

A WEB-BASED TOOL FOR CREATING GEOREFERENCED BOUNDARY MAPS

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Abstract: This work presents a web-based application with the capability of creating, manipulating and editing georeferenced boundary maps (polygons) of geographical areas using georeferenced images. The application is platform-independent. It can run on any computer with a browser and an Internet connection. The application provides the capability of locally storing boundary maps attaching to them spatial information from the images that facilitates image searching. Boundary maps can be imported from other sources and they can also be exported to make them available for other GIS applications. A usability test conducted with the application demonstrated that it is easy to learn and use. Participants were able to complete 96% of the tasks with a fifteen minutes tutorial. In addition they found all the interaction actions tested to be easy to use.

1 INTRODUCTION

Geographical Information Systems (GIS) applications are very powerful information systems. Most of them are desktop software from commercial vendors, which are usually very expensive. The fact that these are stand alone and isolated information systems limits their usefulness to the very few that have physical access to them.

Advances in networking technologies and Internet protocols and applications have made possible the development of GIS applications that can be accessible from all over the world at a very low cost (Athan, 2007). These technological advances facilitate the development of methods and environments to visualize, manipulate, and analyze geospatial data through the Internet with direct manipulation user interfaces (Sayar, 2005).

The core technologies of an application or its functionality do not guarantee the success of an application from the user's point of view. Usability plays a major role on the acceptance of an application. A very good example of this is presented in (Traynor, 1995). In this research a group of social scientists were given a tutorial by a GIS expert on a GIS application used by residents in inner-city neighborhoods. Despite the tutorial, the software resulted very difficult to use.

The tool described in the next section is a GIS application that was developed using Web development technologies such as AJAX (Asynchronous JavaScript and XML) (Ahmet, 2006) and PHP5, and share wear database technologies such as MySQL. The tool allows users to create, edit, manipulate and stores boundary maps (polygons) through the Internet. The tool manages high-resolution images that are used as references without using many system resources and unnecessary bandwidth. It was developed as a platform independent tool so that it can run in any computer with any operating system in any place of the world.

2 A TOOL FOR CREATING BOUNDARY MAPS

This section describes the operation of a web-based application capable of creating boundary maps using spatial data contained in aerial and/or satellite images as reference. Boundary maps are useful to delimit geographical areas of interest. These maps could be superimposed on satellite images of different types of atmospheric or terrestrial attributes to study the effect of them on the delimited area.

