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EDITORS' LETTER

This volume 2, number 2 gathers a collection of articles related to the access to information and communication systems: a research on a device specific for wheelchair users to control ICT tools; and articles related to the accessibility of educational resources and information and communication technologies by students with auditory disability and motor disability

From the area of architecture, it is presented a study about the different types of Pedestrian crossings and their functionality.

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MOUSE FOR COMPUTER CONTROL FROM THE JOYSTICK OF THE WHEELCHAIR

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***Abstract*:** Becoming autonomous is one of the biggest challenges for many people with disabilities. Increasing their autonomy usually involves the use of both a wheelchair and any kind of digital assistant such as a computer or a tablet to communicate, to work or even only for leisure. In such situations, those people are forced to use two different human interfaces, one to move a pointer and the other to drive the wheelchair. A joystick is the most common commercial solution to control a wheelchair whereas there are many different adapted interfaces to emulate the use of a mouse. In this paper we propose the use of a wheelchair joystick as a human interface for electronic devices such as computers, tablets or smartphones. This designed system captures the motion of the joystick on a wheelchair to move the cursor or the pointer of any digital device including an USB port. It avoids any mechanical or electronic change in the joystick to keep its original safety and warranty. This non-invasive mouse is fast and simple to install. In addition, it is fully configurable to meet any potential user needs. Communication between the device and the computer (or any other digital assistant) uses the USB protocol, although it could be easily upgraded to a Bluetooth wireless connection. To verify the designed system it has been tested by different people: users with disabilities, and physiotherapists and other professionals in disabled people with positive results.

Keywords: Mouse control, Disabled people, Wheelchair control.

Introduction

The growing potential of digital electronic devices in the fields of communication, work, education or leisure makes the number of their users larger than ever. Many people with disabilities use them for tasks that otherwise could not be carried out by themselves. For instance, some speech-disabled people use a software speech synthesizer to communicate. Some other handicapped people use electronic devices to control their immediate environment (lights, air conditioning, automated doors, etc.) People with mental disabilities might use electronic gadgets for therapies that give them immediate feedback like encouraging words, music or graphics which is more motivating for them than traditional exercises with paper and pencil.

Most of these electronic units run graphical operating systems (like Windows, Linux or Android) which ask for the use of some kind of pointer. Commonly, keyboards, mice or joysticks constitute the user interfaces to these graphical operating systems. However, certain disabilities prevent the use of standard pointing devices, and require a full custom solution. Therefore, different disabilities require specific user adaptation which makes it impossible to design a universal human interface for the disabled.

Nowadays, different approaches to solve this problem can be found in the literature. The systems described by Sporka, Kurniawan and Slavík (2005) and Qidwai and Shakir (2012) uses a voice command to control the pointer. Here, the sound card in the computer is used to process the user's sounds which are converted into basic mouse functions: click, double click and axial movements. The key advantages of this method are its low power consumption and easy installation since no special or additional device is needed. In the field of speech recognition software tools like IBM ViaVoice or Dragon Naturally Speaking (www.nuance.com) can be found which are intended to assist the user in typing texts. An alternative to this is visual technology, which has been studied. This method analyses the images captured by a camera in order to determine the user's gestures and head movements. While this technique requires few pieces of additional equipment it demands a high computational load (Tu, Huang & Tao, 2005 and Luqman, Ananta & Muda, 2011.) Kasun, Samarawickrama, Chandima, Chathuranga, Harsha and Abeykoon (2010) use computer vision and voice recognition technologies to facilitate the interaction of computers with handicapped people. To reduce the processing algorithms some systems use devices that are sensitive to non-visible light, such as infrared cameras. Adjouadi, Sesin, Ayala and Cabrerizo (2004) present a commercial system that tracks the user's pupil and lets him or her move the mouse. Other commercial systems from Prentke Romich Company (www.prentrom.com) capture the movement of the head by tracking the light spots emitted by a small device worn by the user which are then translated into mouse movements. Reflective elements or special glasses can also be used to create the light spots.

Systems based on physiological sensors can also be used to detect the intentions of someone by translating the electrical signals from the brain (electroencephalography, EEG) (Dong, Yuhuan, Hongzhi, Baikun, Yong & luk, 2009) or from the muscles (electromyography - EMG) (Changmok, Micera, Carpaneto, & Jung, 2008) into cursor movements. Unfortunately, the use of EEG or EMG to control a cursor is extremely complex because there is no simple way to separate the signals related to the mouse movement from the rest of signals (Pregenzer & Pfurtscheller, 1999), (Tarng, Chang, Lai & Kuo, 1997.) Moreover, these systems need to be periodically calibrated.

Inertial systems are also widely used. Tilt sensors (Chen, 2001), accelerometers and gyroscopes (Kim, 2002) make it possible to emulate a conventional mouse by sensing movements of different body parts (head, hands, body, etc.)

Despite the user can choose the system that best fits his or her needs between a wide range of solutions, he or she will have to deal with two problems, the intrinsic difficulty of getting familiar with the new pointing device and plus the fact of using two user interfaces at the same time the joystick of the wheelchair and an adapted mouse. In this paper we propose the use of a wheelchair joystick as a human interface for electronic devices such as computers, tablets or smartphones.

Design requirements

Our device is intended for people, with reduced mobility, who use motorized wheelchair and are interested in using computers or similar equipment. It is designed to emulate the behaviour of a conventional mouse by sensing the movements of the wheelchair joystick and the clicks of external switches. The same switches that are used for environmental control or augmented communication can be adapted to our system.

In order to fit any user and offer an optimal user experience, the system has to:

1. Be non-invasive with the wheelchair and easy to install.
2. Adapt to the installation position and to the user mobility by means of calibration during its setup.
3. Neutralize the effects of the initial inclination when it is powered up. It should also be suitable for being installed up to 45º.
4. Be compatible with any wheelchair.
5. Offer two input connectors for customizable switches to emulate the mouse buttons. One of these inputs must allow the user to disable the cursor movement.
6. Be plug-and-play. The operative system has to automatically install it. Besides, the installation software has to allow the calibration for an optimal response.
7. Be customizable by its configuration software. Configuration options have to include the usual ones that operative systems offer for the mouse (cursor type, buttons behaviour, etc.) as well as special ones:

limitation of degrees of freedom in the axial movement and the filtering of unwanted movements such as trembling or shaking. The setup should be saved in the device, not in the PC, which will make it easier to use the same device with different PCs without repeating the configuration process.

System description

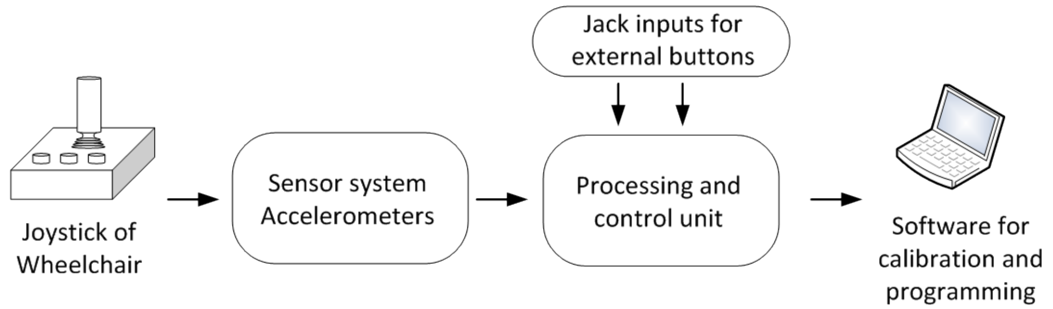
General overview

On the basis of the above objectives and requirements, we designed a low cost device intended to control the cursor of any computer, tablet, etc. provided it has a USB input connector, emulating a conventional mouse. The user moves the cursor by using the same joystick used to drive his or her wheelchair without interfering with this function.

As any modification on the electronics of the wheelchair would void its warranty, we based our design on the addition of an external biaxial accelerometer (ADXL202 or similar,www.analog.com) to sense the movements of the joystick.

Figure 1 shows the block diagram of our design and the main function of every subsystem. Details are explained in the following sections.

Figure 1. Block diagram of the mouse system



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Data processing for pointer position calculation

The accelerometer used is a piezoelectric transducer for the measurement of dynamic acceleration (to sense the movements to control the mouse cursor) and static acceleration (that allows the control of the mouse by measuring the absolute tilt of the joystick). Its wide dynamic range makes eliminates the use of amplifiers. Only low-pass filters are needed to limit the bandwidth of the signal and reject the noise system.

One of the most important aspects for the measurement accuracy is how the accelerometer is fixed to the joystick. The sensor should be firmly and securely fastened, as any movement would cause the need for re-calibrating the system, with the associated inconvenience for the user. On the other hand, the fixing mechanism has to be simple, so users can install the mouse in a short time. This installation can be performed by an unqualified person (family, educator, ...). The idea is to remain installed in the wheelchair since the user can switch between the use of mouse and the control of the wheelchair. In order to ease the system use, this switching between the mouse and wheelchair control can be selected by an external button. For safety, this change must take place when the chair is completely stopped.

An analysis of different wheelchair models from several of the most popular manufacturers like Invacare (www.invacare.com), Otto Bock (www.ottobock.com) or Sunrise Medical (www.sunrisemedical.com) showed that all the levers in the joysticks have cylindrical supports of 38 mm in diameter. Given this, a simple solution is to place a disk around the lever where the accelerometer can be placed on (Figure 2.) This disk needs a hole for the joystick shaft to pass. It can be fixed to the lever by a self-tapping screw which allows its correct and easy installation on any wheelchair and in a few steps (Figure 3). The disk contains the accelerometer only, so it is necessary to route a cable for powering the sensor and for transmitting the acceleration signals.

Figure 2. Accelerometer sensor system in the joystick of the wheelchair

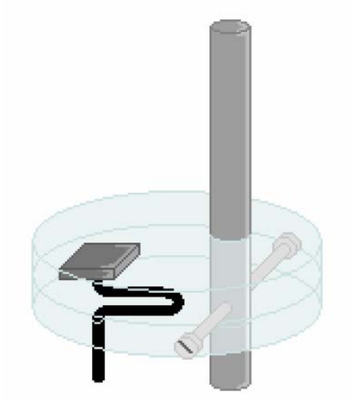
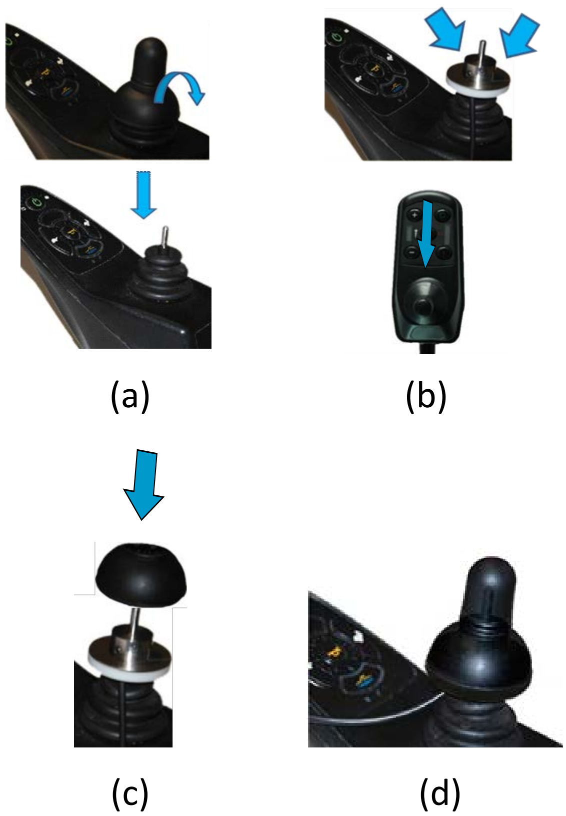


Figure 3. Mouse installation (a) Remove the handle and the protective cap of the joystick of the wheelchair, (b) insert the ring and tighten the set screw, (c) mount the protective cap and (d) reassemble the joystick of the wheelchair.



