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PREDICTIVE SYSTEM TEXT ENTRY CONTROLLED BY ACCELEROMETER WITH ANY BODY PART

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Abstract: This paper presents an update of DasherUS, a predictive text system controlled by an accelerometer. The DasherUS software can be installed in any computer and it becomes faster with its use. Thanks to the calibration procedure included, user can put the sensor on any part of the body and, in a few steps, the system is able to adapt to the user mobility. In contrast to the previous version, the text can be now sent to any application that is running at the same moment of using DasherUS, without replacing any other application the user likes to utilize. Other improvements of the system will help us to polish DasherUS much better, carrying us closer to our objective: the guarantee that no one will be deprived of the right to express what feels any time anywhere.

Keywords: flexibility, text entry systems, access system based on accelerometer, dasher.

Introduction

DasherUs is presented by I. Gómez et. al (2010) as an augmentative and alternative communication system based in Dasher software. This research aimed to analyze possibilities that an accelerometer like a control device of Dasher software can offer to improve communication capabilities of people with disabilities.

It was proven that this low cost system reached text entry rates close to those obtained when the software is controlled with a standard mouse. Two lines were opened as planned activities:

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1. To connect Dasher with input devices based on biosignals.

2. To study the use of accelerometers in telerehabilitation systems design.

In this work, improvements are established and a first version of DasherUS with some of these improvements is presented.

In section 2, state of the art is described. In section 3 system architecture is explained. In section 4 previous state of the system is exposed briefly. In section 5 improvements that can be done are studied. In section 6 improvements that have been done are very fully detailed. And finally, in section 7, conclusions are established.

State of the art

Several uses with dasher with different input devices can be found in (The dasher project). It can be used with a device based in breath in the 1-D mode (Shorrock, Mackay, & Ball, 2005). In the discrete mode, it can be used with buttons in different forms depending of the number of buttons (Mackay, Ball, & M. Donegan 2004). In the 2-D mode it can be used with eye tracking systems based on image processing (Ward&Mackay, 2002). Some proposals about the use of dasher with a Brain computer Interface system can be found in (Wills&Mackay, 2006; Felton, Lewis, Wills, Radwin, &Williams,2007) but results are not good, the conclusion is that at the moment another alternatives are preferable.

Accelerometers can be applied in Assistive Technology in different ways. In (Cech, Dlouhy, Cizek, Vicha &Rozma,2009; Hamel, Fontaine & Boissy, 2008) they are used in rehabilitation systems. In (Cech, Dlouhy, Cizek, Vicha &Rozma,2009) an automatic head position monitoring system is designed for controlling the recovery process after an ophthalmological operation. In (Hamel, Fontaine & Boissy, 2008) accelerometers and gyroscopes are settled in wrists and ankles to detect the appropriate movements in a telerehabilitation system design.

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In (Nakazawa N., Yamada K., Matsui T., Itoh I., 2005; Chen Y., 2001) accelerometers are placed on the head, they are used for computer access proposal. The systems described are complex because the whole computer control is pursued.

In (Sad&Poirier, 2009) the accelerometer is placed in a handheld device, effectiveness and reliability as an interaction device is evaluated. The advantage of using this kind of interaction is that one of the user's hands is free and the device's tiny screen is totally visible.

System Architecture

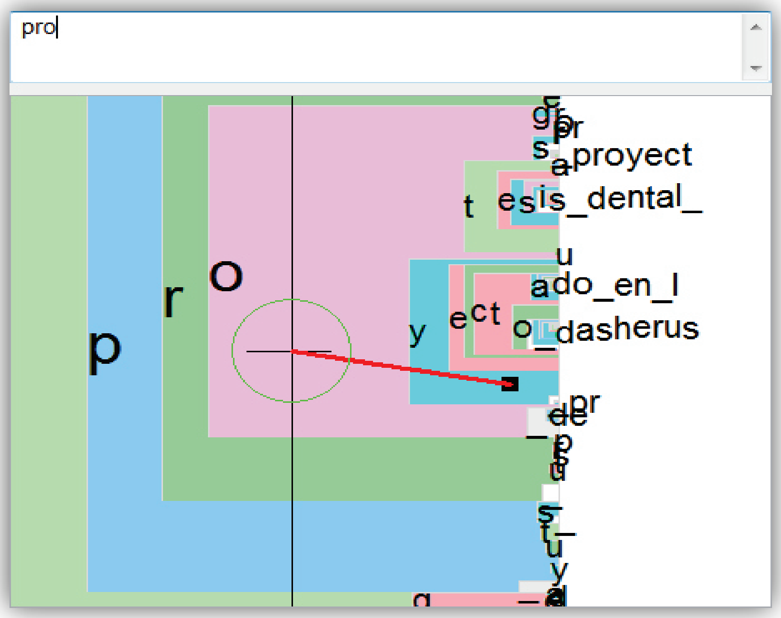
For the development of this research project, different technologies have been used. They can be classified:

1. Software, Dasher, that is the user graphical interface .
2. Hardware, including accelerometer and a microcontroller based system (*Arduino board)*. Accelerometer registers user movements while Arduino allows communication between accelometer and Dasher.

