Using Crowdsourcing to Improve Accessibility of Geographic Maps on Mobile Devices

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Abstract— **The continuous growth of the use of technology and mobile applications means that more people have access to information published on the web, including geographic information. However, for visually impaired people interaction is difficult if maps are not accessible. For this reason, in this paper we analyze accessibility barriers of webpages with geographic content presented on mobile devices. With the purpose of showing an alternative to improve accessibility in these pages, this study proposes the use of a technique called crowdsourcing, i.e., a group of people that voluntarily access to webpages and provide information about physical accessibility and a general description in each map element (point, line or polygon). This description is written into the Scalable Vector Graphics Tiny (SVG Tiny) code. SVG Tiny is used to represent geographic maps with HTML. In this way, screen readers can interpret the descriptions to visually impaired people, thus making maps more accessible.**

Keywords- Web accessibility, map, crowdsourcing, geographic information, SVG Tiny, mobile devices.

I. INTRODUCTION

The geographic maps are very important in everyday life. They are present in several media such as television, magazines, Internet, and newspapers. The advancement of technology, the increasing number of mobile phone users, and the rapid growth of geographic information systems (GIS), has caused mobile devices to become an essential tool for accessing geo-services for social, professional or personal purposes.

We are witnessing a new era of geographic tools online such as Google Maps, Google Earth, NASA World Wind, OpenStreetMap, MapQuest and Microsoft MapPoint. These tools have a large number of users. For example, in the five largest European economies, 50% of users access online maps from their personal computers, and 35% of users access from their mobile phones on a daily basis [1].

However, not all people can access geographic information on the Web with their mobile devices. Due to the graphical nature of geographic information, some groups of users, such as visually impaired people may experience problems when accessing geographic information.

This study presents an alternative solution to improve accessibility of geographic maps. It uses the crowdsourcing technique and the specification Scalable Vector Graphics Tiny (SVG Tiny) for the implementation of geographic accessible maps.

The next sections are structured as follows. In Section 2, this work reviews the state of the art. In Section 3, it presents definitions of crowdsourcing, SVG Tiny, and web accessibility that guide the readers to understand the use of these concepts in the research. In Section 4, this study shows the accessibility barriers in geographic content. In Section 5, it shows a proposal to implement accessible geographic maps using crowdsourcing and SVG Tiny. Finally, in Section 6, it shows the conclusions of our research.

II. STATE OF ART

Finding a satisfactory alternative that allows visual impaired people to browse geographic information is a very active research field. There are several practical solutions for mobile devices developed by different authors: although some of them are already implemented, most of them are still prototypes. In the following paragraphs, these relevant works are described.

A. Mobile GIS based on SVG

Mobile GIS applications are becoming very popular from the last few years. However, the mobile devices used to execute these applications have serious constrains in three areas: screen size, memory and speed. Wu and Bin [2] present a mobile GIS application based on Mobile SVG (Scalable Vector Graphics) for hand held devices with limited resources.

Their case of study is a mobile application for tourism. This application uses mobile SVG as data carrier, display and parser of maps. It introduces constraints on content, such as attribute types, properties, and user agent behavior, due to low memory, low power and limited display. Wu and Bin [2] describes the application data format, presents the map, and points out the areas for future development.

These authors conclude that Mobile GIS can help people with disabilities to move around cities and other places, both outdoors and indoors. For example, blind people can use a mobile GIS to find the directions to arrive at a chosen place. Or a person with a motor impairment (e.g., a person in a wheelchair) can use a mobile GIS to find an accessible route in an airport or a railway station.

B. Generic Multi-touch Presentation of Accessible Graphics

Goncu and Marriott [3] present the design and evaluation of a new tool for accessing graphics. Graphics Viewer using Vibration, Interactive Touch, Audio and Speech (GraVVITAS) provides a generic approach for presenting 2-D content. It supports dynamic, interactive use of graphics and could be integrated with existing applications.

GraVVITAS is a multi-modal presentation device. Its core is a touch sensitive tablet PC that tracks the position of the reader's fingers, allowing natural navigation. Haptic feedback is provided by small vibrating motors of the kind used in mobile phones, attached to the fingers and controlled by the tablet PC. This allows the user to determine the position and geometric properties of graphic elements. The tool also provides audio feedback to help the user with navigation and to allow the user to query a graphic element in order to obtain non-geometric information about the element [3].

C. Touching OpenStreetMap data in Mobile for Low Vision Users

Kaklanis et al. [4] present an application that enables access to OpenStreetMap data for blind and low vision users using mobile devices. During the exploration, the user moves his finger on the touchscreen of the mobile device and receives feedback vibration when finger is on a road or a point of interest. Sonification and a text-to-speech module provide audio feedback about distance to the next crossroad and information of the road or point of interest [4].

