



Software Development to Assist in the Interpretation of Tactile Maps
Desenvolvimento de um Software para Auxílio na Interpretação de Mapas Táteis

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Abstract

Accessible geographic maps are useful for gaining insight into the environment. Traditionally, tactile maps are always used in cartographic literacy. These maps have proved to be efficient for the acquisition of spatial knowledge by people with visual impairment, but they have significant limitations. For example, due to the specifics of the tactile sense, only a limited amount of information can be represented on the map. It should be noted, however, that only a small percentage of the visually impaired population can read Braille. Recent technological advances allowed the design of interactive maps in order to overcome some limitations. A significant feature of the maps is the potential to provide extensive monitoring of phenomena with spatial knowledge, regardless of the age of the user. It is in this sense that, this research presents the creation of a computational resource that aims to enable or not students with basic education deficiency in the teaching of Cartography. The developed software uses simultaneous sound and image resources with data from the 193 member countries of the United Nations, which allows inclusive education, interaction between students with or without visual impairment.

Keywords: Visually impaired; Computer application; Tactile maps

Resumo

Mapas geográficos acessíveis são úteis para obter informações sobre o meio ambiente. Tradicionalmente, mapas táteis são sempre usados em alfabetização cartográfica. Esses mapas mostraram-se eficientes para a aquisição de conhecimentos espaciais por pessoas com deficiência visual, mas apresentam limitações significativas. Por exemplo, devido às especificidades do sentido tátil, apenas uma quantidade limitada de informações pode ser representada no mapa. Deve-se notar, no entanto, que apenas uma pequena porcentagem da população com deficiência visual pode ler Braille. Recentes avanços tecnológicos permitiram o desenho de mapas interativos para superar algumas limitações. Uma característica significativa dos mapas é o potencial para fornecer monitoramento extensivo de fenômenos com conhecimento espacial, independentemente da idade do usuário. É neste sentido que, esta pesquisa apresenta a criação de um recurso computacional que visa capacitar ou não alunos com deficiência na educação básica no ensino de Cartografia. O software desenvolvido utiliza recursos simultâneos de som e imagem com dados dos 193 países membros das Nações Unidas, o que permite educação inclusiva, interação entre alunos com ou sem deficiência visual.

Palavras-chave: Deficiente visual; Aplicativo computacional; Mapas táteis

1 Introduction

According to data from the Department of Continuing Education, Literacy, Diversity and Inclusion (Secadi) of the Ministry of Education, in Brazil, there are more than one million students with visual impairment enrolled in basic education. Considering these challenges, it is known that Cartography, being considered as a graphic language materialized in the cartographic representations (maps, models, graphs, tables, among others), is an essential instrument in the process of interpretation of the geographical spaces constituting, in a medium of communication that is not only that of written language. It is important to note that the intrinsic relationship between Geography and Cartography is of fundamental importance, as one is necessary to understand the other (Barbosa & Sá, 2016).

In Brazil, some philanthropic organizations support people with disabilities. According to Loch (2009), in Brazil, there are three major references in the area of production of materials for the visually impaired, the IBC - Benjamim Constante Institute, in Rio de Janeiro linked to the Ministry of Education, the Dorina Nowill Foundation for the Blind and Laramara - Brazilian Association for Assistance to the Visually Impaired, both in São Paulo. The focus of these institutions is to produce, adapt and distribute maps for pedagogical activities.

The advances in public policies, began in 2009 with the CDPD - International Convention of the Rights of the Person with Disabilities. It was the first international human rights treaty approved by the National Congress of Brazil and into force internally since August 25, 2009. It refers to a universal consensus treaty that concretely specifies the rights of persons with disabilities, due to the basic rights bias adopting a social model of disability. By this model, the disability can not be justified by the personal limitations resulting from a pathology.

When it comes to visual impairment, maps are very useful tools for exploring and analyzing geographic data as well as acquiring general knowledge on various subjects, such as demography, geopolitics, history, and others Ducasse *et al.* (2017). As stated by Alexander *et al.* (2015), there is an imme-

diante need for research and development of new technologies to provide access to inclusive graphic material. While the importance of this access may seem obvious in many educational, vocational and social contexts for the visually impaired, the diversity of the user group, the range of available technologies, and the breadth of tasks to be supported make the research and development process a complicated endeavor.

