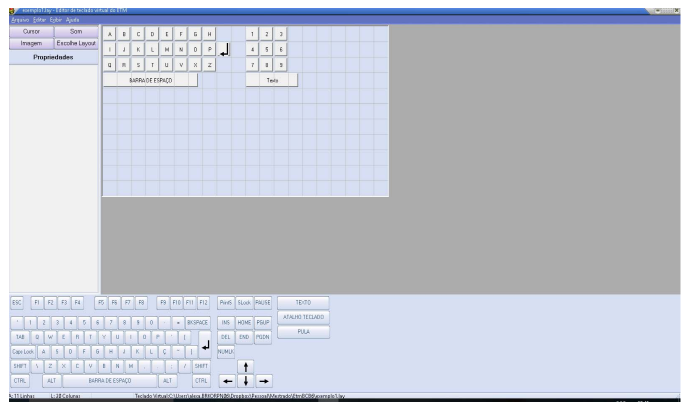

Fig. 2. Layout Editor

A layout is a set of buttons, not a set of keys as on a conventional keyboard, where each key has its function. Each layout button can receive some properties, besides its function. A sound can be associated to a button. An image can be associated to a button. Complex functions can be associated to a button:

Image File: it allows the user to associate an image with a button. This property is useful when the user wants to create layouts with images representing the letter or text or action being performed;

Sound File: it allows the user to associate sound files in Wave format. In this case, the sound will be played when a button is about to be chosen. This helps visual impaired users;

Cursor File: it allows the user to associate the Windows cursor type files. In this case, the mouse cursor shape is changed to the shape of the cursor assigned to when the button is selected;

Text Key: its function is to simulate the character key. The main difference is that character keys are already preset for execution of the command in hand. For example, if one adds the letter A key on the layout, it is already configured to send the letter command. The text key allows, in a single action, send text or a series of commands, rather than sending a single

978-1-5090-4171-8/16/$31.00 ©2016 IEEE

character. This key has a property named Text, where the user can configure set phrases;

Shortcut for Layout: ETM allows the user to add a button on the layout containing a name of another layout so that the user can switch between layouts. For example, when the user is using a layout with letters from A to Z and wishes to change to another one containing only the mouse buttons. This allows small and efficient layouts. There will be a gain in the scan time, too.

A. Command Processor

ETM has a command processor system that allows sending a series of instructions for the operating system through the push of a single button. With this feature, the user can create a task automation processes facilitating his day-to-day. For example, he can create a button to load a program, perform tasks such as Ctrl + C (shortcut to copy selected text), select text, save files in a text editor, among others. It is considered one of the main features of the software and implemented via the mentioned Text Key.

B. Keyboard Emulator

ETM works in the scanning mode, and it can be automatic or manual. In the automatic mode, highlighted with color lines, will be skipping at a configurable time until the sensor is pressed.

Automatic Scan tends to minimize the amount of interactions between the user and the virtual keyboard, as this kind of scan requires only the Selection stimulus from the user [8].

Figure 3 illustrates ETM interface for the custom layout. The system works as follows: letters, numbers and arrows indicating mouse movement are scanned all the time, by label (line highlighted in yellow). When the marker is positioned on the desired line, the user triggers the sensor and the highlight is now on the characters of the selected line. To choose a character, the user presses the sensor to activate the letter or command he wants. The software features a word prediction technique in the first line of the layout that will suggest as one goes typing initials. This feature is based on a predetermined word dictionary.

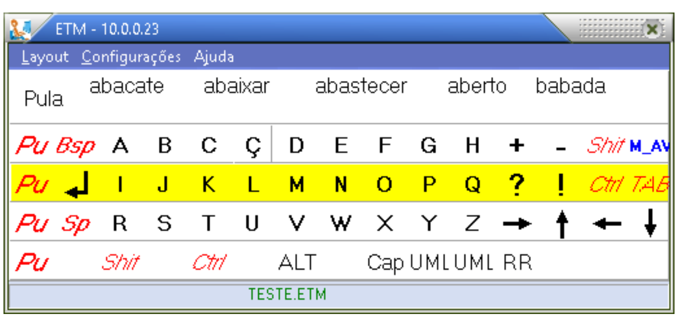

Fig. 3. Default Layout

C. Mouse Emulator

The mouse emulation is similar to the keyboard emulation. The user selects a line, then selects the button that will perform the action he wishes. The mouse emulator has several buttons for different purposes to ease the use of the mouse. For example, to prevent the user having to choose a button for clicking the mouse and then choose another button for moving the mouse, or "click and drag", there is a button that performs two actions at the same time. In fact, there are four keys to drag up, right, down, left. It is also possible to create drag keys 45 degrees or other directions. The mouse buttons were divided in colors for easy identification.

Figure 4 shows an ETM layout with buttons including all mouse options, beyond keyboard arrows.