D. Crowdsourcing techniques for augmenting traditional accessibility maps

Rice et al. [5] present a contemporary approach to collect and capture geospatial data using crowdsourcing. It reports, locates, and defines transitory obstacles in a built environment. These obstacles represent a significant hazard for visually impaired people when navigating through known and unknown spaces. Efforts like this that allow to quickly report, geolocate, and define transitory obstacles would present a major advance in cartographic support for visually impaired people. The contemporary techniques described in this paper include: gazetteer-based geoparsing, active harvesting of navigational points of interest, and ambient geographic information (AGI) present in social media. These techniques contribute to the characterization of transitory obstacles and facilitate their display in a crowdsourced accessibility system [5].

The papers presented in this section focus on hardware devices and touch and haptic vibration responses. Although it is true that these studies help to improve accessibility of geographic information, many people cannot access these devices.

Our study is a proposal to develop a technique at the software level (code) to describe details of the geographical maps that can be interpreted by screen readers.

III. DEFINITIONS

The following definitions are used in this work:

A. Crowdsourcing

Crowdsourcing is a phenomena of 21st century in GIS to generate online information from individual action voluntarily, i.e., a group of people that voluntarily access different webpages and save various kinds of information such as points of interest, addresses, ideas or content.

Crowdsourcing implies collecting large amounts of information and add it on the web through an interface. With this technique, geographic maps with a lot of descriptions of the places within can be obtained.

The mapping through crowdsourcing is usually done by means of a process called Volunteered Geographic Information (VGI) [6]. For this, there are several kinds of software and/or websites that gather information through an algorithm developed specifically for maps. OurMap [7] and WikiCrimes [8] are examples of proposals for data collection using volunteer users to report problems related to cities, crimes and transportation. The information can be loaded manually and/or automatically. For example, OpenStreetMap add new data manually.

Digital Globe Company sponsors the Tomnod mission that utilizes crowdsourcing to identify objects and places in satellite images. They created a web application where thousands of volunteers use satellite images to explore the Earth, solve real-world problems, and view images of the planet. When the Malaysia Airlines MH370 plane disappeared in the ocean, the Tomnod mission developed an application to gather recently collected imagery for any sign of Flight 370 that may have been recorded by a data collection sensor to help identify features, i.e., debris, raft, oil slick, and tag objects that could be useful to find the plane [9].

Mobile GIS Solutions for Crowdsourced Data and Real-time Database Editing is a mobile alert solution. It helps government agencies, utilities and transportation authorities by providing them with a reliable, cost-effective source of actionable information by allowing citizens in their communities to report incidents such as graffiti, illegal trash dumping, potholes, water leaks, broken street lights or signs [10].

B. Scalable Vector Graphic Tiny

Scalable Vector Graphic (SVG) has become popular for the development of webpages that contain images. SVG is an open standard defined by the World Wide Web Consortium (W3C) for the representation of vector maps on the web. SVG contains SVG Tiny, which is a profile specially adapted for mobile devices. Although it has many applications, SVG Tiny can be of great help for the design of vector maps presented in navigation systems and geographic information systems (GIS) for mobile devices. Some of the advantages of this format are:

- It is an open standard.
- It is very light because it is based on XML.

- It attaches metadata such as street names, geospatial information, geographic coordinates, RDF, and so on.
- It is scalable, so that it can zoom without deteriorating the quality of map.
- It is easily editable, since it based on XML.
- It can attach animations. This is useful for GPS navigation applications [11].

C. *Web Accessibility*

Web accessibility means that people with disabilities should be able to make full use of the web. Web accessibility is not interested in the specific conditions of people but on the impact these conditions have on their ability to use the web regardless of the technology used, such as personal computer, tablet, and mobile phone [12].

According to a report published by the United Nations in 2011 [13], more than 1000 million people suffer some form of disability. In this work, we focus on visually impaired. According to estimates by the World Health Organization (WHO), about 285 million people suffer from some form of visual impairment and 39 million people are blind, representing 0.7% of the world population [14].

IV. ACCESSIBILITY BARRIERS IN GEOGRAPHIC CONTENT

In this section we describe several accessibility barriers that mobile users face when accessing webpages with geographic content:

- Low contrast in content.
- Pages saturated of complex information and sometimes unintuitive.
- Contents not intended for use in mobile.
- Movement in the maps: distraction and concentration problems.
- Text represented as image: it means that the text that has an image is in image format.
- Problems with color: color blind people cannot distinguish certain shades of color.
- Mosaic maps: map consists of different images placed in an order so that they form a single image.
- Geographical maps without text.

