Systematic review of the literature on studies of User Interfaces in Assistive Technology

Vinicius Kruger da Costa [1], Andréia Sias Rodrigues [2],
Rafael da Cunha Cardoso [3], Tatiana Aires Tavares[4]

R. Gomes Carneiro, 1 - Centro, Pelotas - RS, 96010-610, Pelotas, RS, Brazil

[1] viniciusdacosta@pelotas.ifsul.edu.br,
[2]andreiasias@pelotas.ifsul.edu.br,
[3]rafaelcardoso@pelotas.ifsul.edu.br, [4]tatiana@inf.ufpel.edu.br

Keywords: Human-Computer Interaction, User Interface, Assistive Technology

1 Context

This article aims to present a study about Assistive Technology (AT) and its User Interfaces (UI), specifically related to people with visual and /or motor deficiencies. The proposed is to develop an overview for this scenario, from a Systematic Literature Review (SLR), with analysis of published articles on these themes, creating bases for further research in this field in Human-Computer Interaction (HCI).

In Brazil, there are around 45.6 million people with disabilities, corresponding to 23.9% of the brazilian population; 8.3% of them presents severe motor deficiency and 3.46% severe visual impairment [1].

In this context, therefore, efforts are justified in the search for solutions to this large group of users that are marginalized by basic socialization processes, such as access to education, the world of work and a self-image of the person with capabilities [2]

AT arise as a response for the inclusion of people with disabilities (PWD) in a multidisciplinary field of study that aims to foster the real inclusion of these users, giving them autonomy in the development of everyday activities [3].

PWD need auxiliary means to use the most of devices of Information Comunications Technology (ICT) because its UIs are based on vision, touch and cursor movement to click [4].

2 Method

We used it as a methodological basis for the development of this study the Systematic Review of Literature (SRL) [5], through which it was defined a basic protocol to search for articles with two general questions:

Q1: What modes of computer interaction are most commonly used by people with disabilities?

Q2: What devices and software are used for human-computer interaction for people with disabilities?

The search was performed on Google Scholar (http://scholar.google.com.br/) base, at publications made between 2011 and 2016, only in English language and used in their keywords, title or its abstract the terms described by the following research string:

HCI; interface; user interface; assistive technology; accessible; adaptive; assistive; accessibility; visual impaired; motor impaired; disability; device interaction;

As criteria for exclusion of an article for analysis, it was defined that it could not be related to the area of education, or specific with a medical area approach (*education* and/or *medical* keywords).

Another factor of selection and/or exclusion was the option of only analyzing articles related to motor and visual deficiency, since both are more representative the universe of atypical users [1].

The application of this protocol (November, 2017) results 327 articles in Google Scholar, which were analyzed taking into account the research questions listed.

3 Results

The results present a large range of AT solutions for PWD accessibility to computer. It is necessary to understand a variable context of this atypical users, since within of a restriction there are a lot variation, from mild (such as partial vision, myopia, difficulty controlling the movement of one hand) to severe ones (blindness, degenerative diseases like Amyotrophic Lateral Sclerosis).

Within the universe of possible AT solutions mapped from SLR, according to the approach of accessibility of the computer, the articles analyzed can be broadly divided into two main groups:

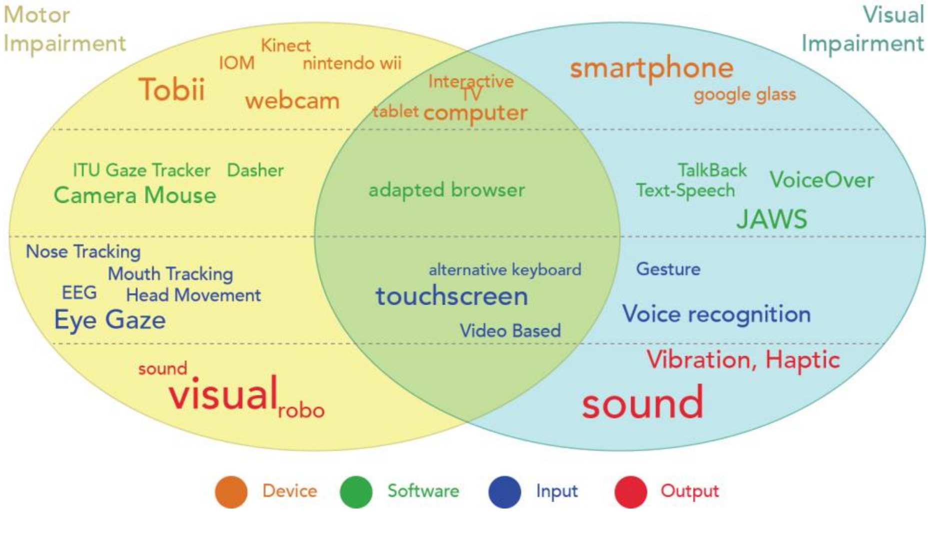
Descriptive articles - present some software/device that adapts the UI of ICT, trying to compensate the deficiency by the use of AT;

Analytical articles - based on analysis/comparative research between the use of several AT with the same purpose, evaluating the efficiency of the UI and the user experience.

Each type of disability required a different type of approach in the way the interaction with the computer is established - using AT devices for data input and output [6].

Based on these considerations, and qualitative analysis of the articles, a representative diagram was created (Figure 1), in which the circles represent the two major areas of deficiency (visual and motor) and, within these, the occurrences of the modes of Interaction, devices and software cited according to the legend.

Figure 1 - Occurrences of interaction modes / devices / softwares, input and output of data vs. disabilities.



Motor disability: the most referenced interaction (**Q1**) is the movement tracking-based (most eyes, head, tongue, mouth and nose) [7,8]. The devices with mouse cursor control through wearable technologies and video-based tracking (through gestures - Natural Interface), the most cited (**Q2**) Camera Mouse software and the Tobii imaging processor device, both used directly at the computer.

They were also cited, but in lesser extend, adapted keyboard (one push button, e.g.) or appendages that allow the use of smartphone with touch interaction. Normally the output information in this disability are GUIs or adaptations of these (such as browser or specific use interactive TV applications) [9].

Visual Impairment: basic interactions established with ICTs in the UI are related to (**Q1**) voice commands input and output . Interfaces haptic (tactile) were also cited and generate recognition component that would normally be translated into sound vibration [10].

Adapted keyboard are also used, typically connected to (**Q2**) computers, while smartphones and tablets are support for TA. Most of the occurrence software were JAWS, VoiceOver and TalkBack (the last two work on iOS and Android) with focus mainly on the use of mobile devices to give aid to urban mobility [11].

Trends of Research in AT and IU: new research trends today focus on solutions that are not yet commercially mature, but promising as agents of inclusion in the use of ICTs . As major tendency of new forms of interaction appear researches with Computer Brain Interface (BIC) with capture of brain waves through EEG (Electroencephalography).

Through ease access to various sensors and improvement of signal collection, studies are not limited exclusively to brain signals, but also to the use of various muscle signals using EMG (Electromyography) and EOG (Electrooculography) [12].

This physiological signal-mediated interaction approach creates a whole new application platform for AT because it enables people with severe movement restriction through body parts manipulate data at more customized interfaces.

Disadvantages of these approach are: the difficulty of extracting the interaction signal, low portability and requirement of highly (expensive) specialized hardware [13].

4 Conclusion

Through this study, based SLR, it is perceived that many research related to the subject, however, there are still gaps in research in the area of Human-Computer Interaction related to PWD.

About the group of **descriptive articles** it was noticed that commercial solutions of UIs of ICTs devices, in general, are created to typical users, what demands a series of adaptations or specific TA that allows accessibility to the PWD.

The varying amount of disability levels determine the difficulty to define a standard general protocol for project development of AT, which generates solutions on demand for each atypical user. That makes any AT device an expansive product, and that is out of reach of the large group of people who need it.