Specialized literature usually describes two methods to move the cursor over a display: absolute and relative positioning. In Evans, Drew and Blenkhorn (2000) there is an analysis about the advantages and limitations of both solutions. The absolute mode defines a correspondence between the position

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of the joystick and the coordinates of the cursor. In this way, when the joystick is at its rest position the cursor is sent to the screen centre and when the joystick is pushed to the right-up end the cursor is sent to the right-up corner of the display. This method is more convenient for user interfaces based on the detection of the user's head position for people with a good control of their own movements.

However, we chose the relative positioning method for our design so joysticks are more efficient in this mode. The relative mode keeps the cursor moving while the joystick is being pushed. The position of the lever sets the direction and the speed for the cursor displacement. So, the movement of the cursor is defined by the deviation of the joystick from its rest position. Experimental tests showed that vibration, trembling or small unwanted movements of the user could result in small movements of the cursor. This annoying effect is avoided by defining a "dead zone" around the rest position. This way, while the joystick is kept in this area, its displacements are ignored and are not sent to the cursor. Experimental testing with potential users showed that the dead zone has to be, at least, 3.5 º around the rest position. The user, however, can customize this value during the calibration procedure. In addition, the control unit processes the signal from the sensor in order to filter noise and avoid eventual oscillations of the cursor due to trembling or unwanted movements of a person with a disability, such as non-intentional hits or bouncing. To avoid the mentioned effects, the response of the sensor has been studied under the different conditions of actuation. The signals from the sensor have been sampled using a 5 ms period. These signals have been processed using average (mean filter) as well as median filtering. Average filtering (the average value in a set of measurements) is suitable for bouncing suppression, but the response of the cursor was not satisfactory under some configurations. Median filtering showed a better response and was selected to be implemented. Median filtering consists in sorting the measured values, dispose the ends of the interval and take the central value. The larger the number of samples, the better rejection of unwanted movements we will get, but, the bigger delay in the cursor movement. Tests have been performance in order to optimize the right number of samples.

The following figures present how unwanted effects have been reduced. Data of these figures are the typical results with one disability voluntary (male, 39 years old, with multiple sclerosis) obtained in one session. The results obtained with the same person in different days and sessions are similar. Figure 4 shows how small oscillations caused by a progressive movement are best rejected by a median filter. Figure 5 shows the efficiency of both filters to reduce bouncing when the user changes the sense of the movement. Figure 6 shows the same information when the joystick is hit and Figure 7 show the filtered bouncing when the joystick is suddenly released. These results validate the implementation of the median filtering.

Figure 4. Filtering of progressive signal.

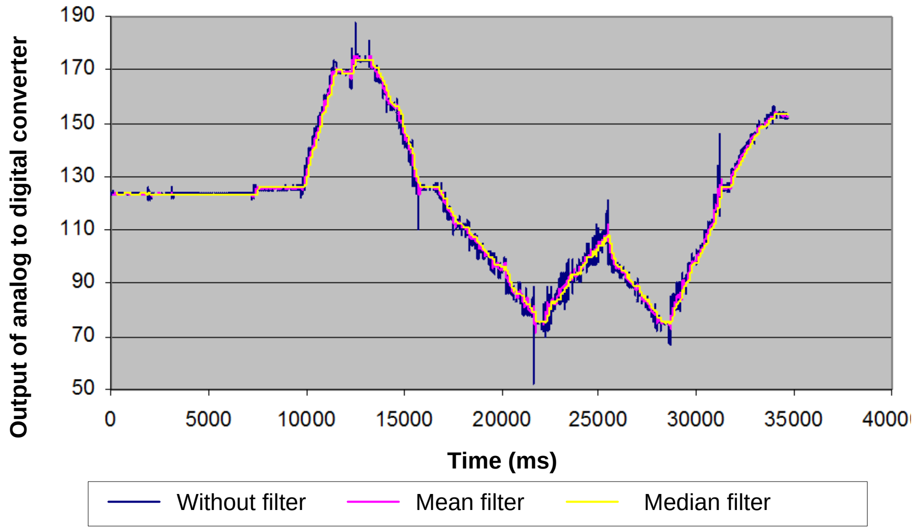


Figure 5. Filtering effect in motion for change of direction

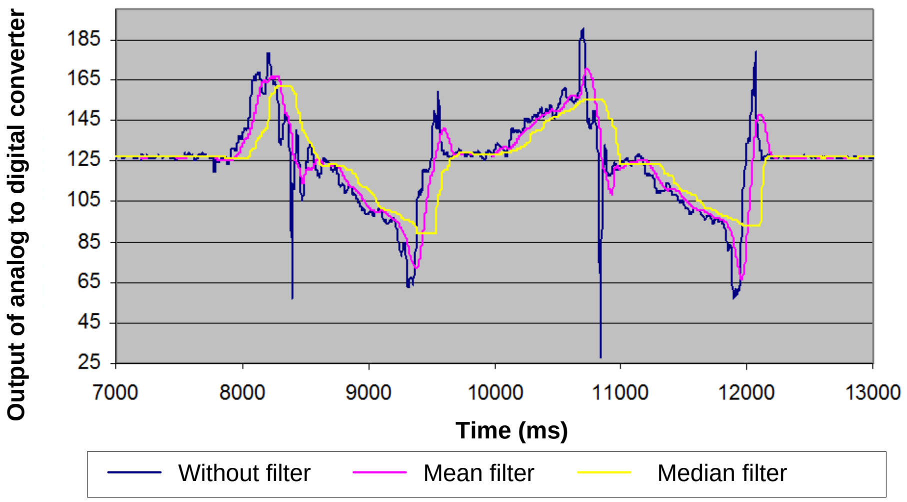


Figure 6. Effect of filtering strikes or violent actuation on the joystick.

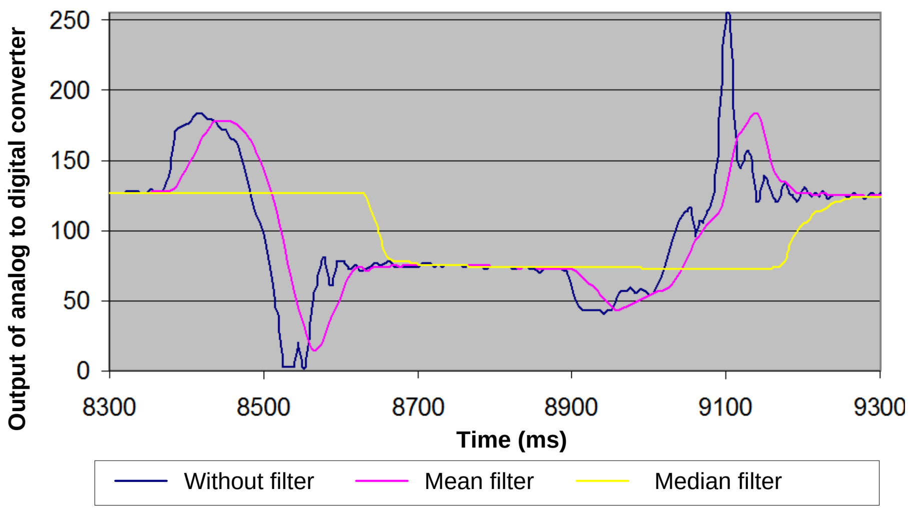
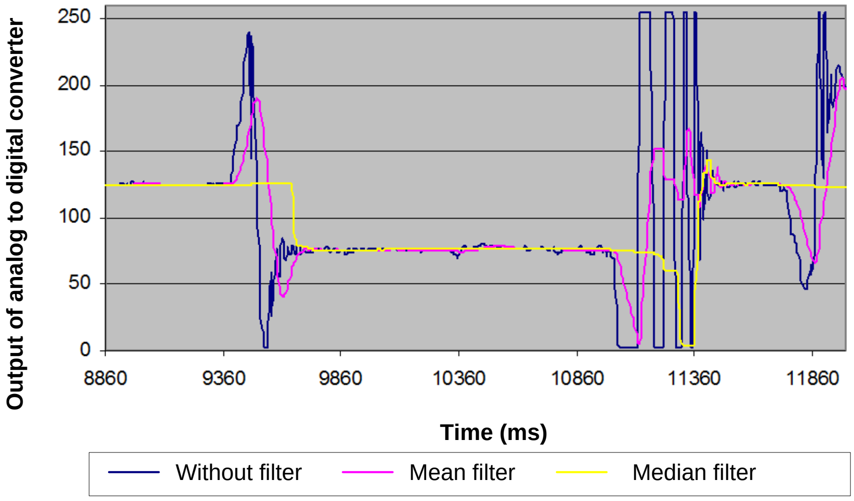


Figure 7. Filtering bouncing and joystick swings.



Customizable features

Besides the analog-to-digital conversion of the accelerometer signal and the reading of the push-buttons states, the control unit is responsible for the transmission of the data to the PC over the USB port. The control unit works together with the PC operative system adapting the movement of the cursor to the abilities of every user and saving the right configuration.

Different users suffer from different disabilities, which make it more or less difficult for them to deal with the pointing system. This is why we defined two different responses for the system, the basic and the advanced modes, in order to suit the abilities of every user.

When the basic mode is selected, the cursor moves at a constant speed as soon as the joystick is pushed out of its dead zone, no matter the inclination of the stick. According to the feedback from several users, the more convenient value for the dead zone is ±13 ° around the rest position and 5 pixels/s for the speed. Anyway, the users can customize both values to fit their personal needs. The basic mode offers the feature of snapping to four or two basic axis. That means that the cursor can move in any direction but it can also be restricted to move into the North-South or East-West directions (two axis restriction), as well as into the intermediate directions (four axis restriction). These restrictions are very helpful for people with

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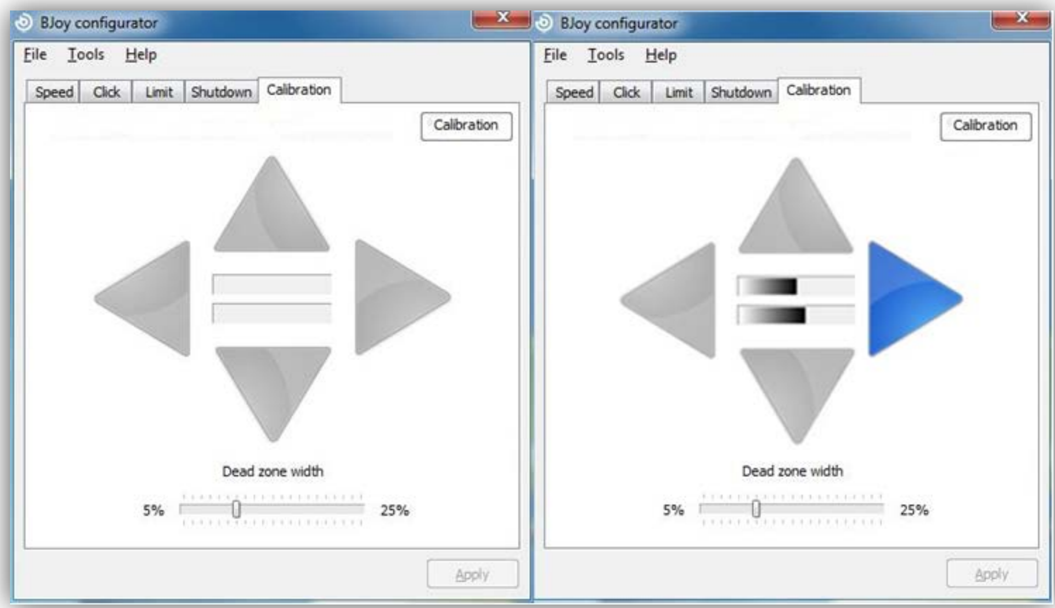
great difficulties to operate the joystick or for people with violent movements. On the other hand, this method is slow, since the speed of the cursor is constant. People with higher mobility abilities will find a proportional control for the cursor speed more comfortable. This is the more relevant feature of the advanced mode.

Selecting the advanced mode, the users will be able to configure the speed for the movement of the cursor. The speed will be proportional to the stick inclination, once it is pushed beyond its dead zone. The feedback from the users after the validation tests, gave us the convenient speed range and joystick sensitivity. The speed range was defined from 0 to 15 pixels, and the speed was set proportional to the stick angle with a recommended proportional constant of ± 0.33 pixels/degree. These parameters can also be customized in a configuration menu that the users will find in the configuration software to offer a higher adaptability.