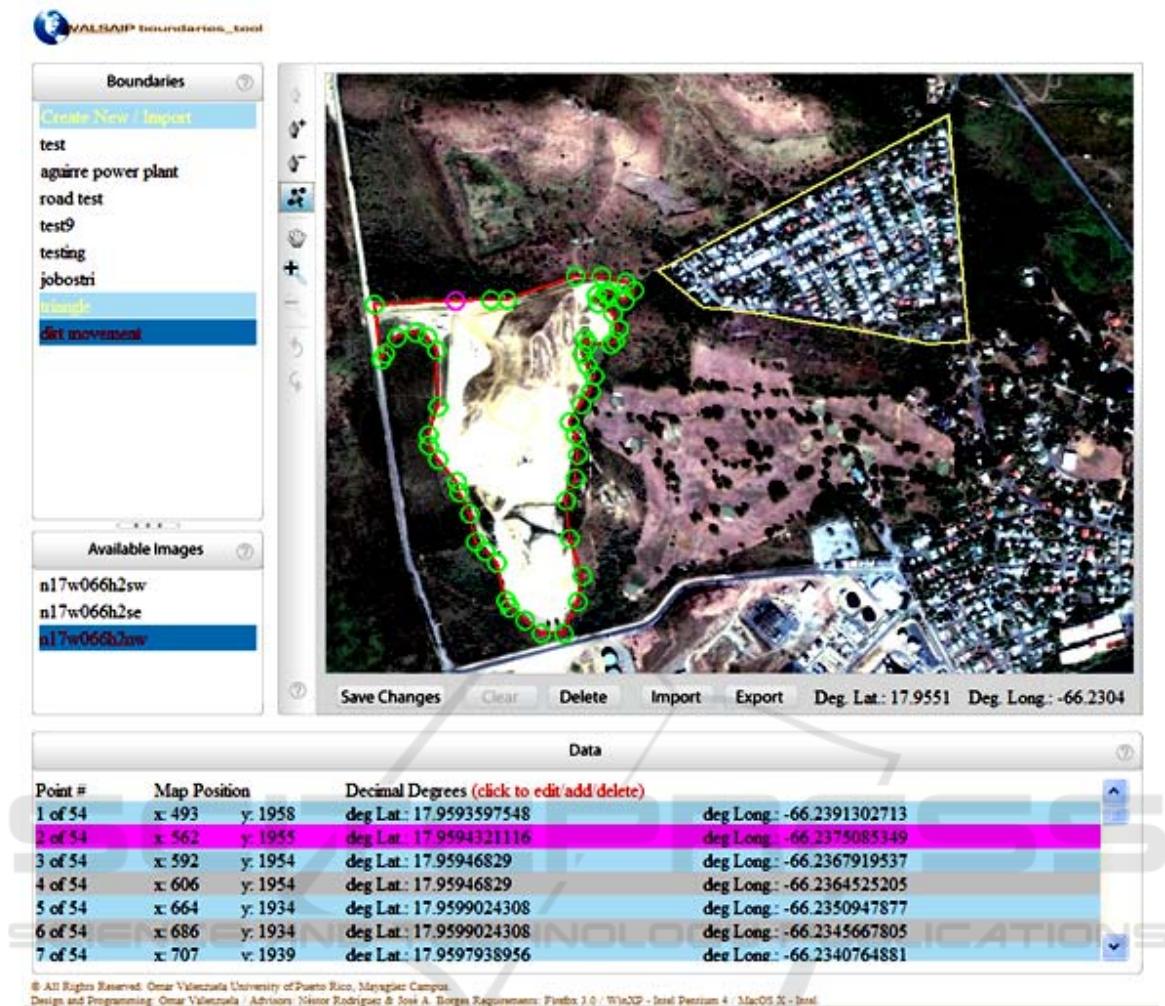


Figure 1: User interface of boundary creation tool.

Since boundary maps are georeferenced they automatically align with the corresponding geographical area on the reference image.

The user interface of the tool is shown in figure 1. The main working area is the large image display window at the top left. The image displayed in this area serves as reference for the creation of boundary maps. Boundary maps are displayed as polygons of lines on top of the image.

Lists of boundary maps and reference images are displayed at the left side of the interface. Users can select one image from the image list to be displayed on the image display window. However, more than one boundary maps from the boundaries list can be displayed on top of the reference image as it is shown in figure 1.

A vertical toolbox at the left of the image display window provides options for creating, editing and manipulating boundary maps. The top icon of the

toolbox serves to create a new boundary map. The following three icons serve to add, remove and move points of a boundary respectively. When one of these three editing options is selected the active boundary is displayed with all its points highlighted with small circles like the boundary shown at the left on the image display window of figure 1. The user can edit any point by pointing and clicking on them. The icon with a hand shape in the vertical toolbox serves to drag the background image along with the boundary. The icons with the plus and minus symbols serve to zoom in and zoom out the image respectively. The arrow icons serve to undo and redo interaction actions. All the actions generated with the toolbox are constantly georeferenced in real-time using the images' World File data.

Below the image display window are a number of buttons that allow saving, clearing, deleting, importing and exporting boundary maps. The first

button from left-to-right controls the saving of boundary maps. This button changes according to boundary status. If the user is creating a new boundary or is importing a new boundary to the database, this button takes the action of saving the boundary and displays the keyword "Save Boundary". If the user is editing an existing boundary, the button takes the action of saving the changes made to the boundary and displays the keyword "Save Changes".

The second button clears all the changes made to the active boundary on the image display area. The third button is used to delete the active boundary, only if it is actually stored on the database. The fourth button, the Import button, brings a boundary map into the image display window. If it is not already in the database the user has the option to save it. The fifth button (Export) has the function to convert the active boundary into a KML file and provides the user the option to save it locally. Following the Export button are two fields (Deg. Lat and Deg. Long) that display the coordinates of the position of the cursor in decimal degrees.