Actions to reduce and eliminate cartographic barriers for the visually impaired are essential to promote fair access to teaching materials that can promote the inclusion of blind people in the classroom, as well as their independence in urban spaces and access to social services.

In Santa Catarina there is LABTATE - Tactile and School Cartography Laboratory, which in recent years has standardized some symbols and models of tactile maps to serve as an example to other institutions in Brazil. The models are available for download on the web http://www.labtate.ufsc.br/ct_atlas_geografico_tatil.html, in addition, they offer videos and tutorials related to the production of tactile cartographic collections.

This research aims to expand the Brazilian cartographic collection in Braille. The tactile resources for the World Atlas in Braille, the final product of this dissertation, follows the model proposed by LABTATE. The availability of the maps will be available for download, free of charge, to any interested institution. A narrator software will also be available to improve the cartographic education of young people and adults. The main advantage is to illustrate and narrate each tactile map chosen by the user, thus also serving the teaching of people who are not visually impaired and allowing integration among students in the classroom.

2 Human Sensory Systems

To understand the challenges that a person with a visual disability faces, it is necessary to understand the characteristics of the senses and the differences that exist between them. Vision is the sense in which people are more dependent, even if other

senses can provide useful information, say (Thinus-Blanc & Gaunet, 1997).

Vision provides a great deal of information, (Cattaneo & Vecchi, 2011). It is the most efficient way to collect information. However, for some tasks, this is not the most appropriate sense. An example is given by (Ungar, 2000): when sitting on a stopped train, while another train next to it begins to move, the vision gives the sensation of being in movement. It is through kinesthetic information that the person identifies to be standing.

Most activities are based on the simultaneous and interactive participation of different senses. Interchanges between people and their environment are multimodal and must be integrated through complex processes (Hatwell, 2003). To better understand, one must observe separately the three senses that are most commonly employed in interactive systems: vision, hearing, and touch. The senses of smell and taste are rarely employed in Assistive Technologies, so they will not be addressed in this research.

3 Design and Production of Tactile Maps

Cartography is a mean of communicating geographic information. The real world is complex, to be represented it is necessary to select the information that will constitute the map. Map production is an engineering activity, so it requires a project. The initial questions are: What is the purpose of the map? What is the target audience, the users? If the map has as its theme geology, census data or watersheds, its purpose is to assist users in spatial understanding of a given phenomenon.

In the Cartographic Project are established methods and processes to be executed according to the purpose and use of the map. The processes of abstraction and cartographic generalization are applied first. As a result, one has a simplified or approximate representation of the real world. The cartographic representation is executed using points, lines, area, texts, colors and textures. The symbolization and selection of the entities to be represented is necessary.

When the visually impaired are the users of the maps, the project requires special attention. When it

comes to the term convention, it is the usual way of doing things. The cartographic conventions are part of the map design and follow basic guidelines. These guidelines apply to various map elements such as title, map scale, legend, text size, positioning of text, and symbols (including selection and placement).

The use of cartographic conventions results in the construction of predictability and familiarity for the user of maps, allowing them to concentrate on the contents of the map. Therefore, a key question for the development of cartographic conventions for tactile maps is repeated and long-term research, aiming to identify the usual forms of cartographic conventions for the visually impaired.

(Lobben & Lawrence, 2012) conducted a survey to determine the conventions and symbols for the tactile map. The tactile symbols were studied as their first focus because they are the resources that represent the reality and the geographic data. Each symbol must have a meaning to be deciphered and mentally transformed by the user of maps into a real-world concept, vegetation, for example. One symbol cannot differ from tactile map to another. Mainly, when the purpose of the map is to assist in the teaching of geography for the visually impaired. The initial set of symbols, Figure 1, was constructed based on researches by (Heath, 1958; Morris & Nolan 1961; Wiedel, 1966; Coulson, 1991; Campbell, 1997; Eriksson, 1999; Perkins, 2002; Rowell & Ungar, 2003).