To achieve web accessibility, we need to be aware of the fact that not all users access the web with the same devices and also not all users are capable of correctly perceiving some kinds of content published on the web. This general idea can be summarized in two basic design principles for web accessibility:

1. Create pages that offer content in different alternative formats.
2. Offer content in an understandable presentation to facilitate navigation through the website.

This study focuses on the second principle and proposes a mechanism to describe elements on geographic maps.

V. PROPOSAL TO IMPLEMENT ACCESSIBLE GEOGRAPHIC MAPS USING CROWDSOURCING AND SVG TINY CODE

At present, there are tools that help visually impaired people to manipulate mobile devices, such as screen readers, screen magnifiers and braille keyboards. These are assistive technologies that certainly help solve accessibility problems to access textual information, but do not help with geographic information such as maps, i.e., screen readers cannot read the maps in detail due to its complex design unless the code contains the appropriate tags.

Also, the crowdsourcing technique can help to input information about physical accessibility characteristics. For example: existence of ramps, elevators with braille signs, escalators, parking for disabled people, etc.

With SVG Tiny code, webpages with geographic information can be implemented and accessed regardless of the user's capabilities. SVG Tiny code includes elements which provide supplementary descriptive information about parent elements. Some specific examples are the <title> and <desc> elements, which can be a child of any graphic or container element in SVG Tiny code, and which contain textual descriptions of the parent element. The <title> tag is meant for a short text description of an element. If the text description is complex, the <desc> tag should be used because it is intended to provide arbitrarily long descriptions (nothing in the SVG Tiny code specification limits the length of these elements). These tags can be read via screen readers. The <desc> and <title> elements are not rendered as part of the SVG Tiny graphics. However, the <title> element can be displayed as a tooltip when the pointing device moves over particular elements. The container element <g> can be used to organize the content of the map at different levels (layers) that can be offered to the user on demand.

The SVG Tiny code can be interpreted by the screen reader for visually impaired users that need to access geographic maps.

The crowdsourcing technique can be used for adding information, i.e., the proposed application can allow volunteers anywhere in the world to access online the map and add physical accessibility information and general description for each of the elements of the map. This information is stored in the SVG Tiny code.

For example, the geographic map shown in Figure 1 is a schematic representation of a university campus with buildings, parking lots, streets and green spaces. The buildings are represented by lowercase letters; the parking spaces with uppercase letters and the green areas with numbers. The goal is to use the crowdsourcing technique to add physical accessibility information and general description to the map. Focusing on the Parking A, when the user positions the cursor on the map, it shows a pop-up window to enter the title and description associated to a specific element.

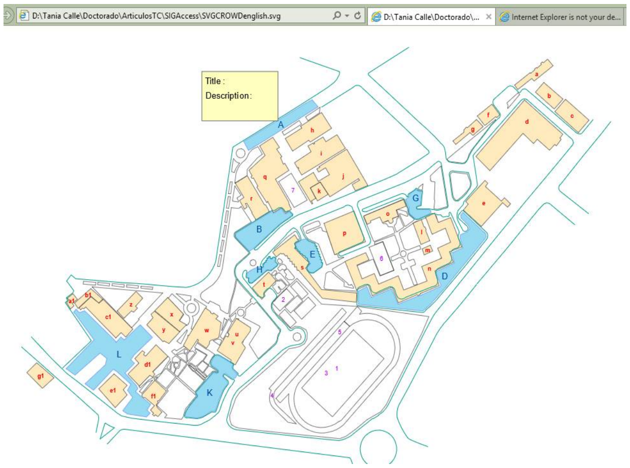

Figure 1. Map without physical accessibility information.

Figure 2 shows an extract of the SVG Tiny code of the geographic map corresponding to Parking A. In this code, there are not elements as description or title.

```
<?xml version="1.0" encoding="utf-8"
standalone="no"?>
<svg xmlns="http://www.w3.org/2000/svg"
version="1.2" baseProfile="tiny">
<g id="Layers">
<path clip-path="url(#SVG_CP_1)" fill="#97DBF2"
fill-rule="evenodd" stroke="none"
d="M856.53969,257.75181L871.41934,274.55127L721.90289,365.74838L697.18347,379.90793L685.66375,358.5486L837.82014,267.3515L856.53969,257.75181z"/>
        <path clip-path="url(#SVG_CP_1)" fill="none"
        stroke="#000000" stroke-width="0.47999" stroke-
        miterlimit="10" stroke-linecap="round" stroke-
        linejoin="round" d="
        M306.47273,710.13743L483.10855,725.01696L422.38999,787.65497L424.06995,789.33491L405.35039,809.01429L306.47273,710.13743
</g> </g>
```

Figure 2. SVG Tiny code without physical accessibility information

Once volunteer users add a title and a description, as shown in Figure 3, it is automatically entered in the SVG Tiny code of the geographic map.