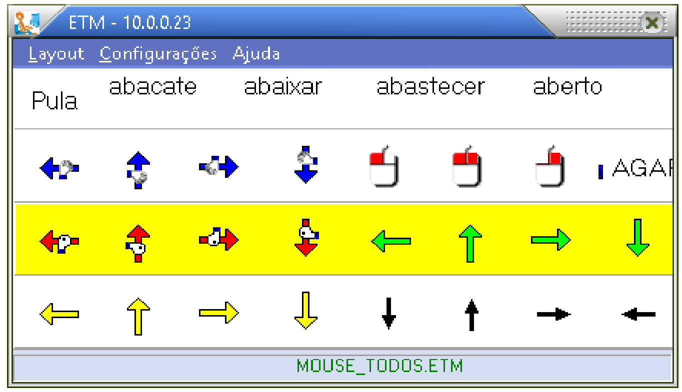

Fig. 4. Layout with Mouse Keys

The optical sensor is a special type of sensor. It consists of an electronic circuit specifically designed for ETM using infrared sensor capable of detecting certain types of movement such as, for example, opening and closing the eyelid. This type of sensor is used in more complex cases such as those with amyotrophic lateral sclerosis than in advanced stage can only perform this move. This sensor is extremely versatile and can be used in various ways. In spite of to be an electronic circuit, its construction is simple and low-cost, making it affordable.

Being small and a low-power circuit, it is generally fixed inside the joystick. So, it is not necessary external energy source for operation because their power is supplied by the USB port. Figure 5 shows a pair of glasses adapted to the optical sensor.

Fig. 5. Glasses adapted to the optical sensor, showed at the left side of the photo

D. ETM Voice

ETM Voice is a text-to-speech background program developed to use in addition to ETM. It talks whatever running on Windows clipboard. This can be achieved by cleverly designing the layout through Command Processor. The purpose of this program is to enable communication

978-1-5090-4171-8/16/$31.00 ©2016 IEEE

between the user and another person at any distance, when provided a loudspeaker on a suitable placed.

E. Configuration Interface

The graphical interface configuration must be done by someone able to use the true mouse. It is not possible to configure ETM or edit layouts, using ETM itself. This is to prevent the disabled user to unwillingly interfere with the setting parameters. Delays, sizes, sensors choices, background and foreground colors are among settings (configurations) offered to customize the software.

IV. DISCUSSION

ETM has been used by several people and schools as a communication tool. It has been adopted by many people and institutions assisting people with disabilities in Brazil. Due to its facilities for customization and adaptation, it is gaining new users every day. Although originally developed for people with cerebral palsy, the application extended to other types of disability, such as amyotrophic lateral sclerosis. Figure 6 shows an individual with cerebral palsy using ETM.

V. CONCLUSION

In this paper, we presented ETM system: a powerful configurable and customizable keyboard and mouse emulation software for AAC. It has been demonstrating efficiency as a solution for alternative communication for people with speech and motor difficulties.

Fig. 6. Cerebral Palsy individual using ETM

The software can be downloaded for free through the project website [9]. All requests made on the project website [9] are analyzed and defined together with those responsible for the user. The challenge is to define which sensor best fits the need. ETM is constantly evolving and new studies have been conducted to add features such as artificial intelligence in predicting words to make it more versatile and agile. A video about ETM operation and use can be seen at **bit.ly/etm008**, for approximately 04:30 to 06:30 minutes.

REFERENCES

[1] Miranda, Leidy e Gomes, Ivone. Contribuições da comunicação alternativa de baixa tecnologia em paralisia cerebral sem comunicação oral.

[2] Sartoretto, Mara e Bersh, Rita. 2014. http://www.assistiva.com.br/ca.html. *Assistiva Tecnologia e Educação.* [Online] 2014. http://www.assistiva.com.br/ca.html.

[3] Jordan, Monica. 2007. Predição de Palavras baseada em Modelos Ocultos de Markov. s.l. : Universidade Tecnologica Federal do Parana, 2007.

[4] Garcia, Luis e Luis, Oliveira. *Sistema de CAA com Adaptação ao Contexto*

[5] Gomide, Loja, Lemos, Flores, Melo, Teixeira. A new concept of assistive virtual keyboards based on a systematic review of text entry optimization techniques. Res. Biomed. Eng. vol.32 no.2 Rio de Janeiro Apr./June 2016 Epub May 06, 2016. http://dx.doi.org/10.1590/2446-4740.01715

[6] Henzen, Alexandre. 2003. Acessibilidade ao Computador para Portadores de Paralisia Cerebral. Junho de 2003. [6] USB, Usb Specification.

[7] http://www.usb.org

[8] Molina AJ, Rivera O, Gómez I. Measuring performance of virtual keyboards based on cyclic scanning. In: Calinescu R, Liberal F, Marin M, Herrero LP, Turro C, Popescu M, editors. Autonomic and Autonomous Systems. ICAS 2009: Fifth International Conference on Autonomic and Autonomous Systems; 2009 Apr 20-25; Valencia, Spain. Hoboken: IEEE; 2009b. p. 174-8. http://dx.doi.org/10.1109/ICAS.2009.35

[9] Projeto ETM. http://www.projetoetm.com.br

978-1-5090-4171-8/16/$31.00 ©2016 IEEE