Dasher

Dasher is a predictive text entry system developed by the University of Cambridge. The user interface shows all the letters of the alphabet, which can be chosen by the user even including oriental symbols, inside of boxes with several sizes. Each of those boxes contains the entire alphabet too. By this way, the user has to move the cursor to one box and then move it again through one of the boxes inside of the first box. When the cursor enters in one box the software writes the letter it contains. In addition, this process becomes faster as the user writes with Dasher. This is possible because the software is able to predict what the user is going to write. The prediction makes some boxes bigger or smaller depending on the probability that the box's letter will be the next one. This interface can be viewed in figure 1.

Figure 1.User Interface of Dasher being used



Another of its advantages is the possibility to train the system with any text. Using statistical methods Dasher is able to infer what letters goes frequently after other. This inference process uses the training text and what the user is writing too. In the figure 1 can be observed how Dasher is modifying the size of the boxes according to this inference process.

Dasher gives the possibility to work with different operation modes: 1D, 2D, discrete input, etc. In 1D mode the cursor can be moved only across of one axis. Several screen ranges are defined to give the user the possibility to execute different actions when the cursor enters on that range. In 2D mode the cursor is moved like a standard mouse in any direction. Finally, with the discrete input the software can be used only with one event: a button, left-click, right-click, etc.

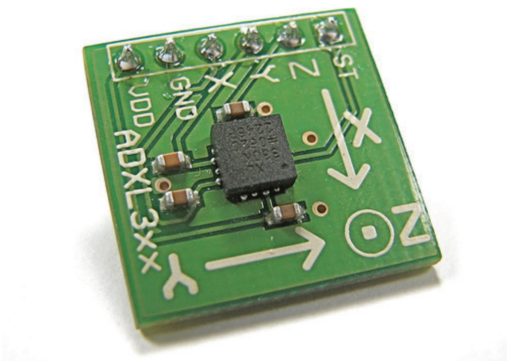
In our case, we use the 2D mode to control Dasher using an accelerometer. Thanks this, any user can utilize Dasher with movements of his/her body moving the cursor as if you were using a traditional mouse.

ADXL3XX Accelerometer

This hardware component is in charge of measuring the accelerations produced by the movements that we apply to the system. There are a lot of accelerometer types based on different technologies like electromechanical, optical, thermal, capacitive, magnetic induction, among many others.

The way an accelerometer works is so simple: a damped small mass with a spring and when the accelerometer experiences acceleration, the mass is displaced. The displacement is then measured to give the acceleration.

Figure 2. Picture of an accelerometer ADXL3xx



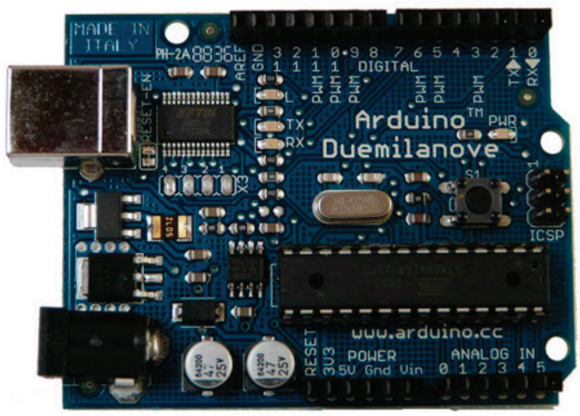
Our accelerometer is the model ADXL330 (Figure 2) from Analog Devices and uses the technology called MEMS (MicroElectroMechanical Systems). The sensor is a polysilicon built in a silicon board. Silicon springs suspend the structure and provide resistance against acceleration forces. The structure displacements are measured using a variable capacitor that is able to change its output depending on the movement. This process is possible because the capacitor has inside parallel plates which distance between them is different when the structure is displaced. The distance between plates its proportional to the accelerometer's output.

This small device can be placed in any part of the body. Thanks this, we are able to obtain any movement the user. Processing those data, the user can utilize the accelerometer to control Dasher instead of the mouse. However it is needed another element for this system. That element will receive all the information from the accelerometer, will process it and will send to the computer. This element is called Arduino (figure 3).

