Evaluating Accessibility in Crowdsourcing GIS

Liviu COTFAS
Bucharest Academy of Economic Studies, Bucharest, Romania
liviu.cotfas@ase.ro

Andreea DIOSTEANU
Bucharest Academy of Economic Studies, Bucharest, Romania
andreea.diosteanu@ie.ase.ro

***Abstract**: A recent development in Geographic Information Systems is the use of crowd-sourcing to acquire and share information that was difficult to collect, organize and update in the past. Taking into consideration that the people entering data into the system might not have geographic training, an important concern is related to accessibility. In this paper we propose an algorithm for evaluating accessibility based on the Web Content Accessibility Guidelines defined by W3C.*

***Keywords**: Geographic Information System (GIS), Collaborative, Crowd Sourcing, Volunteered Geographic Information (VGI), Accessibility, Software Metrics.*

1. Introduction

According to a broadly accepted definition, a Geographic Information System is composed of hardware, software and procedures to facilitate the management, manipulation, analysis, modeling, representation and display of georeferenced data to solve complex problems regarding planning and management of resources [1]. GIS initially appeared in the 1960 and have since become an essential tool for both public administration and business due to its ability to store, retrieve, analyze and display huge volumes of spatial data.

Public administration can use GIS for transport and infrastructure planning, utilities design and operation, public safety, tax assessment, sustainable development and disaster management. Business can use GIS to better manage vehicle fleets, to analyze market areas, profile customers or provide advanced Location Based Services (LBS). Many GIS implementations are used in retailing, financial services, media, insurance and real estate sectors. Other application areas include natural resources, education and military [2].

GIS applications include mapping locations, mapping quantities and densities, finding distances and routes, monitoring and predicting changes.

First GIS applications were manly targeted for government and military use as they required expensive mainframe computers running UNIX based operating systems. Their use in business was limited due to high cost and need for specialized personnel. The situation gradually changed with the introduction in the late 1990s of desktop GIS applications like PARC Xerox and Map Server that could be run on personal computers. Later on, web GIS applications like MapQuest and Google Maps [3] (2005) allowed everyone to access detailed maps using only a web browser. In the last few years, the step to mobile devices has been made, mobile GIS applications becoming increasingly popular. From the architectural point of view, recent trends include integrating GIS with cloud computing, creating easily

reconfigurable applications using automatic and semi-automatic web service composition. Moving from isolated GIS applications towards web, mobile and cloud GIS also created the premises for developing collaborative map based applications.

2. Collaborative GIS

Collaborative geographic information systems are generally defined as processes that integrate people and technology in order to manage, transform and analyze spatial data. Because they allow the integration of knowledge from multiple stakeholders, collaborative GIS applications are useful in areas such as planning and decision making. The spatial representation is considered to make both data and decisions easier to understand among groups with different expertise [4].

Due to high costs, the creation of geographic information was considered for a long time an area reserved to official agencies and large companies. Web 2.0 created a revolution in user generated content, which can now help acquire and share information that could hardly be collected and organized in the past. Relying on people to generate content is also called crowd-sourcing [5] or Volunteered Geographic Information (VGI) [6].

Even though using crowd-sourcing for information acquiring in GIS usually leads to less accurate data, it is considered a viable option in cases where classical methods are too expensive. Crowd-sourcing typically implies no costs and allows not only gathering huge amounts of data in a short period of time, but also keeping the information up to date. Also, people leaving near a mapped feature can easily discover and correct wrong information inside the crowd-sourcing GIS.

A recent example of crowd-sourcing is Google Map Maker [7], a service that allows users to add information to Google Maps [3] in areas where classical methods are considered unprofitable. In 2010 Map Maker proved useful to map disaster affected regions such as Chile and Haiti.

3. Evaluating the degree of accessibility

Taking into consideration the differences between users that can range from general public to experts an important aspect of VGI applications is the accessibility degree. Bellow we propose a method that provides an easy way to evaluate accessibility at any development stage. The method takes into account the guidelines suggested by the *W3C in their WCAG 2.0 (Web Content Accessibility Guidelines) initiative* and allows determining the degree of accessibility for collaborative GIS applications.

The W3C guidelines are grouped into four categories: *perceivable, operable, understandable and robust*. For each class there are four, four, three and one subclasses of features that have a certain level of importance (AAA, AA and A).