The tactile map symbol set, Figure 1, brings together the main characteristics for navigating a visually impaired person in an urban area. The figure contains twenty-eight tactile symbols that represent common features of the street network, such as roads, sidewalks, intersections, entrances, terrain changes, parks, water. The symbol set is available for download and tactile printing on the SMCRL website - Spatial and Map Cognition Research Laboratory <http://geog.uoregon.edu/maps/tactilesymbols.jpg>

In the production of maps and tactile images, several methods are employed, some for large quantities involving suitable technologies and others for small quantities, that can be done in a handmade way. The most common methods for the production

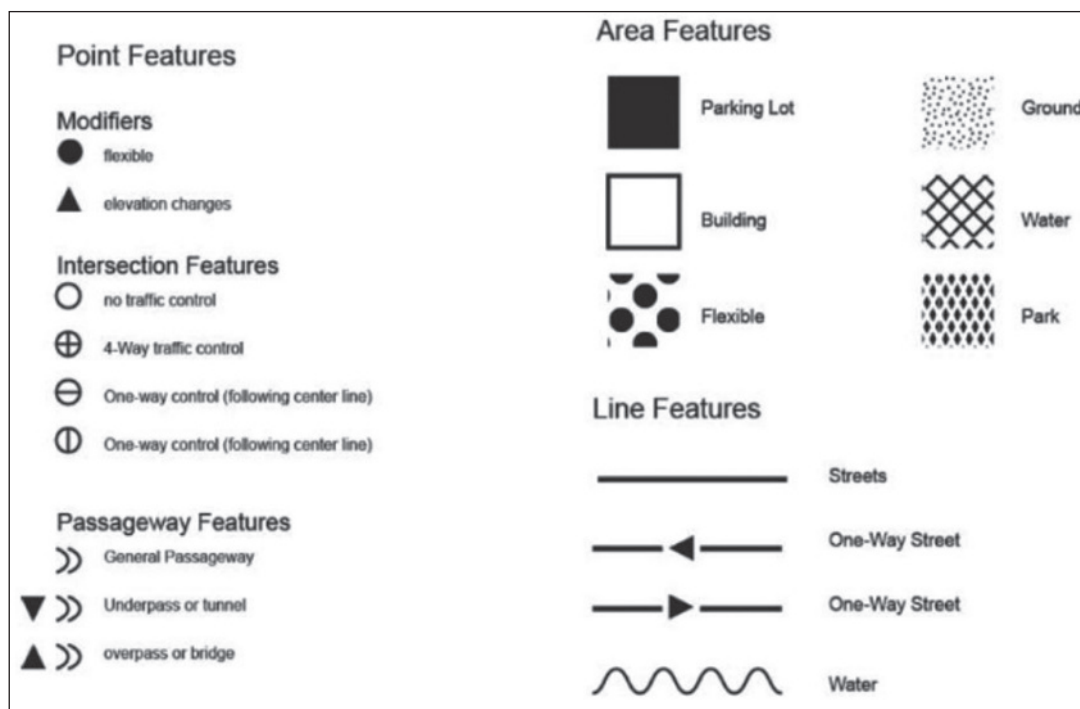


Figure 1
 Convention
 of Tactile
 Symbols.
 Lobben e
 Lawrence
 (2012).

of large quantities are by vacuum forming methods and the other by microcapsule paper, which is heat sensitive. Both are presented in (Brock, 2010)

The microcapsule method works with a normal printer, but the paper is special, and a heater is required. The map is printed on paper that contains alcohol microcapsules in its coating. As the black ink absorbs more heat, the alcohol capsules expand when the paper is passed in the heater (Edman, 1992). The production method is easy, and the costs are lower than for vacuum training (Lobben & Lawrence, 2012). The printer is a normal inkjet printer.

Images can be prepared using a computer and printer. The resulting image is perceptible both tactile and visual, thus allowing the sharing of information between visually impaired and disabled people, meeting one of the objectives of the LDB - Guidelines and Bases for Inclusive Education Act.