Arduino

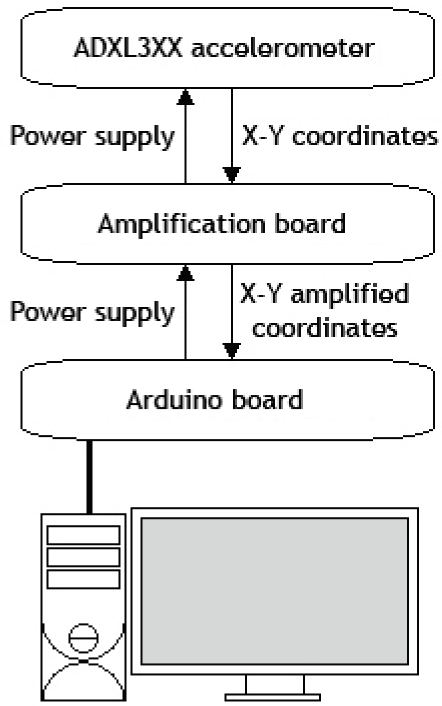
In 2005, Smart Projects company decides to launch a free programmable hardware platform using a simple development environment based on C programming language. Its easy programming and the number of the existing devices to extend hardware such as touch screens, GPS, Ethernet or Bluetooth among many others, make this board a cheap and affordable alternative to work on research projects. This board will act as an intermediary between the PC and the accelerometer (Figure 4).

Figure 3. Picture of an Arduino Board



The model that we use is the Arduino Duemilanove. This board incorporates everything needed to program it so that the user can execute their designs in it. His microcontroller is a Atmega328 at 16MHz and has 14 digital input/output pins and 6 analogical inputs. A USB Type B connector by means of which connects to the computer is included, communicating via a FTDI chip that converts USB signals for transmission through a virtual serial port.

Figure 4. System Architecture Connection Diagram



The accelerometer detects toward where we are moving and sends those data to Arduino. It collects the data, interprets them, applies a moving average filter and sends the result of that processing to PC in a format understandable for Dasher. These data are used to control the cursor.

Previous State of DasherUS

To take stock of the state of DasherUS must differentiate on one hand the state of Dasher version that we used to implement the system and on the other hand the changes that we made on the source code of that version.

We began to implement DasherUS on 4.10.1a version of Dasher. This version had the following characteristics:

- Language: Selection of the alphabet to use. Orientation writing and prediction options.
- Control: Selection of style control and input device. Speed options. Start and stop writing options.

- Appearance: Selection of color scheme. Cursor and boxes appearance options. Font options.
- Aplication: Toolbars, dictionary, Voice and clipboard options.

In its previous version, DasherUS presented the first implementation of the system. It was a very basic version that we use as proof of concept and was intended as the basic schema for future revisions. In this version the following features were implemented:

- Control: Use the accelerometer as an input device.
- Calibration: Ability to calibrate the accelerometer.

Features to be improved

As it is mentioned in before section, DasherUS is a versatile software. However, it has not an important characteristic: Does not allow to send text to others applications. An augmentative and alternative communication system must not be only a direct communication system between people who are in the same place, but also must allow to communicate in a remote manner with other people. In addition, a handicapped person could want to write in a blog, a book, to make a relationship by Internet, an electronic mail, etc.

There are some features to improve in the implementation of DasherUS. The previous version was a prototype.

In other hand, a study of how DasherUS is used could gather interesting information. Some parameters such as fatigue, usability, text entry rate, etc. could be meant by recording each user session. The recorded information could be used to make the system easier to use. Also, new systems could be designed to meet their needs.

In this system, a mouse device is implemented using an accelerometer. This device replaces a conventional mouse device. If a conventional mouse device is required, it is necessary to offer to the user an alternative to select which device he/she is willing to use.

To control DasherUS using an accelerometer it is required to install Arduino on the COM3 port of the PC. However, technical knowledge must not be required. Therefore, an automatic port detection or setting options must be implemented.

The first version of DasherUS is controlled successfully using an accelerometer, but the way in which this interaction is shown on the screen could be improved. The used accelerometer means using a small range of 300 values, and therefore the DasherUS cursor is moved in a discontinuous manner because of a higher screen resolution (640 x 480). To solve this problem, a circuit which amplifies the accelerometer measures up to 1024 values could be designed.

Present state of DasherUS

After detecting the features which could be improved, we started to work to make DasherUS a more efficient and useful system. Two priority points were focussed on:

Send text to others applications

DasherUS has to be a system that helps people. A system with many restrictions does not work. During the development of DasherUS, we visited to some disables organizations whom members have active blogs in Internet and use instantaneous message applications. The difficulty to entry text using their systems is a hard challenge for them. Sometimes a too large physical effort is required (Figure 5).