The reference position of the sensor its inclination at rest is a very significant issue. It is unknown a priori as it depends on how the device is installed, on the position of the joystick or even on the slope of the floor. This is why the system needs to be calibrated when the joystick is first activated. It needs to be calibrated only once, with the wheelchair at rest. This calibration is run on the computer by means of a simple GUI (graphic user interface) (Figure 4.) The calibration time is very short (<1 s) to avoid any inconvenience to the user.

Figure 8. System calibration software.



The calibration algorithm calculates the offset voltage when the inclination sensor is at rest (motionless joystick.) To find the offset value, we acquire and stored the value to be subtracted from later measurements. This correction of the initial position will allow the system work properly even if the initial inclination of the joystick is up to 45 °. In addition, unwanted movements due to psychomotor limitations of the user can be filtered. This can be done by adjusting the value of the variable "Minimum slope" that sets the threshold to detect any change in the position of the joystick.

The action associated to click buttons can be also customized. To emulate the buttons of a conventional mouse, four inputs using standard 3.5 mm jack connectors have been included. The user can plug any external switch such as pedal, chin or blow switches (figure 9) used by him in some other application (environment control or augmented communication, for instance.)

Figure 9. External devices to implement pressing mouse buttons. (a) with foot, (b) with chin, (c) by blowing.

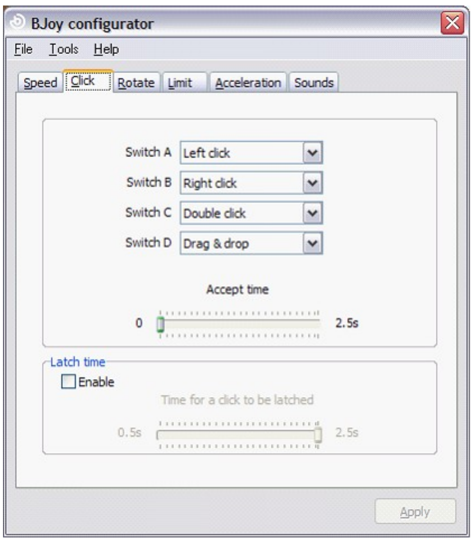
(a) (b) (c)

The function of every switch is selected by the user from the options available in a drop-box list in the configuration software that is installed in the computer. (Figure 10). In addition, the user can customize some of the push-buttons features:

a) Minimum duration for a valid push: This control lets the user select the minimum duration that the button has to be hold so that the function assigned to the button is run. This feature is intended to ignore unwanted clicks.

b) “Long click”: this option enables the “hold on” function for any button. When any button is hold for a while, its function will be active even when the button is released. This way, actions such as drag and drop, or multiple selections can be done with a single click, with no need of holding on any button.

Figure 10. Software for external mouse buttons



User validation of the system

To verify that the designed system is suitable for controlling the cursor of any computer, it has been tested by more than 20 users. The first tests were performed with J. R., a 39 year old man with multiple sclerosis (figure 11). This disease has caused a severe mobility loss. As he cannot walk, he uses a wheelchair with a conventional mouse to control the computer he uses at work.

Figure 11. User with de BJoy Ring during the first test

The positive results of these first tests allowed for a second test. These were made in the Pont del Dragó centre (www.bcn.cat/pontdeldrago/ca/index.html). Pont del Dragó is a public school for people with physical disabilities. This centre aims to provide a better quality of life through the use of technology and communication as tools and strategies applied individually to facilitate greater personal and social autonomy. Here the system was tested on users with disabilities, children who study at the school and a centre staff group in a work session dealing with technical assistance. The group consisted of an occupational therapist, a physiotherapist, a speech therapist and the school's teachers. Later tests were performed on 7 new disabled aged between 14 and 55 years. In table 1 we present the data of the participants in these tests.

Table 1. Data of participants in the later tests

User	Genre	Age	Region	Disability	Previous experience
1	male	44	Barcelona	Multiple sclerosis	Experience in wheelchair control with manual joystick
2	female	45	Valencia	Tetraplegia	Experience in PC control with chin
3	male	55	Valencia	Amyotrophic Lateral Sclerosis	Experience in wheelchair control with manual joystick
4	male	33	Valencia	Cerebral palsy	Experience in wheelchair control with manual joystick
5	male	14	Galicia	Cerebral palsy	Experience in wheelchair control with manual joystick. Experience in PC control with n-abler system
6	female	30	Galicia	Acquired brain injury	Experience in wheelchair control with manual joystick. . Experience in PC control with Smartnav system (head control)

To draw the conclusions in the following lines we interviewed the users asking about the features of the adapted joystick that were useful for them. Their feedback can be summed up as:

a) Having a system integrated with their own chair joystick add great value and convenience.

b) The system increases their autonomy since they do not need someone else to activate any pointing device.

c) The system prevents the device from falling, getting broken or out of the user's reach.

d) It helps in allowing multiple users for the same device without making any changes or any specific configuration. In the same way, any user can use the same system to interact with many different computers or devices

e) There is no need of having a dedicated and adapted PC for each user. Many people can share a conventional computer.

f) The fact of being a plug and play device makes it easier to use while also increasing the user's autonomy as he or she does not need someone else help.

g) Inclusion of the drag and double-click actions as a selectable function for the buttons makes its use easier and gives people higher agility in their activities.

h) Some training is needed to get familiar with the system and take profit of its features, since the use of a joystick is different from a mouse.

This system can be upgraded to include wireless communication, such as Bluetooth, instead of using a USB cable (Casas, Quilez, Romero & Casas, 2006). Incorporating Bluetooth wireless communication presents the problem of power management. Charging or replacing the battery might be an issue for disabled users without someone else's help.

Conclusions

The design of the new system covers an existing gap in the field of disability assistance: an independent and easy to control user interface to digital assistant devices (such as computers, tablets) based on the joystick on a wheelchair. This noninvasive mouse is fast and simple to install. In addition, it is fully configurable to meet the need of any potential user. In addition, the configuration parameters are stored in the device, which avoids reconfiguration when the chair is connected to a different computer. Its features make this mouse a very useful aid for people with motor disabilities to maximize their own performance and to improve their quality of life.

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CLASSIFICATION AND VERIFICATION MODELING OF PEDESTRIAN CROSSING

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Abstract: The requirements demanded for pedestrian crossings, as the meeting point of pedestrian and vehicle traffic, are becoming more and more numerous and to guarantee that they are understandable, employable and feasible for all people in safe and convenient conditions, and in the most natural and autonomous manner (LEY 51, 2003).

Natural stone is a highly demanded material used for covering and surface finishing of public external spaces. However, complying with the increasingly demanding requirements for pedestrian crossings, makes using natural stone much more difficult due to the inherent limitations that this material presents: from the labour-intensive mechanical procedures required to modify its shape, (as it cannot be moulded), to the inability to change its properties by chemical addition.

This situation has been the premise of this investigation, with the objective of establishing a verification model of the functionalities of the pedestrian crossing, in general, and in particular, a verification model which can be used for a pedestrian crossing built with natural stone.

The result is a model that can be used for the verification of the functionalities of a pedestrian crossing. In the process of building this model, the functionalities had to be classified in order to systematize the own verification method by which this classification can be considered as a secondary result of the investigation, even though it was not the main object.

After realizing this investigation it can be confirmed that the functionality of a pedestrian crossing depends on almost a hundred parameters which must be checked or measured, in turn proving that this design and construction process is indeed complex.

Keywords: Accessibility, Pedestrian Crossing, Classification, Verification.

Introduction

The Moscow Declaration emerged from the First Ministerial Worldwide Conference of the United Nations about Road Safety, which took place at the end of 2009, which proposed eleven general action lines for road safety treatment. In particular, line number four says:

"To develop and to apply policies and general measures for the protection of all people who participate in transit and especially for vulnerable groups"

The protection of those groups, understood as those who, based on the means of transport that they use, (principally cyclists and pedestrians), as well as the physical characteristics of the age group to which they belong, have a greater risk of suffering injuries in case of accident, has become in recent years one of the most important objectives in the international organisms; their safety is considered to be a global public health matter (PARIS, A. et al, 2011).

The present human range, comprised of people with mobility problems, vision, hearing, problems comprehending their own environment and all those people that do not have any of those problems, constitute the reference to design and build new cities, or to transform the ones that exist in the horizon of sustainability. The regulations and the laws, furthermore, demand that they be as such (DEL MORAL, 2010).

All of that brings us to the elaboration of this investigative task, which forms part of a larger study which, under the title of "Design and Technological Conditions of Granada Sierra Elvira Limestone in public streets: pedestrian

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crossings"; which is being carried out as an initiative of ONCE (Spanish National Organization of the Blind) Foundation and with the Department of Architectonic Construction of the University of Granada.

Objectives

The object of this research is the pedestrian crossing, understood as the place where both the moving pedestrians and moving vehicles intersect at the same level. Some of these pedestrian crossings have to be surfaced in some of its parts with natural stone. These are not considered crosswalks that are on a distinct level and are neither subterranean nor elevated, because these particular crosswalks present other problems.

The objectives that are considered in the project are the following:

a) The classification of the different pedestrian crossing types is a task required prior to determining the method of verification. One must take into account the different forms in which they can be modified, as the parameters are distinct in the type of pedestrian crossings that we find.
b) The obtainment of a verification method of the functionality of the pedestrian crossing made with natural stone.

Classification of pedestrian crossings

Methodology for the classification

Classification, considered as an activity of reason, can be defined as the division of types, according to the etymological origin of this word, of a diverse and compound group, by means of separation of what is different and the grouping of the similar (SIERRA, 1999).

The main rules for this classification are the following. It must be complete and exhaustive without excluding any element of the whole; each class is mutually exclusive, meaning that no part may be categorized in two

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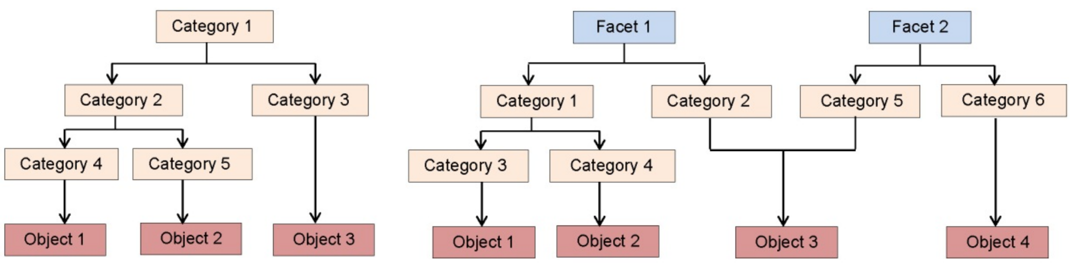
different classes; the criteria for classification must be unique and consistent in all cases of the same classification.

Normally, the application of these rules takes us to a simple hierarchical classification, where the successive establishment of categories and subcategories takes us to the final grouping of the elements in their own classes and subclasses. However, when we tackle the definition of the elements that must serve to classify different types of pedestrian crossings, we find elements, that after making the division, are common as distinctive elements and therefore do not allow a clear grouping by similarities, unless we are redundant in the subclasses that we establish.

This brings us not to suggest an outline of a simple gradual or hierarchical classification, but instead a faceted or multi-hierarchical classification (HASSAN, MARTIN, & MARTIN, 2003). Faceted classifications are used to organize groups of things with enough homogeneity so that they can be described by a definite number of attributes or properties (categories and facets) and their values (pertaining to categories).

The difference between both systems of classification can be explained graphically in the following figures.

Figure 1. Organizational diagram of the simple hierarchical classification and of the faceted classification. Source: own development from HASSAN, MARTIN, & MARTIN, 2003)



Simple hierarchical classification — Multihierarchical or faceted classification

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The faceted classification is different from the simple hierarchical in that the objects are characterized through multiple dimensions or facets; each one of them has its own category group.