According to (Sena & Carmo, 2018) the maps can also be constructed using simple handmade collage techniques, for example, paper and Styrofoam for the base, wires to display the zoning and buttons to display the points. The advantage of this

type of map is that it adds more textures for the presentation of the information, whether punctual, linear or zonal.

3.1 The Braille System

Braille is an alphabet in high relief. It was invented by Louis Braille in 1824, and today is the international standard writing system for blind people. It is used in many countries for text, music, math and even computer science. Each letter in the alphabet is a rectangular cell composed of 6 to 8 points. A Braille cell can be entirely covered by the tip of the finger (Cattaneo & Vecchi, 2011).

According to (Hatwell, 2003), Braille is well adapted to the sensory capabilities of the index finger. However, he argues that it is a great challenge to learn it, due to the absence of semantic and phonological aspects. Figure 2 shows the Braille Cell model and the alphabet, with an example of a printed code.

As can be seen in Figure 2, the Braille code adapts to the native language of the user, in most cases, just use the cells corresponding to the word that is to be written. The word *casa*, in Portuguese,

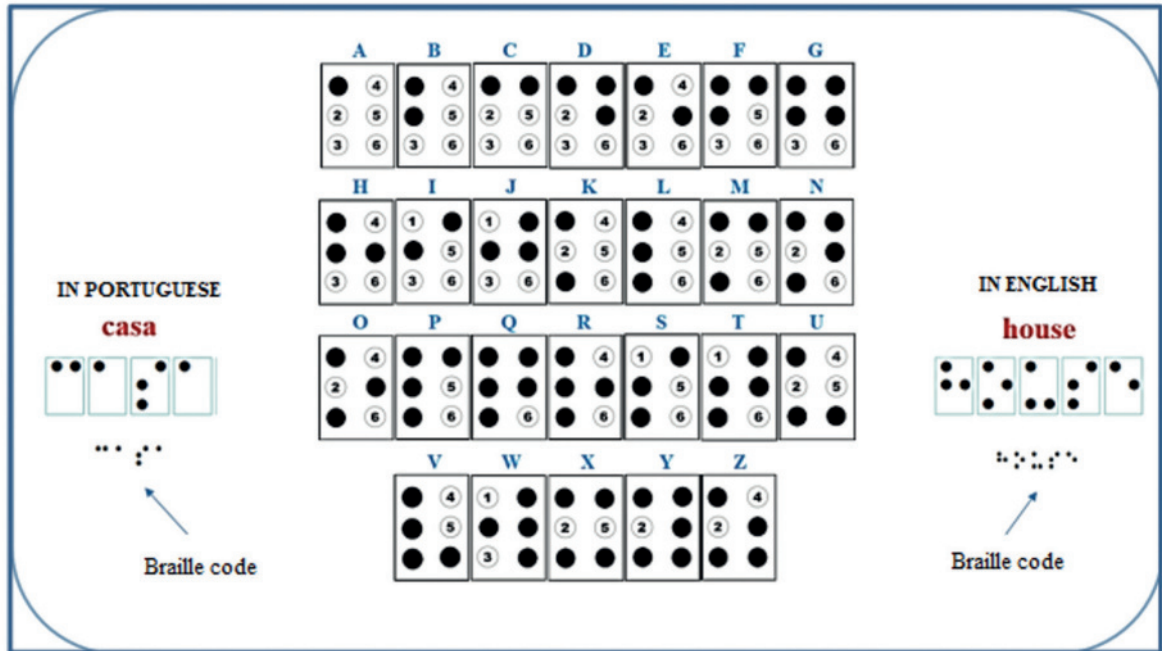


Figure 2
 Braille
 alphabet,
 with print
 illustration

example in Figure 2, has four cells, in English, house needs five cells. The meaning is the same and the spelling is different. The example was used to show that Braille is not a language, but a transcription code. For this reason, it is used across the globe for literacy for the visually impaired.

4 Methodology

The development of the research began with the theoretical basis. Geoinformation Technologies were used in six steps, arranged sequentially, to achieve the proposed objectives. For this, a set of softwares and database were used, as well as sound and image resources, for communication between the application and the user, and standardized tactile map printing. Figure 3 presents the steps for implementing the research.

