Model Interpretation of Topological Spatial Analysis for the Visually Impaired (Blind) Implemented in Google Maps

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ABSTRACT

The technological innovations promote the availability of geographic information on the Internet through Web GIS such as Google Earth and Google Maps. These systems contribute to the teaching and diffusion of geographical knowledge that instigates the recognition of the space we live in, leading to the creation of a spatial identity. In these products available on the Web, the interpretation and analysis of spatial information gives priority to one of the human senses: vision. Due to the fact that this representation of information is transmitted visually (image and vectors), a portion of the population is excluded from part of this knowledge because categories of analysis of geographic data such as borders, territory, and space can only be understood by people who can see. This paper deals with the development of a model of interpretation of topological spatial analysis based on the synthesis of voice and sounds that can be used by the visually impaired (blind).The implementation of a prototype in Google Maps and the usability tests performed are also examined. For the development work it was necessary to define the model of topological spatial analysis, focusing on computational implementation, which allows users to interpret the spatial relationships of regions (countries, states and municipalities), recognizing its limits, neighborhoods and extension beyond their own spatial relationships . With this goal in mind, several interface and usability guidelines were drawn up to be used by the visually impaired (blind). We conducted a detailed study of the Google Maps API (Application Programming Interface), which was the environment selected for prototype development, and studied the information available for the users of that system. The prototype was developed based on the synthesis of voice and sounds that implement the proposed model in C # language and in .NET environment. To measure the efficiency and effectiveness of the prototype, usability tests were conducted with the visually impaired (blind). The qualitative and quantitative analysis of samples demonstrated the feasibility of the model and its computational implementation. The prototype is being used at a special school for the visually impaired (blind) and has helped and benefited approximately 500 people.

Keywords: Spatial Analysis, Web GIS, Sound and Speech Synthesis, Human-Machine Interface, Visually impaired (blind).

1. INTRODUCTION

Belonging to one of the strands of Geotechnology, the GIS constitutes a major instrument, linked to GIS software (Geographic Information System), allows different readings of reality. Within these techniques, we can mention the use of technologies of Photogrammetry and Remote Sensing, GPS and Total Station (Electronic Theodolite) as well as the processing and analysis of data collected in the form of digital maps (raster or vector / raster). Thus, Geographic Information Systems (GIS) it is a fundamental resource in making decisions on the area of study, because it seeks the best means of intervention by taking into account all its complexity, allowing different interpretations that are so agile. Geography, characterized by a holistic approach, uses transdisciplinary studies to analyze its main object of research: the space, composed of different elements that interact and transform, in a complex, dynamic and systemic mode. Facing this definition, the geographical teaching and research use various mechanisms for understanding, representation and spatial analysis. In this context, Cartography and Geoinformation sciences, in general, work together widely with geography in the use of techniques for capturing, assembling cartographic maps, preparation and spatial analysis in addition representation of information. Since the gain of knowledge occurs through the generation of information, its dissemination is essential, using the internet can be an excellent information tool. Thus, the geographical information found on the Internet, in general, can be alphanumeric or data derived from maps in raster or vector format (pictures). The maps are designed as a tool for exploration and communication of geospatial data, fitting as processes of cartographic visualization and geovisualization [1]. Regarding the term geovisualization, it is observed that this is "an integration of scientific visualization, exploratory cartography, image analysis, information visualization, exploratory data analysis and GIS to produce theories, methods and tools for visual exploration, analysis , synthesis and presentation of geospatial data" [2]. In this context of (r) the evolution of technology and cartographic representation, there are growing demands for exploring the possibilities that are impossible to perform in traditional cartography, by ink. Within these possibilities, there is "the animation, interaction, scalability and generalization, using new technologies of open source code available for the Web, applying to process of information dissemination" [1]. So it is the correct understanding that democratizes and disseminates information that allows different users of different needs and interests (such as the blind) to have access to information in different ways and degrees, especially through the internet.