Classification of pedestrian crossings

In the case of pedestrian crossings, four groups of facets are found that allow us to characterize them from four different points of view:

A. *The relationship between the pavement and the road.*

- A.1. Pavement and road at the same level
- A.2. Elevated pavement
  - A 2.1. In the event of an elevated pavement and to meet requirements for ease of access and movement, the level of the pavement and road must be the same. This can be resolved in three ways:
    - A 2.1.1. Build a pedestrian crossing on one level with a dropped kerb with an incline designed to match the elevation of the crosswalk and the pavement.
    - A 2.1.2. Build a crossing on two levels: lower the entire pavement to the street level, in which case it is necessary to implement two inclined planes
    - A 2.1.3. Build a pedestrian crossing of three inclined levels that converge toward the pedestrian crossing in the street.

- A.3. Raising the road to the same level as the sidewalk in order to provide a pedestrian crossing on the raised platform of the road.

B. *The presence of traffic lights.*

- B.1. Pedestrian crossings without traffic lights or “zebra crossing”.
- B.2. Pedestrian crossings with traffic lights

C. *The presence of a traffic island.*

C.1. Pedestrian crossing without traffic islands.

C.2. Pedestrian crossing with traffic island.

C.2.1 Traffic island placed at the same level as the road.

C.2.2 Raised traffic island in relation to the road with access ramps.

D. *The existence of a cycle lane.*

When referring to pedestrian crossings, there are two manners to address the relationship between the pedestrian crossing and the cycle lane.

D.1. Pedestrian crossing for the cycle lane: the cycle lane is integrated in the street.

D.2. Pedestrian crossing for cycle track: the cycle track runs along the pavement, and the pedestrian crossing is set back in respect to the road.

Variants

In each of the three solutions of pedestrian dropped kerbs, formal distinctions are established according to if it is a pedestrian crossing in the pavement or if it is on the corner.

According to the dimensional parameters to which pedestrian crossing design must adhere, variants of type are found. By this we mean the solutions according to if it has been designed in conformance with the criteria of the new Ministerial Order of Urbanized Areas (ORDEN VIV/561, 2010), or if has been designed previous to that date and/or if it has been designed under criteria of different autonomic regulations.

It can also have variants of the pedestrian crossing according to the covering material of the footway; concrete, clay or natural stone.

In any case, it has been considered that they are variants of a main type that do not give way to a new type, but a different form of carrying out the defined type.

Method development to check the functionalities of a pedestrian crossing made with natural stone.

Method objectives

The pedestrian crossing is a complex element in the field of urban public spaces. It is not only because it is the space that pedestrians share with the drivers in their vehicle, each one of them with their own distinct interests. It is also because the variety of situations and conditions that can be found in the group that we generally call "pedestrians"; each of them with their own needs and rights. This complexity of the element and the variety of urban situations present when a new pedestrian crossing is implemented create the need of a verification protocol of the functionalities that the element has to answer as a quality control tool of the final result.

In the design of this protocol, special emphasis has been placed in the implementation of the principles of the Universal Design (CDU-NCSU, 1997). This represents an important effort due to the complex nature of the elements and the parameters that have to be taken into account.

Method implementation.

The methodology used to introduce the verification procedure of the functionality of the pedestrian crossing can be broken down in the following processes:

1. To identify all elements of the pedestrian crossing that will be verified.

2. To define the parameters which characterize the identified elements.

3. To quantify the parameter values which will be used as are reference for its verification.

4. To measure the value of the parameter that it is being verified.

5. To compare the measured value with the reference value, to determine if it is adequate or not.

6. Finally, the adequacy levels of the pedestrian crossing values will be verified against the parameter reference values will be presented with expressions of type A/B, being:

   a) The number of parameters of the pedestrian crossing where verification is positive.
   b) The complete number of parameters verified.

The proposed procedure, that in general terms, can be considered the protocol that has to be taken in all the verification procedures and raises a series of questions that are necessary to address.

In step number 1, the exhaustive and indiscriminate elements that can be found in a pedestrian crossing result in a long inventory that can be cumbersome to manage. To simplify this step and to systematize the process, the elements should be organised in groups according to the classification described in the previous section. To do so, it is necessary to introduce a first verification list that we will call "Zero List" and it will become the master list, where the general data of the pedestrian crossing will be stored to allow classification according to the different types. Afterwards, it is possible to choose exclusively the lists that are necessary for the verification.

For example, if after checking the Zero List of general facts and classifications, we ascertain that we have a pedestrian crossing over a raised platform, without traffic light control and without a traffic island, but with a cycle lane, we can exclude several verification list elements that will not appear in this case: verification of dropped kerbs, traffic lights, traffic islands and cycle lane conditions.

The Zero List has a second function, that of verification of the general design criteria of the pedestrian crossing. In the selected example, we mentioned that the pedestrian crossing does not have traffic lights nor traffic islands, so it is not necessary to verify those elements. However, we could find an error in the design, such as that the pedestrian traffic of the crossing might be raised and the distance between the two pavements could be greater, and this, in turn, could require the installation of traffic lights

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and the design of an intermediate traffic island. The use of the Zero List during the verification process should point us to these circumstances.

A verification process of the chosen functionality types should not make the process repetitive or question it, as that is not its objective, but to check that the chosen type was the right option among all the suitable potential types, so as to avoid serious design mistakes and, most of all, to detect possible changes in the conditions that were used to formulate or estimate what are termed “great initial determining conditions”.

For that reason, during the verification process a verification of the threshold values for pedestrian and wheeled traffic is suggested in order to analyze the uniformity of the design of the footway, its place in the environment and to define the desirable function of the pedestrian crossing in its location, with the purpose of eventually determining the yes/no satisfaction of the functions that have been assigned (IVP-MADRID, 2000).

In steps nº2 and nº3, we find a varied casuistry. The parameter to be checked in step nº2 as the quantification of the reference parameter adopted in step nº3 can be established by different foundations. There are two types of foundation:

a) Legal foundation, which we identify with “L”. These come from a norm that has legal oversight, so they are of obliged execution.
b) Practical foundations, which we identify with “P”. Specifications from guidelines are included in this group, as the UNE norms. These are not of obliged execution, as the ones that are in the handbooks or sectorial studies. They do not have legal oversight, so they are not of obliged execution. However, they are supported by studies or practice. These are what we call “good professional practices”.

For the same parameter to be studied, we can find foundations of different nature in nº2 and nº3. Thus is the case of the “nonslip” parameter of pavements. As a parameter, it is described in all the legal norms that the pavement must be nonslip (step nº2) and so it is based in the legal fundament “L”. However, this legal requirement is not measured quantitatively so the determination of reference values (step nº3) is done in basis of practical fundaments “P”.

Step nº4, depending on the nature of the parameter to be evaluated quantitatively or qualitatively, an actual observation of the situation could be required, by conducting some field measurements or researching any documentation to find the desired information.

In step nº5 the reference values are compared to the ones obtained from the pedestrian crossing that is under verification, using a binary number of “0/1”, “0” when the verification is negative because the measured valued is not adequate for the reference´s value and “1” when the verification is positive. This way of expressing the results makes the partial sums by groups of verified elements easier, as well as the final global result. There are two more options:

- When it has not been possible to qualify or quantify the parameter that should to be verified. In this case, it will be defined as an “N”.
- When the verification of the parameter in the list is not applicable. This option has not been possible to eliminate.

Finally, step nº6 of obtaining results from the verification requires the separation of them into two groups; “AL/BL”, for the verified parameters that come from legal requirements “L”, and “AP/BP” for the verified parameters that come from good practices “P”. In both cases they will be accompanied by all the “N” that have been produced in the verification process, with a final expression, that is not an operable math formula, of the following type:

AL/BL – NL and AP/BP – NP, where:

A= number of parameters where verification has been positive or marked with “1”, legal “L” or good practices “P”.

B= number of parameters that should be verified, according to the chosen verification lists, legal “L” or of good practices “P”.

N= number of parameters that could have not been verified, legal “L” or good practices “P”.

The final expression is read in the following way:

There have been "A" parameters that have a positive verification, from a total of "B" parameters that have been verified, with "N" parameters that have not been able to be verified.

The following mathematical formula must be:

$$A + N = B$$

A final SUMMARY LIST gives us a global vision of the global verification results, with the following expression:

$$\Sigma(AL)i \; / \; \Sigma(BL)i - \Sigma(NL)i \qquad \Sigma(Ap)i \; / \; \Sigma(BP)i - \Sigma(NP)i$$

Results

The definition of the different types of the pedestrian crossing has generated a classification that helps in their theoretical and practical understanding, as it includes a visual aid catalog that includes most of the situations described in the text. In the appendices of the present article, a sample of the graphics that comprise the catalogue is presented.

By developing a verification model of the pedestrian crossing we have obtained a method that systematically organizes the elements and the parameters that regulate them.

From the application of the verification lists we can point out:

- The zero list is composed of 9 items of selection from the verification lists, where 2 to 4 lists will be used depending on the facets that concern the pedestrian crossing along with 9 checking items from the general conditions of the pedestrian crossing.
- For the verification only two, three or four of the elaborated lists will be used, depending on the type of the pedestrian crossing that will be checked, so that the number of elements to be evaluated ranges from 34 to 37, that are also defined as a whole by a number of parameters that range between 77 and 92.

Conclusion

The complexity of the pedestrian crossing as an element in urban areas has been highlighted, where a high number of elements are involved, which in turn are also regulated by numerous parameters and are difficult to manage in the designing, building and service life span of the pedestrian crossing.

The classification and the verification procedure proposed in this investigation are useful tools to help in the management of those processes.

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APPENDIX

APPENDIX 1.Graphic documentation of the different pedestrian crossing types

It has been considered appropriate to document the different pedestrian crossing types proposed, formulated on the basis of the described criteria, with graphic aids. Although the graphic representation of a concept has the advantage of providing an immediate comprehension of the idea, it has the risk of losing some of the generalities that need to be conveyed, as these details and characteristics of the represented elements must be specified: shape, colours and textures which induce thinking in terms of specific construction systems and materials.

Figure 2 and 3 present samples of the elaborated graphics to illustrate the different pedestrian crossing classifications that have been conducted.

Figure 2. Details of the traffic island at the same level as the driveway (see previous figure C.2.1). Access to the central sidewalk via dropped kerb.