4.1 Spatial Databases

Data from the following entities were used:

193 Member countries of the United Nations
 - United Nations.

LABTATE Tactile Map Standard - Tactile and School Cartography Laboratory.

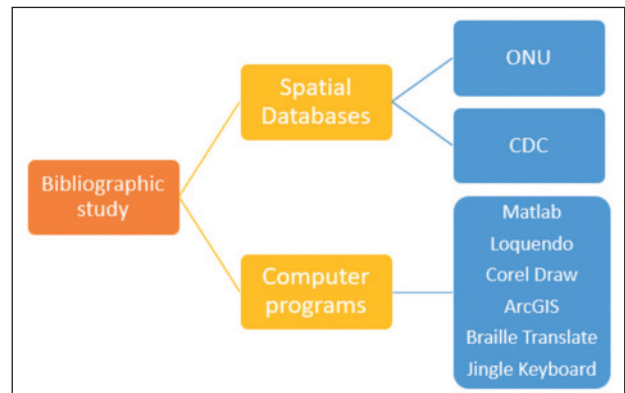


Figure 3 Flowchart of the methodological process

Population 2017 of UNFPA - United Nations Population Fund.

CDC shapefiles files - Center for Disease Control.

4.1.1 United Nations Organization

As the research deals with a World Atlas, it was necessary to define a reliable database to quantify which and how many countries exist in the world. The most appropriate option was the UN, which is an international organization made up of countries that have volunteered to work for world peace and

development. The right to become a member of the United Nations rests with all peace-loving nations which accept the commitments of the Charter and which, at the discretion of the Organization, are able and willing to fulfill such obligations.

In addition, to be part of the UN, the country must have defined borders, economic support and have national government. Table 1 shows the list of countries that are not part of the UN and, consequently, no data were assigned to the world atlas proposed in this research.

| Flag | Name | Motive |
|---|------------------|--|
|  | Taiwan | It is not independent. |
|  | Samoa | It is a territory ceded to the United States. |
|  | Western Sahara | It is considered property of Morocco. |
|  | Falkland Islands | It is considered a British colony. |
|  | Greenland | It is considered Territory of Denmark. |
|  | Hong Kong | Administrative Region of China. Former British colony. |
|  | Palestine | It is not recognized as a state. |
|  | Puerto Rico | It is considered an American Territory. |

Table 1 Non-UN countries

4.1.2 Tactile and School Cartography Laboratory

LABTATE is part of the Department of Geography of the Federal University of Santa Catarina, being a reference in the production of tactile materials for teaching cartography, being sought by a large number of people who want to know more about these school resources for the classroom. The LABTATE portal, located at http://www.labtate.ufsc.br/cartografia_tatil.html, provides the collection of standardized maps available for download without the need for prior registration. Maps can be made according to the instructions contained in the site itself. There are also explanatory videos and articles produced by researchers from the Laboratory.

Despite the fulfillment of some specific requests for the preparation of cartographic materials,

the focus of the Laboratory is the development of projects and research in the area of Tactile Cartography, with the creation of materials within a cartographic pattern based on national and international research (Loch, 2009). Due to the positive results and the national relevance of LABTATE, it was decided to standardize the maps of the world atlas within the standard proposed by the Laboratory. The Atlas will also be available for free on the web. It is expected to increase the collection of tactile maps in the Country.

4.1.3 United Nations Population Fund

UNFPA is a UN agency responsible for all population issues on the planet. It is an international cooperation agency for development that promotes the right of every human being (woman, man, young person and child) to live a healthy life with equal opportunities for all.

The Agency supports countries in the use of socio-demographic data for the formulation of poverty reduction policies and programs. It also prepares an annual report and presents sociodemographic indicators updated for all countries, as well as formulate a detailed analysis on a significant theme for the global population and development agenda.

An important fact is that UNFPA helps countries that are not financially able to finance their own population census by funding and regulating control agencies. All reports are available for free at <http://unfpa.org.br/novo/index.php/situacao-da-populacao-mundial>. The annual report is always available in December of each year. So, the Atlas was formulated with 2017 population of each country of the UNFPA report 2017 which is the most recent.

