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TGlass: A Custom-made Wearable Promoting Accessibility for Tetraplegic

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Abstract: Although the law of quotas enables people with disabilities (PwD) to join the labour market, better paying working positions require more skilled professionals, thus demanding specific professional qualification. Tetraplegic people often struggle to access regular courses, such that online courses could be an alternative to offer them some technical formation. However, they demand special equipment to interact with online courses. In this context, this paper presents the TGlass, a low budget smartglass designed to be distributed as companion material to online courses, respecting users anthropometry and providing them with comfort and movement freedom. Its input/output peripherals together with the eye tracking software technique makes possible the communication between PwD and a learning environment. As a result, we expect that a large scale production will reach a quite cheap price for the device, which will be able to better the life of quadriplegic people as for their professionals opportunities and thus to their quality of life.

Keywords: TGlass; Quadriplegic; Distance education; Accessibility; People with Disability.

1. Introduction

The number of places in the field of Information Technology and Communication (ITC) has been continuously growing, over 40% in 2015 and 30% in 2016 (Zogbi, 2016). Such field offers great opportunities for programmers, some of which are destined for people with disabilities (PwD). In Brazil, there are about 45 million of PwD (Census, 2010), who commonly struggle to access technological resources that could facilitate their learning process towards a better professional qualification, especially those who are tetraplegic or quadriplegic - those with no voluntary movements of the upper and lower limbs. Soares (2014) highlights the need for technological solutions that provide PwD with a better qualification so they can overcome their difficulties. We carried out a wide investigation on the related work addressing this problem in the past ten years, though only a few were found reporting solutions on that matter. These are briefly summarized next.

Guerreiro (2008) proposes a mobile system called "The Myographic Mobile Accessibility for Tetraplegic", which allows quadriplegic people to use the smartphone by sending commands through muscle stimulus. The system consists of four modules: 1) user interface (UI); 2) information presentation (IP); 3) electromyographic control (EC) and 4) application. The UI module communicates with the application module sending and receiving data by the EC and IP modules, respectively. The user wears a type of vest containing electrodes that pick up the muscular stimuli, processes them and sends commands to the system. The application module runs in on Windows operating system. Bluetooth technology is responsible for maintaining connectivity between the modules, serving as a communication channel. Finally, the IP module is responsible for returning the system responses to the user. The information depends on the state of the application. The messages can be displayed via audio or visually.

The Myographic Mobile solves the personal computer data input for quadriplegic problem, however we believe that our approach, in opposition to the proposed vest, brings more benefits to the users because they will have more control over the device that will capture, in a less susceptible to noise, their intentions. In this investigation we aim to take advantage of the natural movements of the human body, to catch data input from user, in a comfortable way.

Caltenco (2010) propose theTongueWise system. A software developed to interact with a computer through a set of sensors located at the tip of the user's tongue. The tongue-controlled system consists in a weareble devices contain of 18 sensors capable of covering most standard keyboard and mouse commands. The sensors were subdivided into 2 types: 10 for keyboard commands and 8 for multi-directional commands that simulate the movements and clicks of a mouse. Each movement picked up by the sensors is converted into the standard keyboard command, called the key code, or mouse movement pattern. The generated commands are sent via USB port to the computer generating a visual display on the operating system. The usability tests report that the distance and location of the sensors directly influence the speed and precision of use, and conclude that the best location for the sensors is on the tongue and not on the sides of the cheek or roof of the mouth. The typing accuracy was about 2.8 correct words per minute (CWPM) with a standard keyboard and 1.7 CWPM with TongueWise system.

The eye tracking system proposed by Ye(2012) aims to detect moments of eye contacts between an adult and a child. his method utilizes commercial smartglass that provide eye gaze tracking technology to determine the adult gaze point and combine this with video analyzes from the child's face. The device is similar in appearance to regular glasses, with an outward looking camera that captures a video of the scene in front of the examiner.