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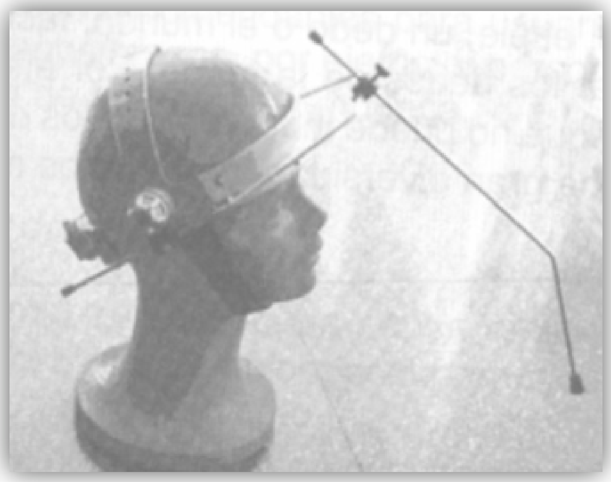
Figure 5. Unicorn Picture

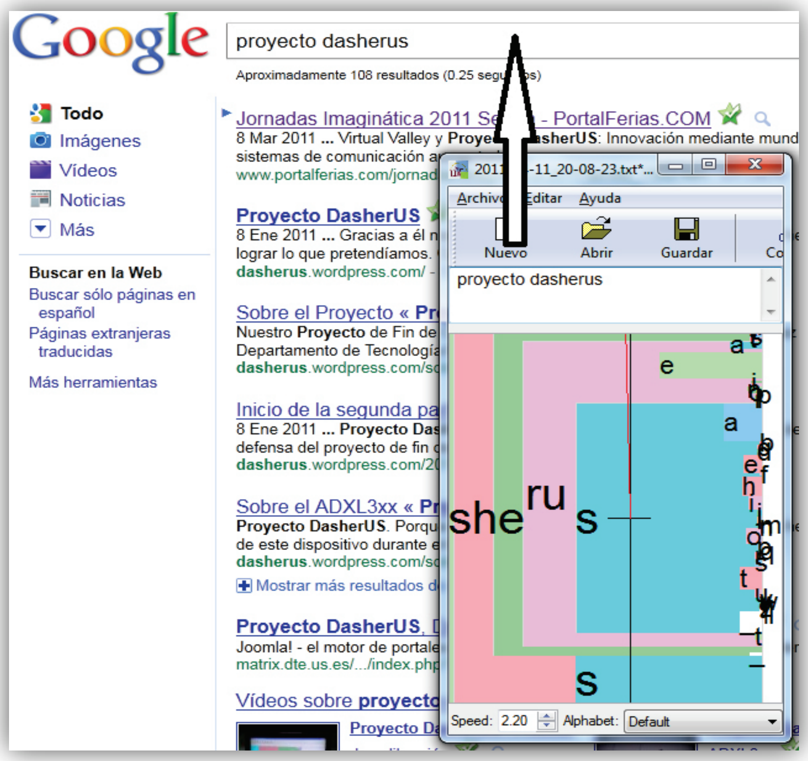


DasherUS cannot replace an Internet Browser or an instantaneous message software. However, it can be a support to use these applications. As in others accessibility tools, DasherUS was improved to communicate with others applications.

A procedure to send the text to the last focussed window before DasherUS was built (Figure 6). The text is sent when the user stops the entry. This stop is detected when the cursor is located inside of the small central circle during some seconds, and then, a stop command is sent. If the “send to others applications” option was selected in the settings, the text is sent immediately without an user interaction.

Users are less reluctant to use DasherUS because of the improvement. In this sense, DasherUS is a support and not a substitute of applications that they usually utilize.

Figure 6. Sending text form DasherUS to Internet browser



Logfile

DasherUS is part of a research project so it is not just an end product but a mean to get information too. The logfile includes time marks, the user selected text, the cursor position on computer screen, data sent by the accelerometer, etc. The logfile allow us to get statistical information from an user, or group of them, such as average character selection time, number of errors, etc. Moreover, it also let us replay the whole experimental session, so we can identify user's movement patterns and recognize the involuntary ones (such as spastic movements, twitches, etc) that can make users difficult to use DasherUS. Identifying movement patterns will improve the user-computer interaction, for instance, by filtering involuntary movements out, what, in turn, will increase the text input rate and reduce user fatigue. To sum up, the logfile allow us to improve DasherUS and increase the number of its potential users.

Conclusions

We had already obtained good results when we used the first release of DasherUS in 2010 getting a high text entry speed. Even though the system was still unstable when it was first used, and seemed to be quite difficult to be used by people with disabilities, it got an unexpected and favorable reception among the people who used it. In comparison with previous applications, DasherUS let people increase text production quickly and easily. Our personal interaction with them gave us enough experience on how to improve DasherUS. Currently we have turned the application into a real augmentative and alternative communication system by which these people can communicate with people closer to them, who can read the screen or hear the synthesized voice generated from the text, or people around the world by sending the output text to a any current internet application like an email, application, facebook, etc.

The fact that there was a person who has been able to get his feeling across on a blog using DasherUS moved and encouraged us to go on including new capabilities to this software so that it can be used to a wide range of disabled people.

Acknowledgments

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