There are applications based on free software searching space with information technologies, the same occurs in Geotechnology, as is the case with OpenGIS. The area of Geotechnology, for several years, has been dominated by solutions of high cost and proprietary formats. Two recent movements have changed this situation by opening up a new range of options, especially for Geographic Information Systems (GIS). These movements are: the creation of the international Open Geospatial Consortium (OGC4) and the revolution of free software (Free Software Foundation) [3]. The specifications established by OGC define standards that target the interoperability environments related to Geotechnologies. Different proprietary systems and free systems can interact transparently if they conform to the specifications of the OGC. Many free systems already follow these specifications and some proprietary systems are already in the process of adaptation to become OGC standard [3]. The free software revolution has done numerous projects born from the collaborative spirit of a growing global community. Based on this context, one can exploit the potential of Geotechnology Internet with the use of free technologies, such as those available on Google Earth and Google Maps to multisensory Cartography teaching for the blind.

2. TRADITIONAL REPRESENTATION: THE MAP AND WEB GIS

It is possible to consider the map as a graphic representation of reality made through the use of lines, polygons, points and colors, of which the complexity varies according to the objective and the type of the intended user. Accordingly, it is shown that the process of producing a map starts with an abstraction of reality for the graphic reproduction, followed by the process of reading and understanding by the user [4]. Certainly, the concepts vary between authors. However, some fundamental characteristics in understanding any kind of map are required in systems such as Web GIS: abstract representation of reality, distortion, scale, generalization and omission, symbology, coordinate system and orientation. About the first item, it is emphasized again that the maps are visible graphical representations, which seek to represent spatial reality. However, in reality this can hardly be contemplated in all its complexity and dynamism of relationships, thus resulting in a more simplified representation of space. In the passage from the real to the abstract and between the three-dimensional to the two-dimensional world, distortions occur, whether in the form of objects or locations they are not very accurate, especially when they represent large areas where the curvature of the earth influences these distortions. At this point, it should be noted that, in the GIS Web environment, there is no need to select the scale of representation, it can be replaced by "zoom" that corresponds to observer level. Thus, it is possible to dynamically define the zoom with that which "reduces reality" to the screen and uses pre-defined parameters that determine the degree of detail, information or even which elements will be presented, generalizing the others from reality. Thus, the, higher the zoom, the larger the degree of detail and the greater the number of entities that can be represented. If, depending on the zoom to represent some real-world objects, you select the type of information that appears on the map and omit others. This is necessary because the representation of multiple elements of reality can leave the complex mapmaking difficult to read and therefore infeasible for use. In general, omitting and distorting reality comes to be necessary as it is done consciously. One can´t forget to use a guidance system (usually a compass rose with the four cardinal points or stylization), as well as a coordinate system (eg WGS84), facilitating the location of the area represented and allowing displacement interpretation of the environment, depending on the type of map.

3. COGNITIVE MAPS

Researchers have investigated how the act of learning and acquiring geographic knowledge is, how that knowledge is structured in the mind, with which form (images or propositions, for example) it presents itself and how it is accessed and used to guide behavior. The popular interpretation indicates that the cognitive map is the result of information processing, that organizes the places and positions, and also determines what is responsible for evidencing spatial relationships that link this information [5]. To Golledge, the term 'cognitive map' refers to a hypothetical construction of the internal representation of the external world, as an interconnected system of geometric structure, a result of information processing on a treatment level of spatial information, that organizes the places, positions and spatial relations that unite this information, incorporating a series of transformation rules [5, 6]. This mental representation, and not logic, represents the geometric aspects of the environment, being topological, metric, among others [7]. On the face of this, it is accepted that people can think and reason constructing images or spatial products, some of which can actually be like a map, although the term 'map' can be just a convenience to refer to the process of understanding the social and spatial information. In the strict sense, it is a mental representation, which has the same properties and mechanisms of representing a physical map, since it can execute, effectively, spatial behavior, based on these maps [8]. Moreover, these can be constructed by images, extensive verbal descriptions of environmental scenarios, and also through a structure organized and synthesized by spatial information, as proposed in this work, considering the patterns of ignorance, information and learning treated by Gould and White in their consideration of Mental Maps [9], besides having in view the models presented by Golledge [8, 10, 11].

4. METHODOLOGY

The question of distortion and generalization of cartographic maps are part of the visual cartographic. However, regarding the cartographic for the blind, it becomes much more necessary in reading the maps for the visually impaired. Therefore, specific techniques for construction and representation of tactile maps for the blind should be considered in digital representation. Assuming, also, that generally the tactile maps have only one type of information. For example, with the representation of Brazilian relief, a map is created with the boundaries of a defined category of relief, with another map having the other category and so on. Already in the digital cartography, different kinds of information can be associated within the same map. Thus, the user must define the layers of information they want to decode through kinesthetic movement and performing mentally the information overlay.