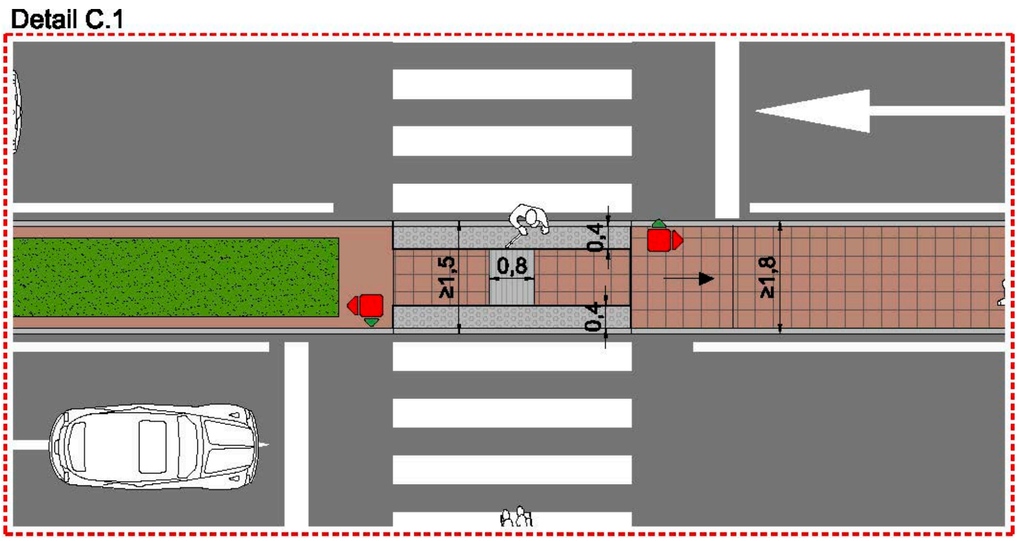

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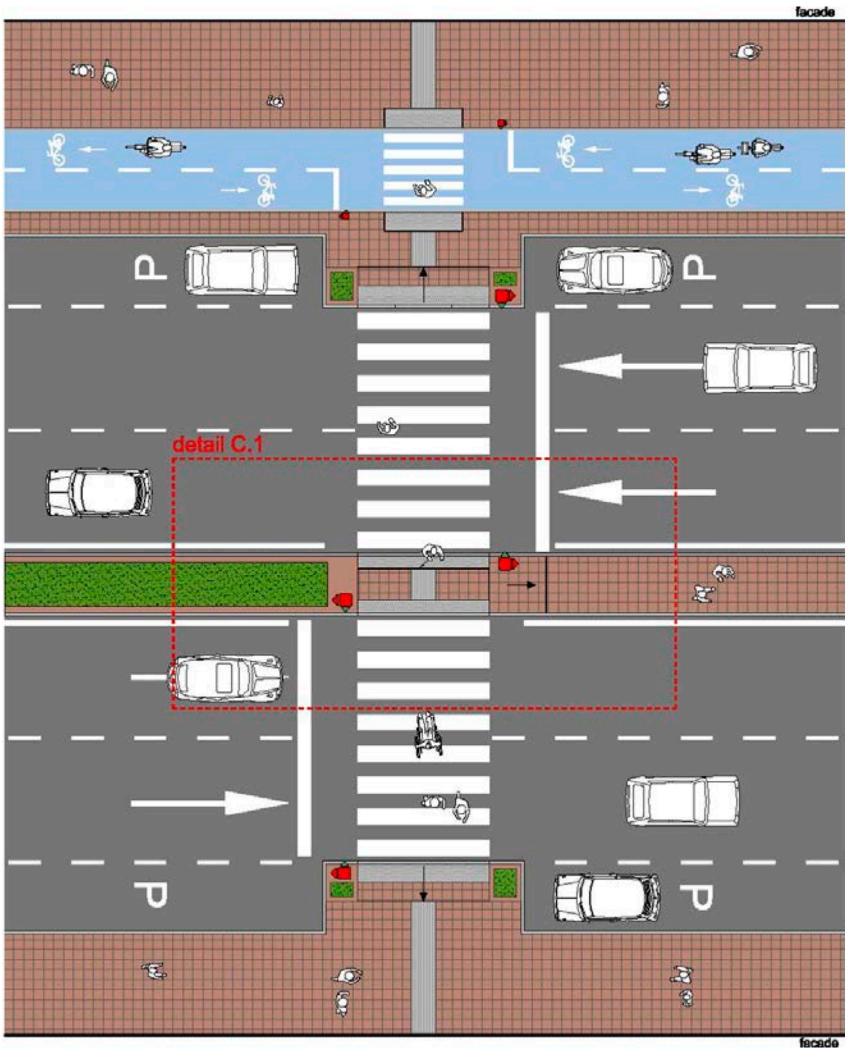
Figure 3. Pedestrian crossing with traffic light B.2 and single-level crossing, A.2.1.1

Traffic island at road level C.2.1.

Cycle track on pavement, cycle track over the pavement D.2. Pedestrian crossing by cycle lane in unique platform (similar situation to the "pavement and street at the same level" A.1)



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APPENDIX 2. Verification list

The following is a proposal of Zero List along with an example of an elaborated verification list.

<table>
<tr><th colspan="3">ZERO LIST
Selection of verification 'list
0 = Not applicable to do the list
1 = list to be verified</th><th>List Nº</th><th>Check with 0 ó 1</th></tr>
<tr><td colspan="5">FACET 1: PAVEMENT/ROAD</td></tr>
<tr><td colspan="3">At the same level</td><td>1</td><td></td></tr>
<tr><td rowspan="4">Raised Pavement</td><td rowspan="3">The pavement lowered to the road: ramp</td><td>Single level ramp</td><td>2</td><td></td></tr>
<tr><td>Lowered pavement: two plane ramp</td><td>3</td><td></td></tr>
<tr><td>Triple level ramp</td><td>4</td><td></td></tr>
<tr><td colspan="2">The pavement is raised to the road: raised platform</td><td>5</td><td></td></tr>
<tr><td colspan="5">FACET 2: TRAFFIC LIGHTS</td></tr>
<tr><td colspan="3">With traffic lights</td><td>6</td><td></td></tr>
<tr><td colspan="5">FACET 3: TRAFFIC ISLAND</td></tr>
<tr><td rowspan="2" colspan="2">With traffic island</td><td>At the same level of the road</td><td>7</td><td></td></tr>
<tr><td>At the same level of the pavement</td><td>8</td><td></td></tr>
<tr><td colspan="5">FACET 4: CYCLE LANE</td></tr>
<tr><td colspan="3">Pedestrian crossing for the cycle lane: the cycle lane is integrated on the street. This type does not require a specific list because its verification is done according to the relation between the pavement and road, analyzed in facet 1</td><td></td><td></td></tr>
</table>

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ZERO LIST **Selection of verification 'list** 0 = Not applicable to do the list 1 = list to be verified	List Nº	Check with 0 ó 1
Pedestrian crossing to pavement-cycle lane: the cycle track runs along the pavement away from the street	9	

ZERO LIST **General Parameters** 0 = The verification is negative. 1 = The verification is positive. N = The verification could not be made.	Check 0, 1 ó N
Pedestrian crossing situated in the natural way of the pedestrian	
Forced crossing by the pedestrian crossing	
Uniformity in the construction and design	
Suitable visibility conditions	
Traffic lights are required	
Traffic island is required	

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FACET 1: PAVEMENT/ROAD		NAME OF THE AUTONOMOUS COMMUNITY				List 4		
Raised pavement - Lower the pavement to the road - three-plane ramp								
ELEMENTS / parameters		Value of reference			Measured value	Verification		Comment
		L		P		AL	AP	
		According to O/VIV	Previous to O/VIV					
UNOBSTRUCTED MEASUREMENTS	**1. Width**	≥1,80 m (1.5 m exceptionally in consolidated urban areas)	≥ 1,50 m, if there is no unique platform. It can be 90 cm in some cases (S/Rgto2009) ≥ 1,20 m (S/D72/92)					
	2. Height	≥2,20 m	≥ 2,20 m (S/Rgto2009)					
CURB	**3. Height**		≤ 12 cm (S/Rgto2009) ≤ 14 cm (S/D72/92)					
PAVEMENT IN GENERAL (low gradient streets)	**4.Type of pavement**	Hard, stable, no loose parts or protrusions	Without loose elements pieces, without flanges between them, without an excess of brighteness (S/RGTO2009) Changing colour and texture in the corners, bus stops and obstacles (S/D72/92)					
	5. Sliding safety	Nonslip	Nonslip	To check that at least one of the following parameters: Rd≥35; R11 ó R10/V4; it has superficial irregularities ≥1 mm				

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SUBTITLED VIDEO TUTORIALS, AN ACCESSIBLE TEACHING MATERIAL

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Abstract: The use of short-lived audio-visual tutorials constitutes an educational resource very attractive for young students, widely familiar with this type of format similar to YouTube clips. Considered as "learning pills", these tutorials are intended to strengthen the understanding of complex concepts that because their dynamic nature can't be represented through texts or diagrams. However, the inclusion of this type of content in eLearning platforms presents accessibility problems for students with visual or hearing disabilities. This paper describes this problem and shows the way in which a teacher could add captions and subtitles to their videos.

Keywords: Educational resources, knowledge pills, multimedia eLearning design, eLearning accessibility, deaf students, captioned video.

Introduction

In many of the subjects taught in engineering, there are complex and dynamic processes whose learning is difficult for students if additional support materials provided with animations, simulations and explanations or video recorded images are not used. In agronomy, for example, with these materials students could observe with detail abnormal growth processes as a crop attacked by a plague. A complex application in computer engineering would be better understood if students could visualize its dynamic behavior [1]. The problem is that these kinds of materials cannot be represented in

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traditional text books, and are not regularly offered by college professors in their online courses yet.

The inclusion of multimedia contents in teaching/learning engineering courses [2] is useful both to help to deeply understand a problem (learning), and to apply knowledge to new problems to be solved (skills).

The creation of small pieces of video by teachers, to be included both in lessons and virtual classroom where they can be consumed several times and by mean of different devices by students, provides additional motivation increasing their learning rate and helping to understand and retain complex contents.

This type of video tutorials, known by many authors as “learning pills” consist on small pieces of learning materials created as audiovisual content. Theses “learning pills” are designed to complement traditional training strategies and to facilitate the understanding of some aspects of curricular materials that presents greater difficulty to understand for students, as evidenced by its conceptual depth and its instrumental complexity.

The production of learning pills can be autonomously done by a teacher, using basic computer equipment and affordable and easy to use applications. Since its purpose is purely educational and targeted to students enrolled on a particular course, it’s not necessary to use sophisticated or institutional means of production or publication that generally meet different approaches [3].

However, this kind of multimedia material unlike other traditional, presents new accessibility problems that must be taken in account. Nowadays there is a special sensitization towards integration in all life spheres for people with some kind of functional diversity. In many developed countries schools are under anti-discrimination legislation and are required to meet the needs of students with disabilities. It is therefore necessary for the authors of multimedia learning content to provide them with the necessary features to make them accessible and interoperable with other systems and external content repositories [4].

Learning pills

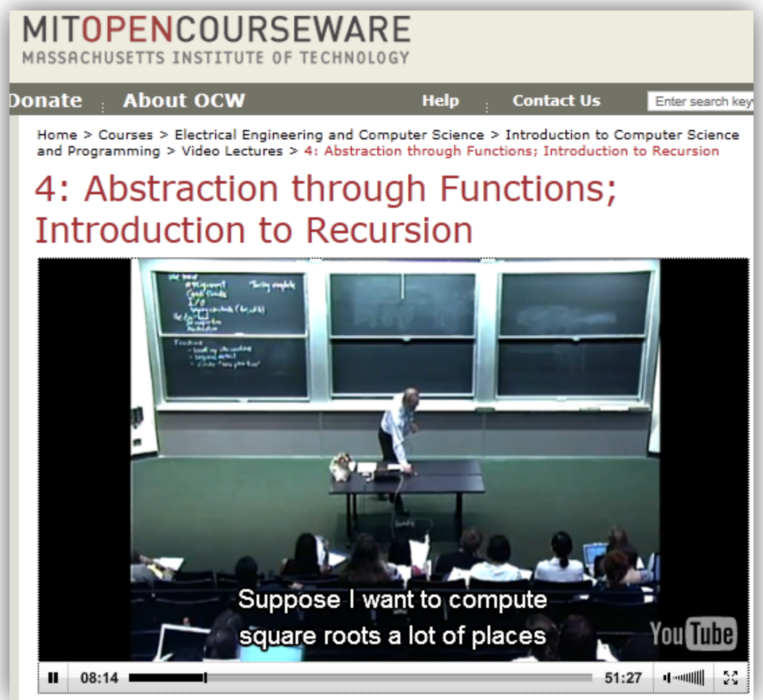
Audiovisual learning pills combine creativity, multimedia integration, sound and animations. Their design as self-contained pieces of videos of 5 – 15 minutes is focused in being integrated into a broader educational content in which several pieces of this kind may appear. Due to its shortness, the concepts or techniques which aim to strengthen learning should be clearly identified and should be part of the unit that is being created. They may be presented arranged in several ways and reused in different learning units, but without losing its characteristic of units with its own entity for themselves.

In this respect, learning pills differ from other types of video learning content, such as recorded lectures offered for example in Massachusetts´ MIT within their initiative of open courses, or in Youtube channels from other universities. Despite its great diffusion potential to students worldwide, these recordings present some drawbacks such as:

Their duration is the same as traditional lessons (50 minutes), which make them uneasy to watch more than once if you want to reinforce a concept developed in that lecture.

- Their duration is the same as traditional lessons (50 minutes), which make them uneasy to watch more than once if you want to reinforce a concept developed in that lecture.
- The video records everything that happens in the classroom, although is not relevant for the lesson. (Fig.1)
- It requires expensive resources and facilities: lightning, professional technical material, specialized staff for recording etc…
- High occupancy of memory in disc of the created media files.