Vidal (2014) presents an interface design for wearables with near-eye display. These devices present the user with a duality of visual worlds, with a virtual window of information overlaid onto the physical world. The author suggests that the wearable interface had to benefit from understanding where the user's visual attention is directed. The eye tracking technique is used to create and analyze interfaces, it can notice when user's gaze is into the application or real world, outside application boundaries. The author takes into consideration some aspects such as when the user looks at an extreme edge of the screen or a display menu inside application. On one hand, research has shown the plausibility of integrating gaze into near-eye displays.

In this work, we propose the Tglass, a low budget smartglass designed to be distributed as companion material to online courses.

2. Methodolody

2.1 Virtual Learning Environment (VLE)

The access of PwD to regular schools is still poor. Knowing that, we provide an accessible E-learning system where PwD can do courses and develop some skills. All the material and tools are developed by an interdisciplinary team made of programmers, pedagogues, language signers, tutors and other professionals and then tested and validated by a team of PwD before being published in the platform, such that all the content is already accessible for people with hearing or visual disability and is currently being adapted to quadriplegic people.

Quadriplegic users of computers report that handling a device in their mouth for interacting with the machine is completely tiring and uncomfortable. Therefore, we believe that a proper device to these people would work based on voice commands or on small movements of the head or of the eyes, besides being light and comfortable so they can do the activities without much effort.

2.2 The Device usability

In this work, we propose a low-cost device named TGlass, which consists of a pair of glasses with sensors that detect head movements and a software that operates upon each command.

TGlass is designed for tetraplegic users over 16 years of age whose level of the cervical lesion is below C5. Tetraplegic will need someone to adjust the glasses to their head to make them firm and ensure that the input and output peripherals are correctly capturing the user's movements.

With Tglass, the user will be able to send commands to the computer by using their own voice or by moving their eyes. The device will enable the capture of intentions through ocular manifestations. Speech is captured by the microphone and then submitted to natural language algorithms in order to process the user's intentions and act upon the VLE.

TGlass will be shipped pre-configured with the student's login and password so that the user can initiate activities immediately after dressing and adjusting the equipment. After initialization, the initial menu containing information related to the course they are enrolled will be displayed on the Tglass screen, and the option to choose a learning object from the lesson, exercise, support material or evaluation. The user chooses the option by pointing with his/her eye the desired icon, and with the blink of the eyes selects the chosen option.

Initially the field of view, merged into a virtual minimalist interface, is projected into the user's eyes. Then, following the eye movement, the user navigates through the existing options and, with a blink of an eye, selects the desired activity. At the beginning of the activity, the application, using augmented reality, plots the first step of the object model over a predefined target on the user's workspace. Through manual gestures, the user can optionally request help to find some of the parts needed to assembly the object. When you complete the step, the system makes the recognition of the mounted object and validates the assembly, releasing the next phase in the event of success.

The design of the interaction considers the Fitts' Law, an empirical model that analyzes the accuracy and speed to perform an activity. According to Fitts (1954), the time required to move to a target area is a function of the ratio of the distance to the target and the width of the target. Such rule originally applies to only one dimension, but there are extensions for two-dimensional activities with direct applications in computer systems in activities based primarily on point and click. In this context, it stems from Steering Law (Accot & Zhai, 1999). Therefore buttons or widgets with a larger size are used in order to reduce the time spent and the difficulty to reach them.

Among the available features to facilitate navigation we can mention:

- Move the mouse cursor by detecting the movement of the iris through the camera.
- Simulation of the mouse click when the user flashes the eye or by resting a certain time limit on the desired target.
- Larger targets in the VLE interface to facilitate navigation and selection of available functions.
- Attracting targets can be activated to attract the cursor if it is in a proximal region.
- Voice commands to access specific features.
- Writing texts via voice recognition.

2.3 Device Assembly

In order to develop the device, we have taken into consideration some important aspects regarding its design and form factor, such as weight and robustness, respecting the anthropometry, cost, comfort and movement freedom.

For building this wearable device, we had to consider the physical particularities of someone's head, by means of parameters such as the head format, nasal bridge format, distance between the eyes and general facial geometry dictate the equipment measures. Alves (2011) found that the average Brazilians' head dimensions were: head's circumference (horizontal perimeter): 51.93cm in men and 53.56cm in women; head width (frontal diameter): 15.2cm in men and 15.65cm in women; and head length (profile diameter): 19.12cm in men and 19.75cm in women.