As for digital maps to be used in web GIS, these must be the same on the graphical environment, without any distinction. Therefore, the best way to analyze and represent likewise should provide the best form of interpretation and representation of information [13]. So it is necessary to teach Cartography for the visually impaired and accompany them throughout their learning process, for the reading and use of the map to be given in an optimized manner.

5. SPATIAL RELATIONS

The map can be considered an abstraction of reality, whose graphic reproduction consists of spatial objects defined in a relationship of points, lines, polygons and surfaces. In this scenario, a spatial relationship determines how an object is located in a space relative to another object. For this reason, the investigation of spatial relations requires understanding of the fundamental geometric properties of the geographic objects for determination of the mathematical part, beyond cognitive, psychological and linguistic aspects.

Despite progress in the formalization of these spatial relationships, there is no consensus on a minimum set of relationships to be applied.

Thus, for the development of spatial understanding through Cartography, the category of topological spatial relations should be considered for the concept of the world.
Undoubtedly, these topological relationships are important for the representation of the information because they provide semantics and some geometric consistency to the analyses performed on the geographic objects. It is noted that the experiences of space are involved with sensations, perception, and conception, together with the rational and emotional senses of man. According to these experiments, it creates a kind of identity, transforming the space in place and relating to it in a topological way [12]. The topological Spatial analysis refers to relations of perception of nearby space, in relation to the neighborhood, and, basically, how it is built. To allow interpretation of topological relations by the blind is considered to be using kinesthetics to cause the perception of relations. The kinesthesia contributes to the movement sensitivity, be it the simple stretching of the arms and legs or physical displacement in space. Regarding space, it emphasizes that it "is experienced when there is a place to move. Moreover, shifting from one place to another, one gets a sense of direction" [12]. In more specific terms, the tact allows the touching of objects, manipulating them in order to understand its shape, texture and size. Thus, with the tact, firstly performing the reading of the parties and afterwards designing the whole thing. The eye, however, provides a view of the whole, synthesis of the space, then it is possible to analyse the parties; it provides people with a space in which to live.