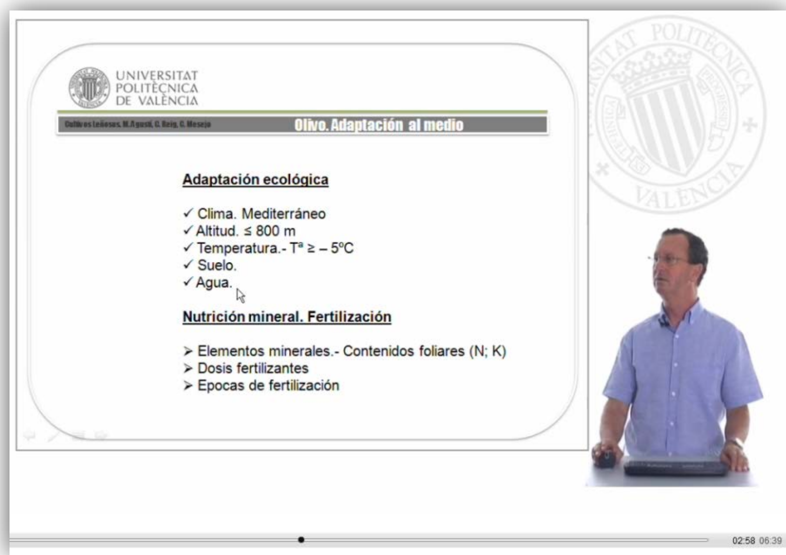
Figure 1. "A Computer Science master class videotaped and offered as part of the "OpenCourseWare" (OCW) by the Massachusetts Institute of Technology (MIT)". Source: MIT



Several Spanish universities are using for the production of video tutorials a tool named "Polimedia", developed at the Polytechnic University of Valencia in 2007. It allows the recording of a talking teacher or student, with a screen that shows slices or videos, while explaining the contents (Fig.2). To minimize the size of the file and an easy transfer of it, "Polimedia" uses a low-resolution image for the teacher and a larger one for the screen. From the point of view of educational content, in most cases the support consists of a central slide presentation accompanied by the figure of the speaking teacher explaining the subject.

Notwithstanding, it also creates learning pills in the sense given in this paper, such as those developed by the authors of a pilot experience at the University of Vigo [6], being the characteristics: "Autonomous objects, focused on a topic, indivisible, clusterable and targeted for an specific audience ".

Figure 2. "An agronomy video tutorial recorded with "Polimedia" at the Polytechnic University of Valencia. The display shows a presentation next to the teacher´s talking head, normally without subtitles". Source: Polytechnic University of Valencia.



Creating a video tutorial

Any teacher who wants to prepare teaching materials in the form of short video tutorials or learning pills, has available a wide range of tools, both free software and owner, assessing aspects such as image and sound quality regarding the size of the files, or the possibility of its spreading by streaming it from the University eLearning platform so students don't need to download it.

In the test we have done to bring out our first video tutorials, we were interested in catch everything that appeared in an area of the computer screen, on which there were superimposed images, video clips, presentations or an application window in which the teacher interacts. At the same time he was recording the explanations through a microphone.

The tools evaluated included 'Adobe Captivate', 'Camtasia Studio' or 'SnagIt' [7]. This last was finally chosen due to its simplicity and good video and sound quality. Videos were produced in AVI format, with a size of 640x480 and 25 frames/sec, and subsequently transformed into Flash Video format (FLV) in order to integrate them into the subjects´ HTML pages

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within the virtual platform of the University, where they can be watched without downloading.

Students with hearing disability

In a traditional classroom, deaf or hearing impaired students may use several means to access educational content. In some cases, a language interpreter is needed, while there are people able to read directly from the lips of the teacher. It can also be made by someone taking written notes that they can read later. None of the methods is intrinsically better than another and mainly depends on the individual and the exact nature of his hearing loss. It also depends on when they became deaf and their prior education [8].

In the case of virtual education, access to multimedia content such as video tutorials by students which have some kind of functional diversity, whether visual or audible, presents a particular difficulty that classical contents doesn't, mainly composed of texts and presentations with text and graphics. To access to written material, students with visual disabilities have programs able to dictate through speech synthesis the displayed text, and will also include if it has been attached, a description of the images.

Hearing impaired students are able to access to texts without an additional difficulty. In this regard it should be taken into account that accessibility considerations for these students should avoid making unrealistic assumptions about their levels of prior knowledge and their understanding of reasoning. In general students with hearing disability have poorer literacy skills due to language barriers during their previous training [9].

Subtitles

Despite of the enormous potential of the videos to prepare teaching materials is not yet fully developed, the need to make them accessible must be taken as a requirement from the earliest stages of planning and production of video tutorials.

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There are several types of subtitles. The most common are those in text transcribing the spoken content in either the same language or translated into another different. These subtitles are very useful for students who do not speak the language in which the video was made. For example, English subtitled video tutorials for a course at our university, allows us to make them accessible to visitors with a limited knowledge of Spanish.

However, this kind of subtitles have been widely criticized by deaf or hearing impaired people because they do not provide enough information about the context in which the action takes place in the video [10].

The accessibility of video tutorials requires the use of captions to provide additional information such as a sound produced in the scene (e.g. a telephone rings), which character has said a sentence, the tone employed (angry or happy), etc. This is an area where more research is still missing. The use of colors in texts to represent emotional contents, the position of subtitles on the screen to identify who is speaking or the size and typography used to provide the written text with the emphasis which is being talked about, are still experiences which have not been transferred to a mostly accepted rule [11].

Both subtitles and captions can be pre-recorded on video, so you cannot visualize it without them, or be contained in separate files so that the user should decide whether to display them or not. There are systems that allow you to see captions and subtitles separately and even choose their language.

Adding subtitles to a video tutorial

The task of adding subtitles and captions to a video is not entirely straightforward. In the literature about the creation of educational material is often recommended to leave this task to specialists. However the runtime and cost requirements make this recommendation only valid if the audiovisual material being prepared is intended for a wide audience and with a long duration in time.

A teacher who has prepared a short video tutorial to reinforce a topic in a course of several dozens of students may provide it with enough quality subtitles to make it accessible both to hearing impaired students and to those with difficulties to understand the spoken language of the video.

Countless programs that allow you to add subtitles to a video are available on the internet. In some cases this can be made by recording the text directly on the video frames and in others by creating a text file with the synchronization information of the video.

It is convenient to separate the subtitles in a file apart so that they can be shown only when the student desires. Videos recoded with subtitles may cause rejection when viewed several times. There are several formats for subtitles, as ‘SubRip’ (.srt), ‘MicroDVD’ (.sub), ‘Universal Subtitle Format’ (.xml), ‘Substation Alpha’ (.ssa), ‘Advanced Substation Alpha’ (.ass), etc.., but there are programs that allow you to switch from one format to another. For our tests we have used the open source program ‘Aegisub’ and the .srt subtitle format.

Another requirement was to be able to embed the video tutorials on web pages with additional information such as a description of its contents or recommendations for viewing. For this we have been using plugins for ‘Flowplayer’´s html. This is a video viewer for the web, allowing open source stream video from a web server, such as the virtual classroom, inside web pages in where the student can turn on or off the subtitles (Fig.3).

Figure 3. An Advanced Programming video tutorial. Subtitles can be removed and activated by pressing the small CC button that appears at the right bottom. Source: Author

Conclusions

Video tutorials as short “learning pills”, addressing the basics concepts of a subject and being available in the virtual classroom as self –learning materials, can help to strength the interest and motivation of students. However, accessibility creates challenges for students with functional diversity, which in the case of hearing impairment can be addressed by creating subtitle files and legends that can be displayed as a desire of the student when they are served from the eLearning platform. Subtitles can also be written in a language other than the one of the video tutorial if the aim is to make it accessible for students with language difficulties.

Both the creation of the audiovisual, and the writing and synchronization of the subtitles can be directly done by the teacher making learning content, using simple and easily accessible tools, and with a learning slope similar to other IT applications widely used.

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EDUCATIONAL E-INCLUSION FOR STUDENTS WITH SEVERE MOTOR DIFFICULTIES

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Abstract: The purposes of educational e-inclusion are fairness, equality and quality in the educational processes and offering the benefits of ICTs to all students. The impossibility of using computers or accessing the Internet increases educational exclusion and segregation. In this paper, we present an experience carried out at a special education center. This experience involved users with severe motor disabilities, and its purpose was to design and develop a computer-access system that was usable and adapted to the user. This system has allowed adding activities to the educational curriculum based on new technologies.

Keywords: accessibility; assistive product, students with special educational needs (SEN).

Introduction

The integration of disabled people to the information society is one of the most relevant challenges for the programs that, since the Lisbon strategy of 2000, are developed under the term e-Inclusion. These people have difficulties using computers and, as a consequence, accessing the Internet; therefore, from an interdisciplinary perspective, we must find alternatives that facilitate and allow these groups accessing and using information and communication technologies.

On the one hand, being able to access computers and the Internet is a necessary condition to have an active presence in this new society and, as well as for non-disabled students, it enriches and offers new educational possibilities (Zubilaga, 2002). However, accessing the Web is not always feasible for all groups, thus becoming a new form of social exclusion.

On the other hand, the teaching and learning process should nowadays be as fair as possible for all students, allowing and favoring the presence, participation and progress of all students in their educational experiences and activities, regardless of their conditions, abilities or characteristics. This fairness should also be applied to virtual education programs, which should also operate within the framework of the Inclusive Education model or Education For All (EFA) that, as proposed and defended by the UNESCO since the International Conference held in Jomtien in 1990, should also manifest as an inclusive information society.

It is estimated that a large number of assistive products are released each year, but most of them do not get to the users due to unawareness of their existence or the cost of purchasing them (Scherer & Gavin, 1996). If the product does get to the user, many systems are not accepted for lack of usability (Dawe, 2006). Therefore, for a system to be accepted by users, it is essential that its design and development follows User-Centered Design guidelines, such as design based on user understanding, tasks and context, involving users throughout the design and development processes, performing user-centered assessments, process iteration, considering user experience (UX), and working in a multi-disciplinary group (ISO 9241-210, 2010).

In this paper, we present a user-centered design and development experience for an assistive product based on computer vision that offers an access system for people with motor disabilities to be able to use the computer. The adaptations implemented to improve the system’s usability are particularly noteworthy. The experience was carried out at a special

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education center, ASPACE-Pinyol Vermell, with students with cerebral palsy, so accessibility has allowed planning and working on new activities that complement the educational curriculum of the students.

Inclusive education as reference framework

Inclusive education focuses on working on achieving two essential goals:

1. Defending educational fairness and quality for all students, without exceptions.
2. Fighting against exclusion and segregation in education.

Giné (2009) proposes that inclusion should be understood as a general principle applicable both to education and society. There is a growing international consensus around the idea that inclusion involves the following:

- Adopting certain values that should preside over the actions that could be carried out: acknowledgement of rights, respecting differences, valuing each individual student, among others. Inclusion is, first and foremost, a question of values, but there are specific issues related to practice.
- The process of increasing student participation in the curriculum, culture and community, and avoiding any form of exclusion in educational centers.
- The possibility of transforming cultures, standards and practices of educational centers to respond to a diversity of needs from all local students.
- The presence, participation and success of all students exposed to any risk of exclusion, and not only those with disabilities or special needs.

In this context, applying inclusive cultures and policies to the practice of e-Inclusion means taking into account the diversity of all people, which requires three central actions that group many others, but that can be explained through these (Muntaner, 2010):

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a) Removal of barriers for learning and participation. Removing the barriers that prevent the participation of all students in educational activities means rejecting all programs and proposals that discriminate against and segregate certain students, and which are in themselves a barrier to equal opportunity education. We must propose actions governed by a balance between the respect for the individuality of each student, with their idiosyncrasies, that is, their particular needs and abilities, different from any other, and the feeling of belonging to a group as a full member, a group in which the students can develop and feel valued, and that incorporates them and allows them to succeed in their learning process.

b) Facilitators. Assistive products are important for disabled people (Sánchez Montoya, 2002) because they offer the possibility of developing and active and independent life and allow connecting with the surrounding environment, increasing their dignity and consideration. The quality of life of disabled people is not just a question of economic safety or the availability of centers and services. It also depends on accessibility to physical media, environmental friendliness, existence and availability of resources that allow crossing communication and mobility barriers and fully participating in society under integration and normalization conditions.

c) For disabled people, achieving an independent life and social inclusion is not an easy or comfortable task, since they are limited both by physical and social barriers and by very diverse attitudes. Thus, disabled people look for acceptable and balanced life spaces that are suitable for their abilities and limitations. We must offer them opportunities that are appropriate to develop their abilities and to build their particular way towards reaching their adulthood within their social environment.

d) Assistive products are closely related to the effort done in the field of technology research. These products have to be constantly improved, and new solutions have to be proposed for the new problems arising from this increasingly complex life we lead. In this line of action, the incorporation of ICTs to the disabilities field has largely helped overcoming some of the barriers faced by disabled people.

e) Application of universal design principles. The removal of these barriers and the appearance of assistive systems as natural facilitators to improve the functionality and participation of all students at educational centers involve adapting the classroom and curriculum. These adaptations should allow for a more flexible and open curriculum. To achieve this goal, we propose incorporating universal design principles to learning, as defined by Orkins & McLane (1998): “the design of didactic materials and activities that allow learning goals to be reachable by individuals with widely different abilities to see, hear, talk, move, read, write, understand the language, focus attention, organize, participate and remember.”