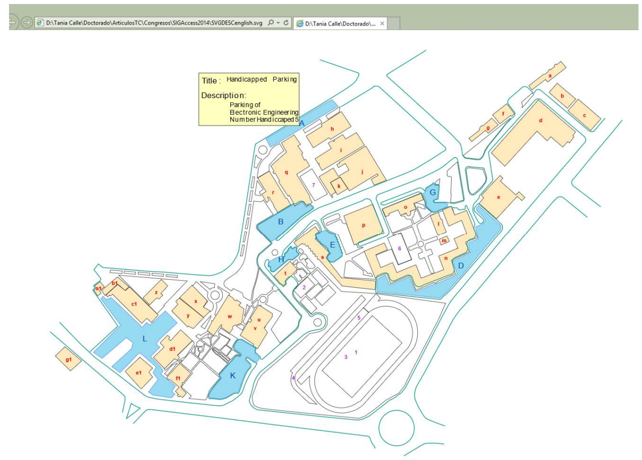

Figure 3. Map with physical accessibility information

In Figure 4, from the code perspective, the tags <title> and <desc> have the following information: "University Campus" and “Parking of Electronic Engineering”. Within this element, another container that describes the <g id = "Handicapped Parking"> containing <title> "Handicapped Parking ", and description <desc> "Parking of Electronic Engineering. Number of handicapped parking 5".

```
<?xml version="1.0" encoding="utf-8"
standalone="no"?>
<svg xmlns="http://www.w3.org/2000/svg"
version="1.2" baseProfile="tiny">
<g id="Layers">
<g id="Parking A">
<title> University Campus</title>
<desc> Parking of Electronic Engineering </desc>
<path clip-path="url(#SVG_CP_1)" fill="#97DBF2"
fill-rule="evenodd" stroke="none"
d="M856.53969,257.75181L871.41934,274.55127L721.90289,365.74838L697.18347,379.90793L685.66375,358.5486L837.82014,267.3515L856.53969,257.75181z"/>
        <g id=" Handicapped Parking ">
        <path clip-path="url(#SVG_CP_1)" fill="none"
        stroke="#000000" stroke-width="0.47999" stroke-
        miterlimit="10" stroke-linecap="round" stroke-
        linejoin="round" d="
        M306.47273,710.13743L483.10855,725.01696L422.38999,787.65497L424.06995,789.33491L405.35039,809.01429L306.47273,710.13743
        <title> Handicapped Parking </title>
        <desc> Parking of Electronic Engineering. Number of
        handicapped parking 5</desc>
        </path>
        </g>
</g> </g>
```

Figure 4. SVG Tiny code with physical accessibility information

Thus, the title and description tags of the SVG Tiny code can be used to provide physical accessibility information associated to the map: a screen reader can retrieve the information of the map and provide it to a visually impaired

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user. If all the descriptions of the whole map are entered with the crowdsourcing technique using SVG Tiny code, then this would help visually impaired people know physical accessibility characteristics of places in online geographic maps.

VI. CONCLUSIONS

This study linked concepts to improve accessibility including languages and tools such as crowdsourcing, SVG Tiny code, and use of screen readers. This helped to propose a solution to overcome a barrier of accessibility providing a textual equivalent to visual content.

New applications in the geographic scope, such as OpenStreetMap and Google Maps make clear the need to use online geographic information opposite to the traditional use of printed maps. However, it is necessary to develop methods to provide more accessible information to the user in several levels such as form, scale and detail, especially for the user of mobile devices.

Most of the studies concerning web accessibility have little or no interest in the application of web accessibility guidelines in the development of geographic solutions, since geographic maps are not generally available and are strictly visual. This shows a clear weakness in the development of geographic maps.

Increased social interaction through the web creates behaviours among people, along with this, the need for mechanisms to obtain web users collaboration on a voluntary basis to solve real problems, such as transportation, pollution, safety, and accessibility. This is what the crowdsourcing technique is about.

This paper presented some elements of SVG Tiny code, such as <g>, <desc> and <title> tags, for describing geographic map elements, i.e., polygons, lines and points, that makes possible to interpret the code by a screen reader, so the visually impaired users can manipulate geographic maps.

Although SVG Tiny code was created to represent the images with dynamic content on mobile devices, the SVG Tiny characteristics also offer the possibility to include code that makes geographical maps accessible.

Most of the efforts to improve accessibility of geographic maps are focused on hardware solutions, such as those presented in the state of the art section of this paper. We believe that integrating hardware with software may provide better results in terms of improving accessibility of geographic maps.

In the future, we intend to combine the format SVG Tiny code, indoor navigation systems, augmented reality, crowdsourcing, and web accessibility guidelines for proposing new ways to access and display the geographical maps available on the web.

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