The glasses will be produced in a unique size, but soft adjustments will be implemented on the glasses, such as size regulation in the lateral temple and also width regulation. The whole glasses frame measures 60cm of width and 30cm of length, so that both men and women can wear them.

A sketch of the physical structure of the TGlass frame is presented in a variety of angles in Figure 1. The front part is equipped with lenses, a microphone and a video camera. These accessories compose the peripheral input and output of the glasses, so that the user can access the computer commands and receive the feedbacks of the system in use. The left and right temples are flexibly fixed with a length adjustment that fits to the users' ears, which makes sure that the glasses will be fixed to the face. The upper part is made with a rim where the width adjustment flaps and the peripheral input and output are.

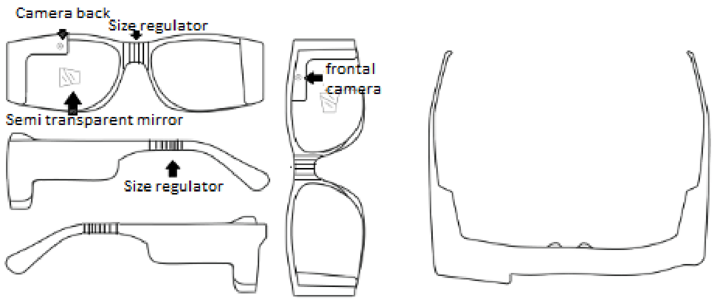

Figure 1. Physical structure of the TGlass.

The weight and duration of the battery are also crucial factors that should be taken into consideration when projecting this sort of device. The average time that a user spends to accomplish the activities in VLE is 60min for deaf people, reaching 80min for people with motor disabilities. Knowing that, the TGlass does not need powerful batteries as tablets and the notebooks do. A smaller battery reduces production cost as well as the glasses weight, thus assisting the user with comfort and mobility.

The TGlass has in its physical structure a series of components that enable data input/output for communicating with the VLE. Front and back video cameras provide the recognition of the working area and visual tracking. An LCD screen shows the user the VLE feedbacks, and a microphone enables the use of voice as input. These peripheral details allow the user to interact with the VLE content without their hands.

Figure 2 shows how the peripheral components are disposed in the physical structure of the TGlass. In Figure 2-A, we see the TGlass front camera, used for scanning the workspace in augmented reality activities, and user feedback is given through an LCD display. Figure 2-B depicts the back camera of the glasses, which will be pointed out to users' eyes to capture images of eyes reactions; from the generated images, users will be able to reach the clickable targets of the VLE with just one look, once a blink of an eye works as a mouse click. In Figure 2-C, we show the micromirror DLP2010, from Texas, responsible for the projection of the virtual environment that assists on the augmented reality tasks. This component has a resolution of 800x600px and it shows the images using 16bits of colors, which is enough to enable the VLE proposed activities. In Figure 2-D, we present the lenses for projections of LVE content in the users eye. These lenses have a semi-transparent mirror that allows the passing of light, making it possible for the user to see both the external and virtual surroundings, thus providing a better immersion on the virtual environment. Figure 2-E shows the microphone of the device, which enables voice commands, where texts in blocks and navigation commands via voice can be entered by the user, being free from the hands to write something.

The base structure, or the glasses frame, are produced by a 3D printer, which makes its confection cost cheaper and accelerates the building of the parts for reposition. In order to guarantee low weight and comfort, the material chosen for printing is the PLA 1.75 mm, a light but resistant and easy to find material.

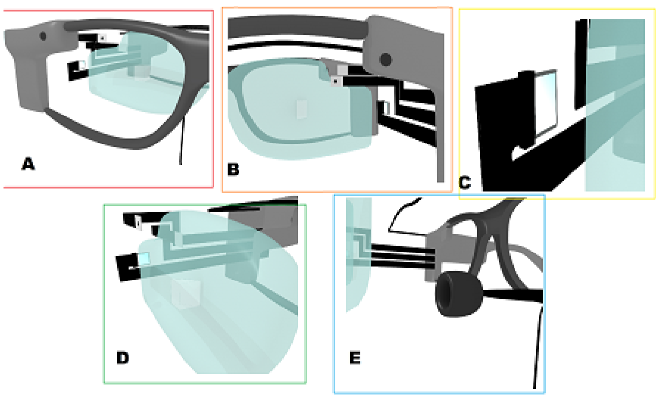

Figure 2. Peripheral components.