Design of a computer access system

A user that is about to interact with a computer faces three different situations: data input, output, and processing. In the case of people with severe motor limitations, they have difficulties mainly accessing the computer and, even though nowadays there is a large diversity of both commercial and free solutions that offer input systems, these are not always appropriate or usable – i.e., effective, efficient and satisfactory, for the user.

The system that was designed is called SINA (Advanced and Natural Interaction System) , and it is a pointer device that uses just a webcam and is based on computer vision techniques that detect the face and nose based on human aspect visual features. Once the nose is detected, the system follows it to ultimately inform the position of the pointer to the operating system. To carry out the actions of the mouse, there is a graphical button bar that is always visible on the screen and includes all the events. These actions are executed through the so-called “wait and click”: the user selects an action by positioning the mouse pointer on the event button and waits a certain amount of time, which can be configured, until the action is selected. From the selection, the action will be executed on any part of the screen on which the mouse position is held for a preset time. From a technical standpoint, the application has been divided in two main modules to get an easy-to-use, user-friendly and, above all, fully automated system: Detection and Processing. The Initialization module is responsible for extracting the facial features of the user. This phase locates the face of the user and extracts the best facial features around the nose for tracking purposes. The Processing phase is in charge of tracking these facial features, recovering them if they are lost, and sending event and position of the mouse to the operating system (Varona, Manresa-Yee & Perales, 2008).

Users, tasks, and context

Students at the educational center were selected based on the following criteria: need for an alternative and efficient way to access the computer, possibility of working towards curricular goals, cognitive level to understand the operating of the program, and previous experience with computers.

The center selected four students and the first source of information regarding their abilities was an initial record gathering their personal information, and physical, cognitive, and behavioral characteristics. This record was divided in data on these areas: motor, visual perception, communication, psychological, pedagogical, computer skills, and prior computer experience.

User sessions were individual and adapted to their curricular needs. The type of activities selected by therapists and/or students to work on with the computer included:

- Viewing Microsoft PowerPoint presentations where the student had to press an element to answer a question, aimed at working on spatial organization, improving the interaction with the environment, etc.
- Playing action/reaction games.

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- Using JClic, Sebran ABC or Pipo applications and educational games, which are compilations of activities to learn how to read, write and compute, solve puzzles, and play association games or memory games.
- Solving educational and fun activities available on the Web or as desktop applications.
- Internet browsing and using communication tools.

Multidisciplinary group

The development team included computer science professionals, educators, physical therapists and occupational therapists. The first fully functional prototype was developed with the advice of a user with motor disability that had a technical background. After assessing it under laboratory conditions with non-disabled users, it was implemented at the special education school. The students at this center could have, in addition to their physical difficulties, some degree of cognitive limitations, so our goal was to present a robust and operating system that would not frustrate them due to technical problems. In the following section, the implementation process is described, as well as the continuous improvement process based on prototypes.

Also, it was very important to work with a centre that was involved in the SINA project at every level of the organization. The support of the management team, the users and their families, and the occupational therapists that led the sessions greatly facilitated the design of a usable system that was adapted to the needs of the users.

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Iterative usability improvement process with users

The improvement process was based on using high fidelity prototypes to favor iteration, improve functional specification completeness, and involving users in the design process and assessing at early stages (Lazar, Feng & Hochheiser, 2010). As problems were detected, they were analyzed, redesigned, and assessed with the users.

The following activities were carried out to gather information:

- The development team observed users using the system and therapists working with the students.
- Sessions were recorded daily by following a template that included data on the system, users, tasks carried out and context of use.
- Semi-structured interviews were conducted with therapists at the end of the school course.
- Reports were prepared on each of the participating students at the end of the school course.
- The sessions were videotaped.
- Ergonomics experts prepared reports on each user.
- Usability assessment: based on the definition of usability included in ISO 9241-11 standard (1998), usability tests were carried out to measure efficiency, effectiveness, and satisfaction factors. Students were presented with a set of tasks and the metrics used were: task completeness and task duration. Finally, there was a questionnaire that gathered information through Likert scales on fatigue, comfort, motivation and satisfaction.
- Comparison with other systems: some students were already using computers with other devices such as joysticks (hand and chin), head pointers or switches, so comparative tests were carried out by measuring the completeness and time required to perform tasks (Manresa-Yee, Ponsa, Varona & Perales, 2010).

The development team considered a set of factors that help involve usability in the development process. Boivie et al. (2003), divide these factors on three different levels: individual, project, and organization:

- On the individual level, both the attitude and skills and experience of those developing the system are key factors to introduce usability. The development team was very aware of the importance of designing a usable device that was adapted to the end user, since they knew that there were other systems whose ultimate goal was accessibility and which the users had already tried and found inefficient.
- On the project level, the main challenges are planning an iterative work model that integrates usability, the complexity of system's development projects, the decision-making process, and involving the users. As mentioned above, fully functional prototypes were used to enable early user participation. With an initial functional prototype, end users were brought into the process to work on their school activities. A summative and formative assessment was carried out (Lazar, Feng and Hochheiser, 2010). Additionally, there was no coordination issues within the work team because it was small and the developers were entirely free to make any usability-related decisions. The students participated throughout the improvement process, and both the development team and the therapists observed in detail how the system was used and analyzed information documents to suggest improvements.
- On the organizational level: as regards possible organizational obstacles, there were no remarkable issues. Project responsibilities were divided based on their nature, with the technical people being in charge of the proper operation of the system and its redesign, and educational aspects and day-to-day work with the students being the responsibility of the educators at the center and the experts in educational technology and special education. The only decisions that could affect the system development process and set deadlines were those related to the schedule and requirements of the educational center, due to the number of sessions that could be held each week, and available times, rooms, students, or therapists. However, project-staff at the center was fully committed, facilitating system assessment, gathering and recording session data, participating in

meetings, providing feedback in relation to possible improvements, and dedicating their time to work with the system.

Improvements to system usability

Based on the information obtained, usability recommendations were made to improve on the following aspects relating to (Juristo, Moreno & Sánchez-Segura, 2003):

- User interface, with modifications on the graphical user interface. The system was modified to allow using mouse graphic metaphors instead of text on the event bar, and the possibility of placing this bar on various screen positions was added. In the case of those students who still did not understand all mouse functionality, events could be disabled to avoid mistakenly selecting them. In the ergonomics report, the correct use of colors was recommended to prevent opposed color combinations. Therapists requested that the window where the vision process was observed (detecting and tracking the user's nose) was hidden because the students kept looking at themselves and did not focus on the tasks at hand. Since this window was not visible, there was no information on nose detection and tracking, so a smaller image was included within the event bar itself to have information on system status at all times.
- Development process, with changes in techniques, activities, and/or products used in the development process. Since the project was the collaboration of a multidisciplinary group formed by educators, computer science professionals, occupational therapists and physical therapists, know-how, methodologies, and techniques used in each discipline were included and exchanged within the group, which helped improve system implementation and communication with disabled users.
- System design, with changes in software functionalities to improve interaction. A parameter settings file was added to adapt the system to the abilities of the user (waiting time to generate events, position of the events bar, initial event selected by default, etc.). The

visualization algorithm was improved to add robustness to nose tracking and avoid losing it or having the nose position moved due to involuntary or sudden movements that the user might have. In the ergonomics report, different webcam heights and positions were recommended, or the use of auxiliary devices such as articulated arms to move the webcam closer.

For and extended review of the improvements in usability due to user experience, the reader is directed to our previous work (Manresa-Yee et al., 2010)

Conclusions

A computer access system has been presented that allows adding new school activities for students at a special education center. In the design and development of the system, factors that help improve usability have been taken into account, and a user-centered design was used, which means that end users were involved in the process from early development stages: they were observed while working on prototypes and the system was assessed with them. Currently, the students are still using the system at their school center (in occupational therapy sessions and computer rooms), and in some cases, their homes. The students have gained in control and interaction with the computer, therapists can select new educational activities, and a step is taken in the direction of normalization and equal educational opportunities for students with severe physical limitations.

In order to fully achieve educational e-Inclusion, physical accessibility to computers should be combined with Web accessibility and accessibility in the rest of the programs used to work.

The final release of the SINA and training applications are available under a freeware license at the Web page http://sina.uib.es.

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ACCESSIBILITY AND READABILITY OF UNIVERSITY WEBSITES IN FINLAND

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Abstract: This article describes a study conducted by the authors to evaluate the accessibility and readability of the contents of the Web sites of seven universities in Finland. The accessibility assessment has been carried out to check compliance with accessibility guidelines for Web content established by the World Wide Web Consortium recommendation in WCAG 2.0. The readability has been evaluated using the Flesch Reading Ease Level formula for English texts. We have tried to determine whether the universities have been concerned to provide accessible information about the university through its website so that it can be accessed by everyone (teachers, students), regardless of whether or not the user has a disability.

Keywords: Web content accessibility, readability, usability, ranking of universities, disability, WCAG 2.0.

Introduction

Accessibility indicates how easy is to use, visit or access something, in general, for all people, especially those who have disabilities. Web accessibility is referred to design allowing these people to perceive, understand, navigate and interact with the Web.

Among standardization efforts, we remark the Web Accessibility Initiative of World Wide Web Consortium (W3C) which tries to establish recommendations for achieving accessible contents, browsers and Web development environments. Among their recommendations the Web Content Accessibility Guidelines (WCAG), or set of guidelines for accessible Web pages, are specially important. The last version of this recommendation is WCAG 2.0 [1,2]. The study carried out in this article is based precisely on this latest version, which provides twelve guidelines to follow. These twelve guidelines cannot be directly tested as they provide the basic criteria that authors should fulfil in order to make content more accessible for people with disabilities. For each guideline, it provides testable success criteria that allow guidelines to be used in situations where appear certain requirements and the need for conformance testing [1].

In this paper, we have analyzed a group of Web pages of the websites of seven universities of Finland, checking the degree of compliance with WCAG 2.0 recommendations. Firstly, in the following section, we justify the choice of universities to be evaluated. In section 3 we describe the accessibility indicators to be evaluated and the calculated metric that will rank universities according to compliance with the established success criteria in WCAG 2.0. In section 4 we discuss the results of the analysis while the last section is dedicated to the results of readability analysis applied to the text in the page in English dedicated to the history of each university.

Selection of websites of universities

The main goal of this work is to contribute to the project ESVIAL funded by the EU Alfa program. It includes, as members, the two universities involved in this project (University of Alcala and Metropolia University). One of the initial tasks in this project is an accessibility review of higher education institutions of the countries of the partner universities. This is the reason why the study includes the Metropolia University as a partner of the project ESVIAL while it has been increased to embrace other universities of Finland. We have chosen the six shown in the latest version (Data from 2010) in the “Academic Ranking of World Universities” (ARWU) available at http://www.arwu.org. We chose this ranking as one of the most known and consistent.

The study includes the analysis of three of the webpages of each of the seven selected universities. The first one is the main page (Home), the second is a page with forms and the third one is a page with tables. The table 1 shows the universities and the pages finally analysed.

Table 1. URL of the analysed web pages.