4.1.4 Center for Disease Control

Considering that the boundaries of the countries are basic information of the Atlas, it was decided to use data from the CDC - Centers for Disease Control and Prevention, which is a body that aims to meet emerging needs around the world for disease control. The public domain Epi Info software created by CDC has in its database the shape files of all countries. At <http://www.cdc.gov/epiinfo/html/>

shapefiles.htm you can download the files in shapefiles format.

4.2 Computer Programs

The software used in the development of the research were: Matlab 2013Ra: used to program; Loquendo TTS 7: used for audio generation; ArcGIS 10.2.2: used to manipulate shapefiles files; CorelDRAW Graphics Suite 2017: used to standardize maps; SimBraille: used for writing in braille. The world atlas was made in eight steps which are summarized below:

1. The shapefiles of the 193 UN member countries were downloaded using the CDC database. Available on Epi Info website;

2. Download the indicators of the current population with the UNFPA database through its UN Annual Report 2017;

3. In ArcGIS the shapefiles were processed;

4. In CorelDraw the map was standardized according to the LABTATE standard;

5. SimBraille was used to assign country information on each Braille map within CorelDRAW itself;

6. Matlab was used to program the information narrator software;

7. The sound narrated by Matlab is of Loquendo Technology with the frequency voice of Fernanda in Brazilian Portuguese;

8. The created Software shows and narrates the standardized map according to the user's choice.

5 Results

The software was developed in Matlab 2015 language. It works through a free compiler, available for download from your Mathworks developer's website at <https://www.mathworks.com/products/compiler/mcr/>. The basic parameters for operation, composition and functionalities will be seen below.

5.1 Composition of the Software

- 193 digital maps with all UN member countries;
- Speech synthesis system with the voice of Fernanda, using Loquendo technology;
- Integrated sound and image feature and interacting simultaneously during execution;
- Speaker clock and internal calendar;
- Pollational data 2017 and neighbors between countries.

5.2 Functionalities

In order to adapt the software to the needs of visually impaired students, it has no graphical interface, and its operation is done through an executable file. This decision not to create interface was taken to generate limitations for the visually impaired, because the student can not identify buttons and locations within the interface using mouse. With the executable file the limitation is remedied because the interaction is totally done via keyboard.

Windows since its XP version in 2003, features an intuitive narrator developed exclusively for accessibility for the visually impaired. This in turn is responsible for narrating all the icons and warning screens that appear on the screen during their use. Therefore, for a visually impaired user to use the software developed by the research, independently, it should be with the computer narrator activated, including to find its icon in the work area.

The narrator is available in English (United States, United Kingdom and India), French, Italian, German, Japanese, Korean, Mandarin (Simplified Chinese and Traditional Chinese), Cantonese (Traditional Chinese), Spanish (Spain and Mexico), Polish, Russian and Portuguese (Brazil).

The use of the narrator is very important in computers that are operated by the visually impaired. Virtually 100% of the visually impaired who are diagnosed with severe blindness and who are computer users, use the Windows Narrator. In

less common cases, they use external and lesser known software.

Computers running the Windows operating system, as of the XP version, and with speakers enabled, will be able to run the software with full functionality without loss of content. The software presentation screen can be seen in Figure 4, Figure 5 shows the functionalities.

6 Test

The test was performed at the Institute of the Blind in Recife. Established on March 12, 1909, by Antônio Pessoa de Queiroz, being the second institute for the blind of Brazil and the first in the Northeast region. Its users come from RMR - Metropolitan Region of Recife and several municipalities in the

state of Pernambuco. The Institute initially operated in Rua da Glória, in the neighborhood of Recife, until 1927. On July 14, 1935, the Institute migrated to the Graças neighborhood, due to the huge demand for services. From 1935, the Santa Casa de Misericórdia of Recife assumed the maintenance and administration of the Institute, which has been occurring until the present day. To carry out this administration in the daily activities of teaching, Santa Casa counts on the support, since 1990, of the religious congregation Daughters of Santana.