In Table 1 we list the all the components used for building the TGlass and its prices.

Table 1: Cost of the components.

Component	Cost (US$)
Raspberry Pi A+	23.00
Camera Module Raspberry	8.62
USB microphone	7.90
USB Micro Camera	4.15
Powerbank 2000 MAH	5.00
3D printing	2.50
DLP2010 (LCD)	2.50
DLPDLCR2010EVM-PCB (DRIVER)	249.00
Total	**About 374.45 U$**

3. Final Considerations

In this work, we propose TGlass, a device that provides accessibility to a VLE for quadriplegic so that they can have access to professional courses without much effort. The target audience are those with a cervical injury level below C5, since the cost-benefit ratio of people with high (C1-C4) injury would not be favourable. PwDs that fit the profile of the target audience need good speech skills so that they will be able to perform effectively in our platform.

The elevated initial price is due to the production of only one single Tglass. However, when taking a greater production into consideration, cost considerably decreases. We expect this device will have a low cost of construction and acquisition compared to the costs of personal computers and accessibility equipment in the market.

Such device represents an innovation in the field of distance education, especially when focusing on people with disabilities in the context of quadriplegics. Additionally, we state that it will provide easy handling and configuration for tetraplegic and for anyone else.

We believe TGlass will bring great benefits for PWD, once it will favour and enable greater interaction of these people with the outside world, thus reducing the visible and invisible barriers that quadriplegic people experience, becoming a tool of social inclusion and online education.

References

Alves, H. A., Santos, M. I. M. D. P., Monteiro, M. A. A., Moraes, P. R., Melo, F. C. L. D., & Ribeiro, W. (2011). Análise dos parâmetros antropométricos da cabeça dos militares da força aérea brasileira no projeto de

capacetes balísticos. *Revista Brasileira de Biometria*, 472-492.
Accot, J., Zhai, S. (1999). Performance evaluation of input devices in trajectory-based tasks: an application of the steering law. *In Proceedings of the SIGCHI conference on Human Factors in Computing Systems.* ACM, 466–472.
Caltenco, H. A., Struijk, L. N. S. A., & Breidegard, B. (2010). TongueWise: Tongue-computer interface software for people with tetraplegia. *In 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology.* IEEE, 4534–4537.
Census. (2010). http://www.censo2010.ibge.gov.br/. (2010). http://www.censo2010.ibge.gov.br/ *Brazilian Institute of Geography and Statistics (IBGE).*
Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of experimental psychology* 47, 6, 381.
Guerreiro, T. J. V. (2008). Myographic Mobile Accessibility for Tetraplegics. *Ph.D. Dissertation. Citeseer*.
Soares, M. I. S. S., Júnior, C. G. F., Castro, L. S., OLIVEIRA, F. C. M. B. (2014). VISUAL JO2: Um Objeto de Aprendizagem para o Ensino de Programação Java a Deficientes Físicos e Auditivos através do Estímulo Visual Um Estudo de Caso. *Revista Novas Tecnologias na Educação 12 (2014), 1.*
Vidal, M. (2014). Looking at or through?: using eye tracking to infer attention location for wearable transparent displays. *SEPTEMBER 13 - 17, 2014, SEATTLE, WA, USA.*
Ye, Z., Li, Y., Fathi, A., Han, Y., Rozga, A., Abowd, G. D., & Rehg, J. M. (2012). Detecting eye contact using wearable eye-tracking glasses. *In Proceedings of the 2012 ACM Conference on Ubiquitous Computing (UbiComp '12). ACM, New York, NY, USA, 699-704.*
Zogbi, P .(2016). Conheça o setor que tem mais vagas que profissionais no Brasil. <*http://www.infomoney.com.br/carreira/emprego/noticia/4447259/conheca-setor-que-tem-mais-vagas-que-profissionais-brasil*>.