In the group of analytical articles, the evaluation and comparison process between devices/softwares as TA presented great disparities, confirming that there is no standardization to development of AT and evaluation of its use by PWD.

From these considerations it is possible to list future research within this scope of User Interfaces and Assistive Technology:

- Creation of technology that consider their User Interfaces based on the Universal Design, that is inclusive like base and not like appendix;

- Development of multimodal AT devices that support more than one sensory input of data, such as audio, head movement, thus making it possible for users with various types of disabilities;

- Definition of more comprehensive evaluation protocols that assess not only the technical usability of these devices, but also their experience of use;

5 References

1. IBGE, Instituto Brasileiro de Geografia e Estatística. **Censo Demográfico. 2010**. Available in <http://www.ibge.gov.br/home/estatistica/populacao/censo2010> Accessed: Aug. 2015
2. SHINOHARA, K.; WOBBROCK, J. O. **Self-conscious or self-confident? a diary study conceptualizing the social accessibility of assistive technology**. Transactions on Accessible Computing (TACCESS)., v. 8, n. 2, p. 5:1–5:31. New York, NY, EUA , 2016.
3. BERSCH, R. **Introdução a Tecnologia Assistiva.** CEDI: Centro Especializado em Desenvolvimento Infantil: Porto Alegre, 2008. Available in <http://www.assistiva.com.br/Introducao_Tecnologia_Assistiva.pdf>. Accessed: Aug. 2015
4. JOHNSON, S. **Interface Culture: How New Technology Transforms the Way We Create and Communicate.** Harper, San Francisco, 1997.
5. PETERSEN, K., FELDT, R., MUTJABA, S. e MATTSSON, M., **Systematic mapping studies in software engineering**. Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering (EASE), 2008.
6. BARBOSA, S.D.J., SILVA, B.S. **Interação Humano-Computador.** Rio de Janeiro: Elsevier, 2010.
7. HUO, X., PARK, H., KIM, J., e GHOVANLOO, M. **A dual-mode human computer interface combining speech and tongue motion for people with severe disabilities.** IEEE Transactions on Neural Systems and Rehabilitation Engineering, 21(6), 979-991. 2013.
8. RODRIGUES, A. S., DA COSTA, V., MACHADO, M. B., ROCHA, A. L., DE OLIVEIRA, J. M., MACHADO, M. B., E TAVARES, T. A. **Evaluation of the use of eye and head movements for mouse-like functions by using IOM device.** In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (Vol. 9738, pp. 81–91). Springer Verlag. 2016.
9. PINHEIRO, C. G., NAVES, E. L., PINO, P., LOSSON, E., ANDRADE, A. O., e BOURHIS, G. **Alternative communication systems for people with severe motor disabilities: a survey.** Biomedical engineering online, 10(1), 31. 2011.
10. CSAPÓ, Á., WERSÉNYI, G., NAGY, H., e STOCKMAN, T. **A survey of assistive technologies and applications for blind users on mobile platforms: a review and**

foundation for research. Journal on Multimodal User Interfaces, 9(4), 275–286. London. 2015

11. LAHAV, O. (2014). **Virtual reality as orientation and mobility aid for blind people**. Journal of Assistive Technologies, 8(2), 95-107.
12. MÜLLER-PUTZ, G., LEEB, R., TANGERMANN, M., HÖHNE, J., KÜBLER, A., CINCOTTI, F., E MILLÁN, J. D. R. **Towards noninvasive hybrid brain–computer interfaces: framework, practice, clinical application, and beyond.** Proceedings of the IEEE, 103(6), 926-943. 2015.
13. KALUNGA, E. K., CHEVALLIER, S., RABREAU, O., e MONACELLI, E. **Hybrid interface: Integrating BCI in multimodal human-machine interfaces. In Advanced Intelligent Mechatronics** (AIM), 2014 IEEE/ASME International Conference on (pp. 530-535). IEEE. 2014.