The Institute serves the visually impaired, with zero visual acuity or low vision, starting the entry into regular school as well as in adulthood (whether or not in educational activity), the age group is 06-80 years old. Of the total number of disabled people, the large percentage of unemployed male users surviving from BPC - Benefit from Continuing Care.

Figure 4
Software
Execution

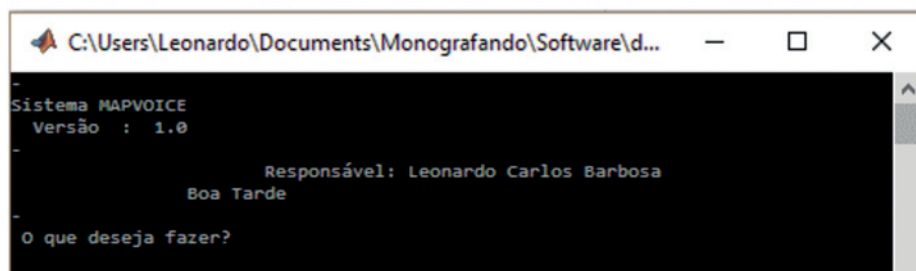
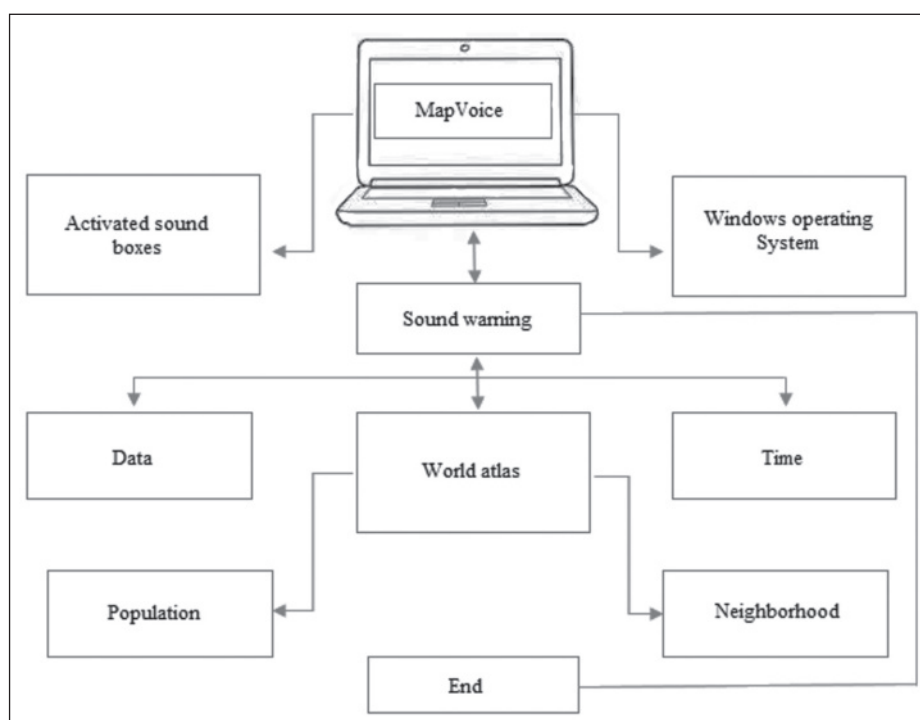


Figure 5
Functionalities



The Institution offers services linked to the Special Social Protection of Medium Complexity, as recommended by the National Social Assistance Policy, that is, services that require individual monitoring and greater flexibility in the protection solutions. It is from this perspective that the Institute of the Blind has as its mission to provide autonomy for the visually impaired through professionalization, habilitation, rehabilitation and psychosocial support.

To perform the test was used a notebook with Windows 7 operating system and connected speaker system. During the test was using the keyboard of the notebook to enter the commands. The students of the Institute already have familiarity with keyboards, as the SENAC - National Service Commercial Learning offers a free computer course.

The methodology followed with the students of the Institute is the same one described in Silva e Silva, (2013) for tactile experiments. The first step refers to the contact of each participant directly with the tactile map. Once the methodology and purpose of the research have been explained, the test is repeated with up to three participants with visual impairment, be it severe or moderate. The product to be shown is the responsibility of the applicator.

