

Can Online Map-Based Applications Improve Citizen Participation?

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Abstract. Public participatory geographic information systems (PP GIS) aim at enlarging citizen's involvement and participation in decision-making processes. In this paper we review existing online PP GIS applications and present the framework of our analysis. We concentrate on the aspects of interactivity of such applications and the GIS functionalities needed for their operation. First results of ongoing research exhibit that a vast majority of applications only deliver information to the citizen in a one-way communication process. Although the technology is available only few applications fulfill criteria of our analysis to be classified as two-way communication tools. We conclude the paper with directions for our further research.

1 Introduction

Geographic Information Systems (GIS) are technically mature and widely used at all levels of administration and planning. Considerable effort has been devoted over the years to utilize GIS for public participatory processes. GIS spatial visualization techniques combined with participatory functionalities form a novel way for the presentation of spatial issues to the general public. They aim at improving the interaction and communication between the citizens and decision-makers. Virtual environments and 3D designed city environment spaces can be used to show the current and future situation in a near realistic way [9]. The aim of public participatory GIS (PP GIS) is to enlarge the level of citizens' involvement in decision-making and to improve access to relevant tools, data and information. The Internet generates a new public sphere that supports interaction, debate and new forms of democracy [10]. Online PP GIS applications can be used as a means to augment traditional methods of participation such as for example public meetings and consultation documents, or to enhance the existing classical participatory methods. Thus far, research on broadening a basis for planning was dissected into technological and societal research. While the first is sometimes criticized for being too positivistic the latter is generally very

critical. This paper demonstrates that the potential of GIS to support public participation planning processes and to broaden the basis for participation is significant. While most GIS research focus on the technical functionalities of such systems, there are almost no empirical studies on the problem of potential exclusions of the citizens with poor computer literacy or computer aversion by certain social groups, especially elderly people.

This paper critically reviews selected online PP GIS applications, develops a framework for our analysis and presents the first results. The following questions are central to our research: “When does an online GIS application become a public participatory GIS application?”, “What are the necessary conditions for that?”, and “Which GIS functionalities are needed for an online PP GIS application?” In the analysis we concentrate on different degrees of interactivity which determine the interaction between the user and an online PP GIS application. Special attention is devoted to the GIS operations. This is a first step within an ongoing research initiative of the new Centre of Excellence for Map-Based Online Public Participation Map³ (<http://map3.salzburgresearch.at>), which focuses on interactivity of PP GIS applications, spatial visualization, information access and social and economic aspects of online map-based public participation.

2 Online map-based participation

2.1 GIS and PP GIS

Increasingly, online public participation in spatial planning utilizes Geographic Information Systems (GIS) and the Internet. A GIS can in this context be defined as “a system of hardware, software, data, people, organisations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth” [3]. A geographical information system used to support public participation is often referred to as public participatory GIS (PP GIS). In general, PP GIS applications range from Internet-dependent spatial multimedia systems to conventional field-based participatory development methods with a modest GIS component [5]. These applications have the linking of community participation and geographic information systems in a diversity of social and environmental contexts in common. In this section we provide an overview of PP GIS definitions, and concentrate on the differences between GIS and PP GIS. We discuss theoretical foundations for interactivity of PP GIS applications, and GIS functions included in most of currently available PP GIS applications.

The term public participation GIS was coined at the I-19 Initiative workshop of the *National Center for Geographic Information and Analysis* (NCGIA) in the United States. At the time, PP GIS was defined as “a variety of approaches to make GIS and other spatial decision-making tools available and accessible to all those with a stake in official decisions” [11]. Talen [14] stresses the importance of the community integrated or neighbourhood GIS (sometime called CiGIS) that provide better access to Geographic Information technologies and opens up the opportunities

for collaboration and participation in planning processes. Craig [5] identifies “PP GIS as a broad tent with multiple meanings and a global reach made of emerging forms of community interaction with GIS that are linked to the social and geographic context of PP GIS production and implementation.” Haklay and Tobon [6] consider PP GIS a research field that focuses on the use of GIS by the general public with the aim to involve citizens in spatial planning processes. A new and novel development of PP GIS increasingly uses the possibilities of the Internet. So-called online PP GIS are being used to facilitate the delivery of spatial information to participants and allow them to return their information for inclusion in the database [5].

Table 1. Difference between GIS and PP GIS [8]

GIS	DIMENSION	PP GIS
Technology	<i>Focus</i>	People and technology
Facilitate official policy-making	<i>Goal</i>	Empower Communities
Rigid, hierarchical and bureaucratic	<i>Organisational structure</i>	Flexible and open
Specified by technologists and GIS experts	<i>Details</i>	Specified by users, focus groups
Led by independent specialists	<i>Applications</i>	Led by facilitators, group leaders
General, multipurpose applications	<i>Functions</i>	Specific, project-level activities
Top-down	<i>Approach</i>	Bottom-up

We are particularly interested in the differences between ‘classical’ GIS and PP GIS, how PP GIS applications differ from the classical GIS applications and what makes them so special. Kyem [8] summarises the topology of differences between GIS and PP GIS. We have modified these differences in table 1. In Kyem’s approach the technology becomes an integral part of the bottom-up spatial decision-making process. This approach differs from Schroeder’s [11] view who suggests GIS to be employed by interests groups to support the official policy-making interest and to empower the process as such and the participants in the decision-making.