At the bottom of the user interface there is a window that displays data about each point of the active boundary. Each point is identified with a number. These are organized in ascending order, following the connection sequence. The relative X-Y pixel position on the boundary display window as well as the georeferenced position in decimal degrees (Latitude-Longitude) is displayed for each point. By clicking on a point entry the point is selected. The user can edit the coordinates of the selected point, delete the point or add a new point. This feature allows for the development of very precise georeferenced boundary maps.

3 IMPLEMENTATION DETAILS

The main tool used in the development of the boundary maps tool was AJAX. This technology made possible to merge the dynamic content obtained from dynamic HTML and CSS, with the coding support of PHP 5 and manage the user interface's dynamic information display with the use of JavaScript. SAJAX (Simple AJAX Toolkit) was used as the AJAX tool to handle the communications between the JavaScript and PHP 5. JSON (JavaScript Object Notation) was used to handle the variable data to/from JavaScript that is sent over to PHP 5 to be displayed in the user interface. These technologies allowed the creation of dynamic content on a web browser in a similar way

as it can be accomplished in a desktop application (Paulson, 2005).

The boundary maps tool application was developed for Mozilla Firefox version 3 because of its stability, standard compliance, and performance of JavaScript at the time of the development. Programming for only one browser makes the process of developing a web application a lot faster. However, the application performs correctly with Safari's, Apple's Internet browser.

Boundary maps are stored on a local database and made accessible through a local website to avoid the use of proprietary APIs that could limit future development of the tool. The tool's database server was implemented with Apache, MySQL and PHP 5. The latter was used to manage queries, image files, and store information inside the database. Since the information generated from the user's work needed to be stored in an open format available to anyone, KML was used as the storage format. The availability of these database server development tools on the Internet facilitated the implementation of the application in a very inexpensive way.

4 USABILITY STUDY

4.1 Methodology

A usability study (Nielsen, 1993) was performed to determine the ease or difficulty of use of the boundaries tool application by potential real users as well as their satisfaction with the application. The study was performed using a local web server to prevent any network related variability in the results of the study. The computer used to run the test was a PC with an Intel Core 2 Duo @ 2.16 GHz processor, 2 GB RAM and 7200 RPM HardDisk. The software used to run the application was Apache 2.2, PHP 5.2.6, MySQL Server 5.0. The browser used for the test was FireFox version 3.0.1.

The users selected for the usability test were ten civil engineering and surveying students with experience in the creation of polygons and/or boundaries with GIS tools. Prior to the test they were given a short tutorial on how to use the application. After the tutorial the users were asked to perform 20 tasks using the boundary tool. The tasks involved handling, creating, editing, saving, importing, exporting, and deleting boundary maps.