Starting from this, the DA *(degree of accessibility)* indicator can be computed by using the following formula:

$$DA = \left(\sum_{i=1}^{4} Ni \times Ai\right) / N \quad (1)$$

where:

N_i= the number of characteristics taken into account from the i category / the total number of characteristics from the i category where i=1...4;

$N=\sum Nt$;

A_i=the value of accessibility indicator for each group:

$$A_i=(\sum_{j=1}^{nci} Aij)/n_{ci} \quad (2)$$

where:

n_{ci}= the number of subclasses from the ***i*** category that are taken into account;

A_{ij}=the value of the accessibility indicator for the ***i*** category and ***j*** subclass

$$A_{ij=} (\sum_{k=1}^{ncij} Aijk \times pk)/(\sum_{k=1}^{ncij} pk) \quad (3)$$

where:

p_k =the level of importance for each indicator (A⇔0,1; AA⇔0,3; AAA⇔0,6);

n_{cij}= the number of characteristics taken into account from ***i*** category and ***j*** subclass;

Each $Aijk$ indicator will have a value in the (0, 1) interval. Therefore, the DA (degree of accessibility) will also be a subunit value. If the value is closer to 1 the software application has an appropriate level of accessibility and also the indicator becomes more relevant. In order to achieve a higher degree of accessibility it is important to constantly evaluate the accessibility trough out the development process. The proposed indicator (*DA*) can be used to evaluate accessibility from the very beginning of a project to the completion stage.

The proposed algorithm for accessibility evaluation was applied for a Location Based Services application that allows users to add and modify objectives in a collaborative manner (Figure 1). Besides sharing information between users, the application also provides route finding in multi-operator, multi-modal public transport networks. The application also retrieves georeferenced information from other sources such as Wikipedia and Flickr.

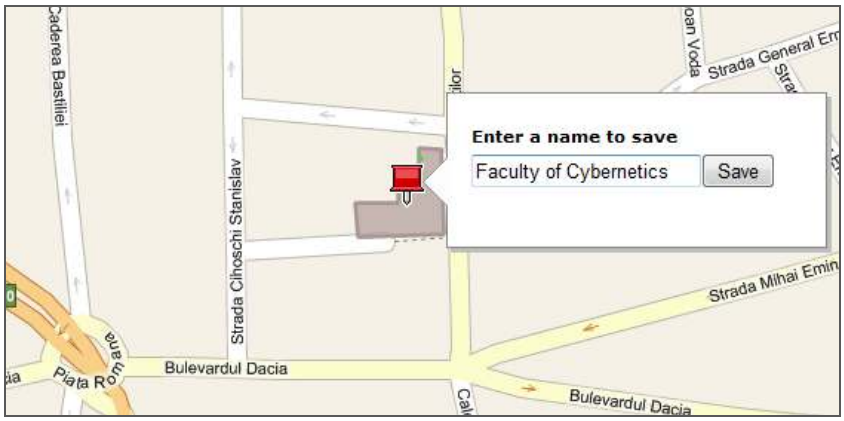

Fig. 1. Adding features to maps

By applying the formulas presented above and computing the indicators N_1=0.23; N_2=0.2; N_3=0.18; N_4=0.5 we obtain a ***DA***= 0.91234985.

The value is closed to 1, therefore we can depict that we have a good level of accessibility.

In order to obtain more rigorous results we have taken into account all the characteristics presented in WCAG 2.0 and we have computed an associated indicator in a manner similar to that presented in Table 1. (Formula (Aijk) section).

After computing the DA we can make some assumptions related to improving the software product level of accessibility. Furthermore, the DA should be recalculated during the development phase.

In our case, the following actions should be taken so that to improve the DA level:

1. we have to provide additional functionalities for sign languages by including a sign interpreter
2. we have to improve contrast by offering the user the possibility to customize it
3. improving keyboard use by using shortcut keys for all functionalities.

4. Conclusions

In this paper we present an algorithm for accessibility evaluation of a crowdsourcing GIS. The algorithm is applied or an application that allows users to add and modify data in a collaborative manner.

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Authors

Liviu COTFAS is a Ph.D. student and a graduate of the Faculty of Cybernetics, Statistics and Economic Informatics. He is currently conducting research in Economic Informatics at Bucharest Academy of Economic Studies and he is also a Pre-Assistant Lecturer within the Department of Economic Informatics. Amongst his fields of interest are geographic information systems, genetic algorithms and web technologies.

Andreea DIOŞTEANU has graduated the Faculty of Economic Cybernetics, Statis-tics and Informatics in 2008 as promotion leader, with an average of 10. She is cur-rently conducting research in Economic Informatics at Bucharest Academy of Economic Studies and she is also a pre-Assistant within the Department of Economic Informatics and .NET programmer at TotalSoft. During the bachelor years she par-ticipate in many student competitions both at national and international level obtain-ing a lot of first and second prizes. The most important competitions she was finalist in were Microsoft International Imagine Cup Competition, Software Design section (national finalist); Berkley University and IBM sponsored ICUBE competition were she qualified for the South Eastern Phase-Novatech. Furthermore, she also obtained the "N.N Constantinescu" excellence scholarship in 2007-2008 for the entire student research activity.