The three students who participated in the test were E.L¹, aged 25; S.F¹, 23 years old; and M.A¹, 28 years old. The three participants of the test have a degree of severe deficiency, with only E.L. having light perception. S.F. severe deficiency in the left eye and severe deficiency in the right eye. While M.A. does not possess the perception of light.

In Figure 6, some photographs of the test moment are shown. The Institute of the Blind is always willing to assist academics in conducting research, but it does not allow the image movement of its students. In this way, the photographs are discrete, preserving the identity of each participant.

Throughout the test, questions were asked about the evaluation of the printed tactile map and software as a learning resource. The feedback provi-

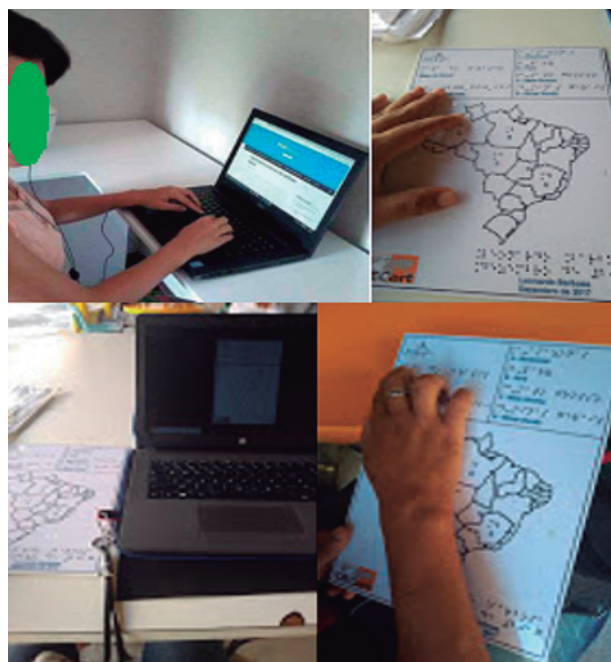


Figure 6 Application of the test

ded by the participants was quite positive, who liked the proposal that the software provides the user.

At the suggestion of the participants, it was necessary to make adjustments in the software to better fit the limitations of the users. For example, instead of typing the full name of the country to be narrated via the keyboard, it would be better to enter only a single number for each country, so a template was prepared in alphabetical order.

The list in alphabetical order was created in Braille and was integrated in the tactile methodology together with the Atlas. The new version of the software already has the call of the countries by unique numbering.

7 Conclusion

The research allowed to observe that the insertion of technology in the educational environment is increasingly necessary and should support the teaching-learning process of students and teachers. Several digital media are capable of bringing about changes in the paradigms of education. By coupling these tools and technology, based on pedagogical

¹ We were not allowed to publish names and images of the students involved.

principles, it creates a dynamic and interactive environment in which the student ceases to be a mere spectator and becomes active character in the process of building knowledge in cartography.

The World Atlas seeks to arouse the interest of students, based on a pedagogical proposal, which is based on motivation, knowledge and fun. From this perspective, it is believed that the use of digital resources in a satisfactory way, where teachers and students converge towards the same purpose, tends to make cartographic education increasingly accessible and dynamic.

The software evaluation done during the test with visually impaired was quite satisfactory. Focusing on the main objective, we observed only one difficulty that was presented previously, and which was considered easy to heal. Being this, already corrected and implemented in the software. Finally, the full Atlas can be downloaded at https://drive.google.com/drive/u/1/folders/1IfURD-K-snBcLKMms_HeYPJvfrEo-iJC and printed on paper or off-set paper. Or any other handmade method that may be used for its reproduction.

It is recommended for future work the insertion of new lines of knowledge using the same methodology, as for example: to apply the methodology in the teaching of biology, arts, mathematics etc. We know that the Law of Guidelines and Bases of Basic Education not only adopts parameters for Geography but also for all disciplines of basic education, in this way, it becomes feasible to insert the resource developed here in other branches of learning.

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