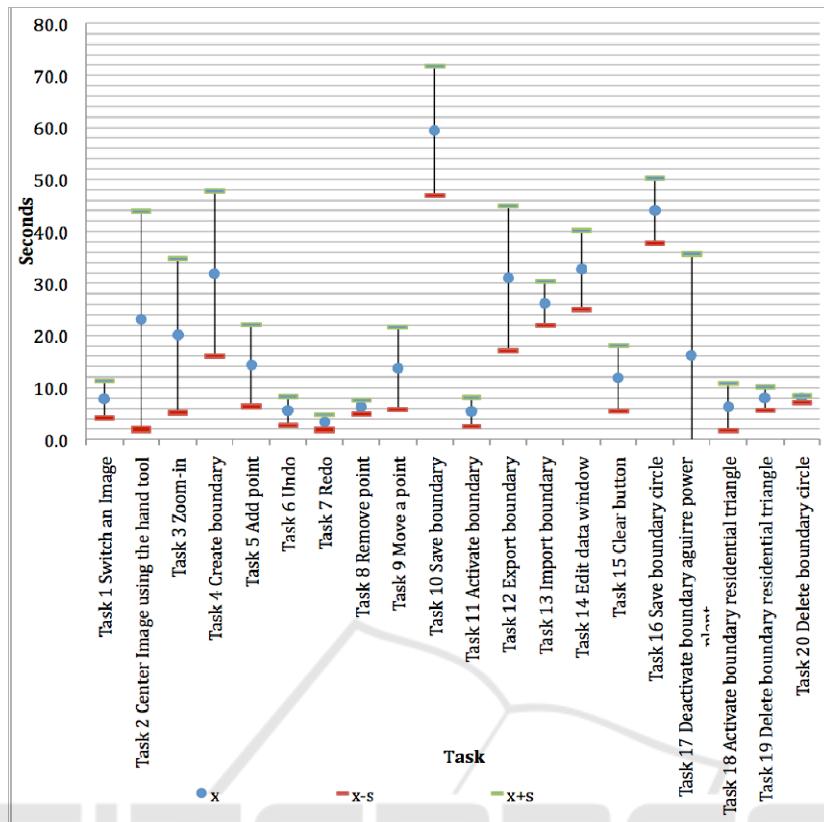


Figure 2: Task completion times.

After performing the tasks the users were asked to rate fourteen interaction aspects dealing with handling and editing boundary maps. They were asked to rate each aspect using a 1-5 (difficult-easy) scale. They were also asked to rate the overall performance of the application and how useful it seems for them. The dependent variables of the study were the time to complete the tasks, the number of tasks completed and the user subjective satisfaction.

4.2 Results

Figure 2 shows the mean (X) and the standard deviation (S) of the tasks completion times. Overall it took the users an average of 378.3 seconds to complete all the tasks with a standard deviation of 63.4 seconds. Saving a boundary was the most time consuming task. The least time consuming tasks were: switching an image (Task 2), undo (Task 6), redo (task 7), remove point (Task 8), activate boundary (Task 11 and Task 18), and delete a boundary (Task 19 and Task 20).

Overall, the participants executed 200 tasks combined of which only eight were not completed. This constitutes a 96% task completion rate. Only

one of the users was not able to complete three tasks, another was not able to complete two, while three were not able to complete one task.

A summary of the average rating given to each of the interaction aspects rated is presented in Figure 3. The results indicate a very high rating for all the items of the post test questionnaire. All the average ratings were on or above 4.6.

5 CONCLUSIONS

The results of the study support the conclusion that the boundary tool is very easy to learn and use. With only a fifteen-minutes tutorial the users were able to complete 96% of the tasks. The users perceive the application as one that is very easy to use in general. They found all individual interaction actions tested as very easy to execute.

The most important contribution of this study is the creation of a very easy to use and learn tool for creating georeferenced boundary maps that could be used from anywhere in the world.

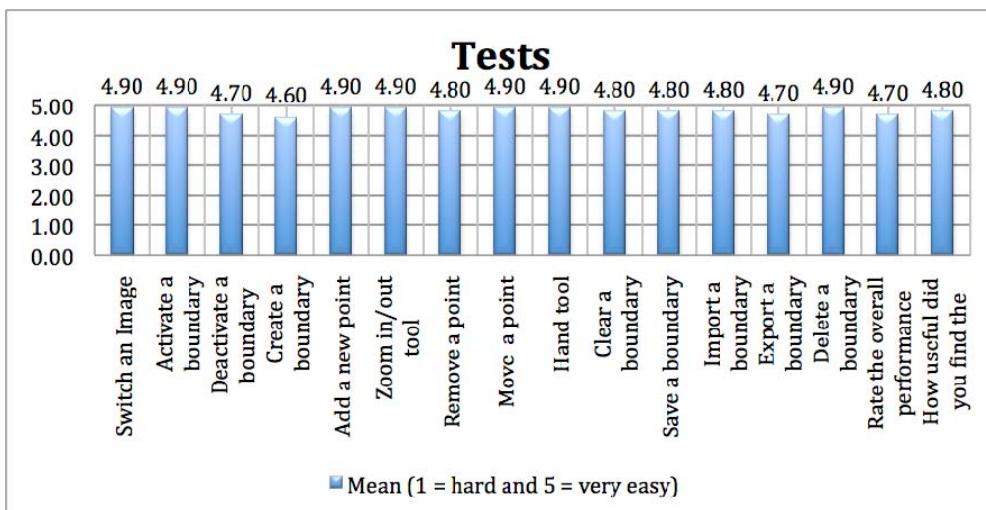


Figure 3: Average Ratings of Interaction Actions.

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