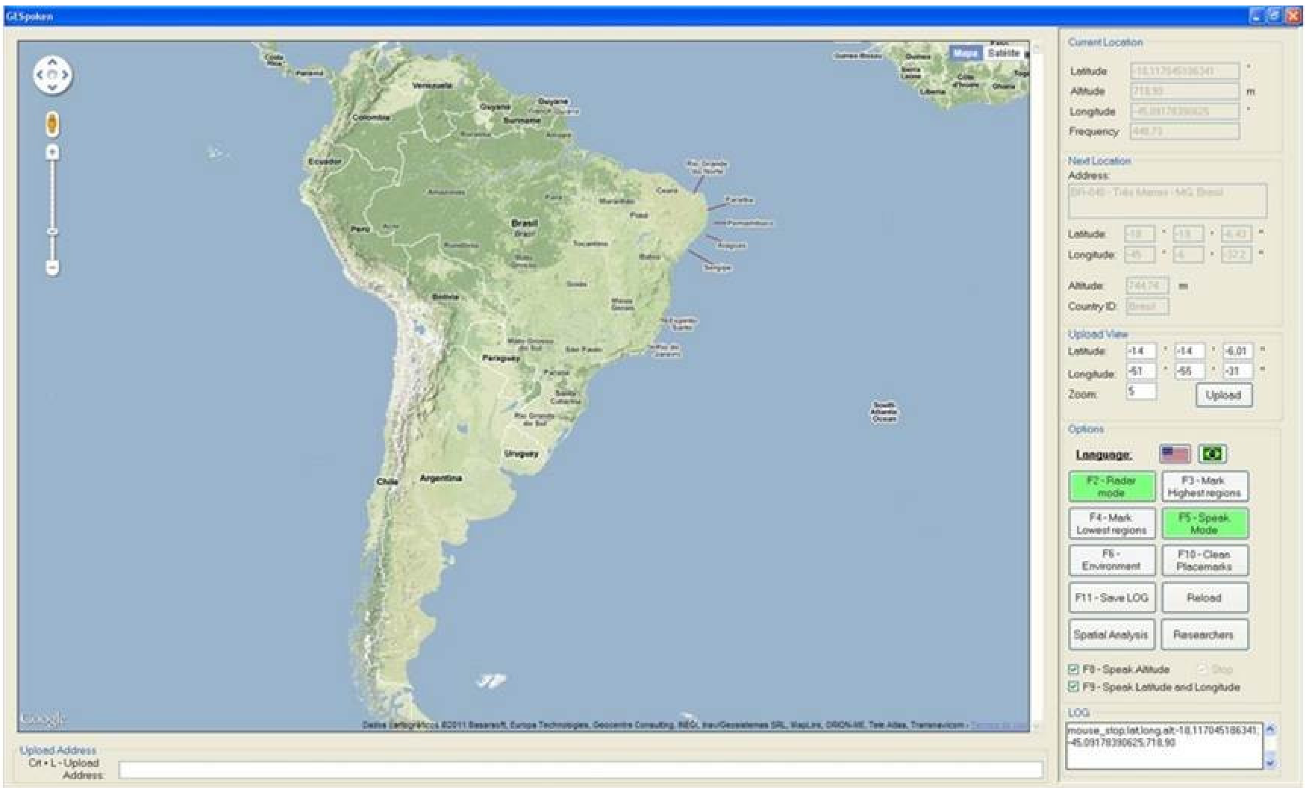

Figure 1. Opening screenshot of the GESpoken.

Source: Prepared by author

6. PROTOTYPE

A new version (3.0) of computational prototype GESpoken, was developed using the programming language C#, at framework .NET, with Google Maps API, shown in Figure 1. The prototype [14] was increased with the called function “Speak Mode” in order to treat the topological relationships of spatial analysis. In this way, clicking on a point on the map, the data group "Near Location" are updated and the coordinates and altitude information are synthesized by a TTS (Text-To-Speech) engine. Thus, the data group of near location, coordinates, altitude and information identified on the map are represented by a point, line or area and are updated automatically due to mouse movement and then dynamically synthesized. An analysis of different classes of information and identification of objects and their attributes is performed on all of them and any modification is presented to the user, hierarchically, also considering the value and size, as well as eliminating redundancies and repetition of the previous state. T Furthermore, this process allows the identification of areas, boundaries and, through movement in the workspace, kinesthesia, recognition and interpretation of the coverage area.

Figure 2 shows the scheme of operation. Through movement and pausing the mouse, the structure of the database is identified. The variables of the data are verbalized. For example, the mouse stops in Paraguay, and then information about the country, state and city is verbalized. By moving the mouse to Brazil, the new information from the country, state and city is verbalized. When moving within Brazil, surpassing a state border, the information from the state and city is verbalized. When moving within the same state, only the information of the city, if you have exceeded the limit, will be verbalized. When passing the border of Argentina, country information, state and city will be verbalized.

While in the talk mode, it should be noted that the hierarchy of the data structure is analyzed and treated so that only the information that is a variant is verbalized. For example, when moving the mouse from one country to another, the information of the country, state and county will be synthesized; when moving within the same country and state,
only the information of the name of the municipality of the new position will be synthesized, and when moving across the border states, the new state and the new city will be verbalized. Thus, the user can explore the entire current map and be informed of the structures and can thus build a mental model of the region in question. One must note that when you click a point on the map, the data group "Next Town" is updated and information of altitude and coordinates are synthesized by the TTS engine (Text-To-Speech). Data Locality Next, coordinates, and altitude information identified on the map with the representation point, line or area which are automatically updated with each pass of the mouse on the object or boundary, and then synthesized. Dynamically, an analysis of different classes of information and identification of objects and their attributes is performed and any modifications are presented to the user in a hierarchical fashion, also considering value and size, and then redundancies and repetition s of the previous state are eliminated. In addition, this process allows movement in the workspace, identification, interpretation and recognition of the areas and borders.