University	Web pages
University of Turku	Home: www.utu.fi/en/ Form: www.utu.fi/en/feedback.html Data table: www.utu.fi/en/studying/programmes/masters.html
Aalto University	Home: www.aalto.fi/en/ Form: eage.aalto.fi/?registration/register&lang=en Data table: www.aalto.fi/en/cooperation/career_services/talentit_en/stands/
University of Jyväskyläse	Home: www.jyu.fi/en Form: www.jyu.fi/en/study/study_frontpage/contact-info Data table: www.jyu.fi/en/contacts/
Helsinki Metropolia University Applied Sciences	Home: www.metropolia.fi/en/ Form: www.metropolia.fi/en/feedback/ Data table: www.metropolia.fi/en/apply/how-to-apply/bachelors-degree-evening-studies/timetable-summary/
University of Eastern Finland	Home: www.uef.fi/uef/english Form: www.uef.fi/palaute Data table: www.uef.fi/tutustu
University of Helsinki	Home: www.helsinki.fi/university/ Form: www.helsinki.fi/funds/feedback.htm Data table: ethesis.helsinki.fi/julkaisut/kas/kasva/vk/karkkainen/6luku.html - table1
University of Oulu	Home: www.oulu.fi/english/ Form: www.oulu.fi/english/contact Data table: www.degree.oulu.fi/admission/language-requirements/

Accessibility: evaluated criteria

This work examines the main accessibility barriers identified in an analysis of a sample of Finnish university websites in relation to the currently applicable W3C/WAI Web Content Accessibility Guidelines 2.0 (WCAG 2.0). The technical accessibility analysis takes into account a set of accessibility criteria based on W3C guidelines.

For the evaluation of each of the pages of the sample, we tool as reference the standard WCAG of Accessibility of Web content in the Web 2.0 of the W3C [1], synthesized in a series of technical checks on those aspects which are most relevant and with highest incidence. Based on the study done by the INTECO [3], this verifications are put into one set of fourteen indicators referred to the recommendations of WCAG.

These indicators have been selected because they reflect most of the guidelines of WCAG 2.0 for the three possible levels (A, AA y AAA). A series of checks to analyse different aspects of each indicator are the key elements used for each indicator. These criteria are commonly accepted as providers of an accurate overview of the accessibility of a website.

The indicators considered for the analysis are shown below:

1. **Valid Web documents:** Checks if the pages are compliant with the grammars of HTML and CSS (used tools: W3C validator of HTML and CSS http://validator.w3.org/).

2. **Images**: Checks if there is an alternative text for images or images maps as well as that images are not used to transmit textual information (used tools: manual review and TAW validator http://www.tawdis.net/).

3. **Headers**: There should be a header structure that adequately reflects the logical structure of documents to facilitate reading, understanding and non-visual navigation (used tools: manual review and TAW validator).

4. **Links**: check possible links without content, links with the same text and destinations, or links that open in new windows without a warning (used tools: manual review and TAW validator).

5. **Contrast and semantic use of colour**: check whether the colour contrast between foreground and background colour is enough and if the colour is not used as the only visual way of conveying information (used tools: Colour checker – extension for Mozilla Firefox).

6. **Presentation**: check if the page uses HTML tables for layout and other requirements related to the visual presentation of text (used tools: manual review and TAW validator).

7. **Text size**: text must be defined in relative units to allow the resizing for readability, adapting to the needs of people who is accessing it (used tools: manual review and TAW validator).

8. **Forms**: Form elements for entering data must be used properly to allow proper interaction with assistive technologies and users (used tools: manual review and TAW validator).

9. **Data tables**: They must be used properly to identify tabular data and related information (used tools: manual review and TAW validator).

10. **Accessibility via keyboard**: The components of user interface and navigation must be operable, so it is necessary to have all the functionality of the page available through the keyboard (used tools: manual review and TAW validator).

11. **Attacks:** Aimed at evaluating access to the site without causing problems of photosensitivity-caused attacks (used tools: manual review and TAW validator).

12. **Navigable**: Web sites should help users to browse and access pages (used tools: manual review and TAW validator).

13. **Understandable**: Aimed at identifying the use of correct language as well as language changes in the document which facilitate

understanding of users who use screen readers or speech synthesis programs (used tools: manual review and TAW validator).

14. **Enough time**: Provide users enough time to read and use contents (used tools: manual review and TAW validator).

Based on the study made by the INTECO [3], the verification are evaluated based on the values “Hits“, “Failures“, “Few Failures” y “Not Applicable (NA)”:

- Hits: Met the requirements for verification.
- Failures: Do not meet the requirements for verification.
- Few Failures: Exceptional circumstances applicable to checks where the failure is minimal. This situation is valued as half a point.
- Not applicable: Non availability of minimum number or conditions of items for evaluation.

The total number of evaluated indicators is the following one:

$$Total\_of\_indicators = Nº\ indicators \cdot Nº\_pages\_evaluated$$

Being the number of evaluated indicators equal to 14 (the indicators described in this section) and evaluated numbers of pages equal to 3. Therefore, the maximum number of indicators taken into account in the evaluation is 42.

From this number it is necessary to eliminate the indicators not applicable (NA). For each of the pages, this number will take a different value. Once you have found the previous data, the success rate of the page is calculated as follows.

$$Success\_rate = \frac{100\% \cdot Hits + 50\% \cdot Few\_failures}{Total\_applicable\_indicators}$$

*Being Hots the indicator that meet the requirements of the success criteria of WCAG 2.0, few failures of the minimal failures, and total_applicable_indicators the value calculated above (42 - NA). In the case of the total number of indicators are fulfilled, then the success rate of the page would be 100%.

Results

Table 2 summarizes the results obtained in the analysis of accessibility for the sample of 7 university portals in terms of percentage of covered or not covered indicators, those with few errors, not applicable and success rate (ranked from highest to lowest level).

Table 2. Results of the analysis made on the portals.

University	Hits	Failures	Few failures	NA	Success rate
1. University of Turku	22	12	1	7	62.85%
2. Aalto University	19	12	4	7	54.28%
3. University of Jyväskyläse	18	17	0	7	51.48%
4. Helsinki Metropolia	17	18	0	7	48.57%
5. University of Eastern Finland	16	19	0	7	45.71%
6. University of Helsinki	13	19	2	8	38.23%
7. University of Oulu	13	22	0	7	37.14%

The principal problems founded are:

1. **University of Turku**: During the validation of documents, there aren't any websites that validate HTML or CSS grammar. In the case of presentation, one of the websites contain common errors such as not fulfilling the required minimum spacing as well as having text blocks that contain more than 80 characters. Even more, there are static sizes in the text in every page. The selected website with forms contains errors because it has not labels in its elements. When

analyzing the accessibility of keyboard, the user cannot access all the elements with the keyboard in all of the websites. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

2. **Aalto University**: During the validation of documents, none of the websites properly validates its HTML code because they contain a large number of errors. Only the CSS code of one website is valid. One of the websites presents errors in the headers because it contains two at the same level and not well structured. Regarding the contrast and the semantic use of color, the pages have many links that change color merely when the user passes over them. The selected website with forms contains errors because it has not labels in its elements and does not show enough support for the user. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

3. **University of Jyväskyläse**: During the validation of documents, there aren`t any websites that validate HTML. Two of the websites have errors in the images because they do not contain alternate text. One of the websites presents errors in the headers because it does not contain the header h1. In terms of presentation, all pages containing the mistake of using tables for layout information from the page without being data. The selected website with forms contains errors because it has not labels in its elements and does not show enough support for the user. There are errors on data tables because there is not an abstract of the table and there are not headers in the columns. When analyzing the accessibility of keyboard, the user cannot access to all the elements with the keyboard in all of the websites. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

4. **Helsinki Metropolia**: During the validation of documents, two websites properly validate its HTML and CSS code, the other website do not validate because it contains five errors. We consider this as a minor error. All of the websites have errors in the images, because

they do not contain alternate text; we consider this as a minor error. Two of the websites presents errors in the headers because they have repeated headers of the same level. Regarding the contrast and the semantic use of color, there are two pages containing a good number of contrast errors in their texts, images and links. In the case of presentation, all pages have errors because they use style attributes within the HTML code. There are static sizes in the text of all websites. The selected website with forms contains errors because it has not labels in its elements. When analyzing the accessibility of keyboard, the user cannot access to all the elements with the keyboard in all of the websites. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

5. **University of Eastern Finland**: During the validation of documents, there are not any websites that validate HTML code. Two of the websites have errors in the images because they do not contain alternate text. Regarding the contrast and the semantic use, we have found out several errors in some of the texts of every page, moreover, there are links that are identified only by passing over them. In the case of presentation, all pages have errors. In one of them, a table is used for layout information. There is static size in the text of every page. Besides that all pages use style attributes within the HTML. The selected website with forms contains errors because it has not labels in its elements. There are errors in data tables: there is not an abstract of the table. When analyzing the accessibility of keyboard, the user cannot access to all the elements with the keyboard in all of the websites. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

6. **University of Helsinki**: During the validation of documents, only one website properly validates its HTML code, the others websites do not validate because they contain a large number of errors. In the case of CSS code, all of the websites are correct. All of the websites have

errors in the images because they do not contain alternate text and they can be replaced by mark-up. One of the websites presents errors in the headers because it contains headers at the same level and they are not well structured. In the case of presentation, no websites are fulfilling the required minimum spacing and one of the websites has attributes of presentation in its HTML document instead in the CSS document. Even more, a website uses absolute units. The selected website with forms contains errors because it has not labels in its elements and does not shows enough support for the user. There are errors in data tables, e.g. there is not an abstract of the table. When analyzing the accessibility of keyboard, the user cannot easily access all the elements of two websites with the keyboard. Two of the websites have errors of navigation referred to location and focus. None of the websites has declared the language of the document in the page.

7. **University of Oulu**: During the validation of documents, no websites validate HTML code. Two of the websites have errors in the images because they do not contain alternate text. One of the websites presents errors in the headers because it does not contain the header h1 and has repeated headers of the same level. All of the websites have errors in the links because contain consecutive links of image and text send the user to the same resource. Regarding the contrast and the semantic use of color, there are two pages containing many contrast errors in their texts, images and links. In the case of presentation, all websites contain common errors such as not respecting the required minimum spacing and including text blocks that contain more than 80 characters. Even more, there is static size declaration in the text of every page. The selected website with forms contains errors, because it has not labels in its elements. When analyzing the accessibility of keyboard, the user cannot access to all the elements with the keyboard in all of the websites. All websites contains problems of navigation as they have many items that do not have focus option for keyboard and mouse.

Evaluation of readability of web pages

Readability is the ease in which text can be read and understood. As an additional part of the research, we have done an assessment of the readability of textual contents of web portals of the seven selected universities using the well-know Flesch Reading Ease Level formula (RES) for English texts [4]:

$$RES = 206.835 - 1,015 \cdot \left(\frac{Tota\_words}{Total\_sentences}\right) - 84,6 \cdot \left(\frac{Total\_syllables}{Total\_words}\right)$$

We have analyzed the readability of the web pages which present the history of each universities, using a free software (http://flesh.sourceforge.net). The results are shown in table 3.

Table 3. Results of readability analysis.

University	Accessibility position	Flesch Reading Ease Level	Level of readability
1. University of Jyväskyläse	3	46.8	Hard
2. University of Helsinki	6	42.91	Hard
3. University of Turku	1	37.58	Hard
4. University of Eastern Finland	5	29.72	Very Hard
5. Aalto University	2	27.27	Very Hard
6. University of Oulu	7	26.85	Very Hard
7. Helsinki Metropolia	4	11.27	Very Hard

Conclusions

Accessibility of universities in Finland is not bad compared with the results other similar universities in other countries (analysed by the authors in previous studies not yet published) as it is shown by above results. Three of the universities which were analysed (43%) exceed acceptable accessibility barrier, but two (28.5%) are very close to the barrier. Only two universities (25.8%) are out of the acceptable accessibility level. Regarding readability evaluation of the selected seven sites under analysis, three of them have show a «Hard» level of readability while the other four are in the «Very Hard» level. Note that the University of Turku has the best results in both categories, accessibility and in readability. This usually means that the organization has devoted special efforts to the goal of offering good accessibility to users.

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