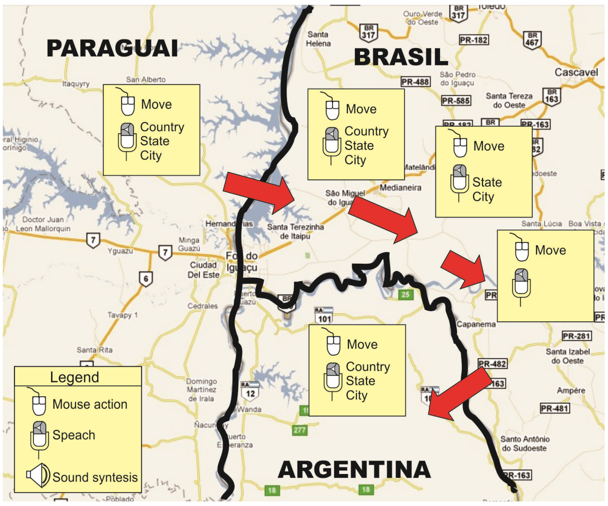

Figure 2. Scheme of operation: Mode Talking
Source: Prepared by author

It is necessary to emphasize that an important consideration was the recognition of the limits of the desktop for the user, when the graphic area was divided into 16 regions, and every two outside edges, were associated with one of the cardinal points or collateral. In this circumstance, when the mouse leaves or enters the bounds of the desktop, the prototype of Google Maps summarizes the sound of asterisk of Windows plus of information of the cardinal point or collateral. The user acknowledges the limits of space of the desktop and its geographical orientation.

Importantly, the loading of a standard view and the search of location to provide testing for systematic evaluation and validation of the model implemented in the prototype.

7. EXPERIMENT

Assuming that the visually impaired, totally blind or those with limited vision - can make the interpretation of maps from the sound information of topological relations, synthesized voice associated with synesthesia, by moving the mouse to spatial location.

In this context, the experiment is to identify if the method of interpretation and representation of geographic information used in the prototype allows users to develop a mental model of geographic space, obtaining an efficient and effective interpretation of the map.

The experiment was conducted with a group of blind people, including blind from birth of Institute of San Rafael, a state school specializing in attending to the blind. The experiment consisted of loading a view from a country known to the user (in this case, Brazil). The user was encouraged to explore the graphic area, getting the information and representations of the data processed in accordance with the current zoom level. At this time, due to the current zoom, the user will receive, at least, the country and state information and, if available, city and municipality. For the kinesthetic experience, promoted by moving the mouse, the topological relations between geoobjetos, boundaries, extent and borders can be identified by the user.

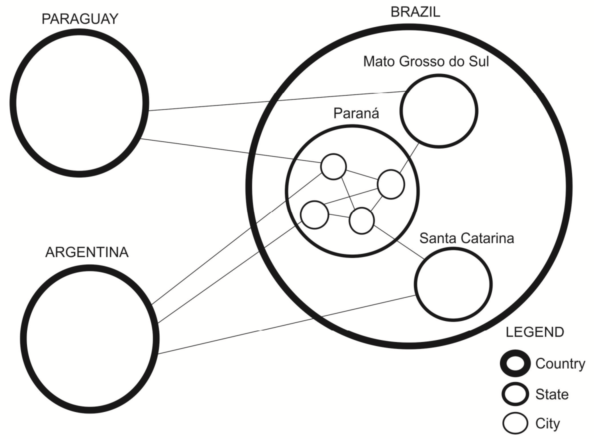

Figure 3. The topological schema. Source: Prepared by author.

After freely exploring the graphical area, the user is asked about the spatial positioning of entities visited and their neighborhood relations. These relationships are perceived and noted by the interviewer who compares with relations contained in the map and consider the spaces visited by the user. When they have performed this step, a new country is selected and the user is encouraged to explore the region, therefore, they are also motivated to talk about the topological relationships identified in that experiment. Figure 3 represents a model of the topological relationships that are identified from the experiment conducted with the view of Figure 2.

8. CONCLUSION

The study presents a new method of interpreting spatial information implemented on Google Maps for the visually impaired. The proposed model was implemented in C# language, in the framework .NET using the Google Maps API. By using Google Maps, the prototype allows the user to have access to interactive maps of the world, leading to this type of user having a new dimension of experience with geographic information. Speak Mode, developed in the prototype allows the user to create mental models from spatial topological relationships observed in Google Maps. The implemented model of topological spatial relations proved effective in experiments with blind. The experiment revealed that the mental models generated by users is similar in most cases, models actual analysis. This study demonstrates the feasibility of using geotechnology teaching and the treatment of geographic information for the blind. It presents practical and efficient results for inclusion measures for the visually impaired.

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