2.2 Interactivity of PP GIS applications

Interactivity implies that some action of the user generates a response either from another human being at the other end of the connection or from a program or application residing on a computer. In the framework of a PP GIS application interactivity refers to the user’s interaction with the application [4], [7] using a computer. In our analysis, we refer to the e-participation ladder after Smyth [13] that we modified for our analysis. The e-participation ladder provides a structured overview of different forms of online participation and focuses particularly on the

degree of interactivity. We distinguish between the following four stages of interactivity (see figure 1):

Information delivery

At the bottom stage of the ladder, participation exists in an entirely passive mode and can be described as “the public right to know”. This stage represents the delivery of online services to the user in one-way direction and has some sort of informative status for the users. The users can extract geographic information by using the PP GIS application and the data stored in the database.

Online discussion

In this stage, the participation has a higher degree of interactivity which is achieved through the two-way exchange of information and the participant’s suggestions and comments. This stage includes online discussions among the participants, planning offices and planning authorities. The participants can, for example, write an email to the planning office in which they attach a specific map extent and write their suggestions and comments in an e-mail. The possibility of drawing changes on a map is not included in this stage.

Map-based discussion

PP GIS applications that correspond to this stage provide the user with the possibility of communication on the basis of an online map. The participants can graphically express suggestions for changes or can make comments on specific objects in the selected map. A PP GIS application and its specific tools enable the participants to send their personal map version together with annotations or additional material to the planning authorities. This level of participation uses maps as a communication tool. Participants send their suggestions to the responsible persons, but are not actively involved in the decision-making process through iterative processes or feedback-loops.

Involvement in decision-making

In the highest stage of the ladder participants can actively contribute to the decision-making process and participate in the final planning processes and, consequently, in the decision making. An example of such decision-making process is voting for the most suitable alternative or predefined planning scenario. An example would be the case where the planning office presents alternative locations for bus stations to the citizens who can then vote for the most needed and desirable location. The location for the bus station that gets the most votes is then finally selected by the planning office and included in the plan.

2.3 GIS functionalities included in PP GIS applications

PP GIS applications include different GIS functionalities ranging from basic operations such as zoom, pan, copy and paste themes between views, spatial queries or simple calculations to more complex operations such as 3D visualisation or statistic calculations. Some GIS operations also allow for “personalized views” of the data sets and enable the user to access information on specific topics.

The following GIS functionalities are standard in all GIS and are usually needed for PP GIS applications. They present a core subset of basic GIS functionalities and they serve as a benchmark for the selected online PP GIS applications.

Topological overlay

A geographical information system is traditionally organized in different layers. Examples of such layers are land use, soil hydrology, streets, and buildings. Different layers can then be combined in a customised map. Topological overlay is an analysis procedure for determining the spatial coincidence of geographic features presented in the layers integrated in a GIS.

Information retrieval

In a GIS, graphic data are related to the attribute data describing their characteristics. Attribute data can be a qualitative description of the object or a number describing the features of the object. With a simple mouse click on a spatial element the user may retrieve attribute data about the selected object. Such queries are basic functionalities of standard GIS. Their results are being displayed on the screen and, for instance, selected objects or data may be highlighted using a specific colour.

Query

Performing a query implies that the user can retrieve the data according to the related terms, phrases or features chosen. The GIS displays the data that match the respective query and highlight them in the resulting map using specific colours or symbols.

Data selection

Data selection tool enables the user to select spatial objects on the specified thematic data layer. This function is used for instance if the participant submits a comment related to the object or perhaps question the characteristics of the selected object.

Zoom and Pan

The zooming buttons within a GIS usually show zoom in (a +) or zoom out (a -) symbol. Even occasional Internet users are familiar with enlargement or shrinking of map extents in applications like route planning systems. These tools enable the users to change their view and the level of detail by clicking on a location or by dragging a box to define a particular extent. With the pan functionality they can move the map on the screen into the position they like focusing on the part of the map that is of interest to them.

Distance measure

The distance measure function enables the user e.g. to measure the distance between two locations or the total distance of a route, with multiple stops. The calculation is performed in the background and the result of the measurement is displayed on the map or underneath.

3 Analysis framework and first results

The analysis is three-tiered. First we selected twelve online PP GIS examples which were accessible and operational at the time of our survey. The second step was the definition of the following analysis criteria: interactivity, visualisation, usability, and GIS functionalities. We designed a questionnaire and interviewed a group of experts by concentrating on visualisation and usability criteria. First results of these

interviews were documented in a recent paper [12]. Here, we concentrate on the interactivity aspect and the GIS functionalities.

3.1 Selected online PP GIS applications

Table 2 shows twelve selected currently available online PP GIS applications which we have found on the Internet. The first seven were developed in US, the following three in UK and the last two in Germany.

Table 2. Online PP GIS applications

	<i>Project name</i>	<i>Internet Link</i>
US1	Pilsen Project – Urban Design Visualization of Pilsen	http://www.evl.uic.edu/sopark/new/RA/#sub1
US2	Orange County Interactive Mapping, developed by the city of Orlando – Florida	http://www.cityoforlando.net/public_works/esd/gis/interactive_mapping.htm
US3	Resource Management Mapping Service	http://space1.itcs.uiuc.edu/website/rmms/
US4	Wyoming Oil and Gas Resource Assessment Mapper	http://wogra.wygisc.uwyo.edu/wyoims2/wims2/awogra.html
US5	Erie International Airport	http://gis.cseengineers.com/erie/viewer.htm
US6	Town of Clover Planning Analyst	http://www.lic.wisc.edu/clover_web/history_bk/grnd.htm
US7	I-map Delaware River Basin	http://bassriver.state.nj.us/imap_delbasin/
UK1	Virtual Slaithwaite Project	http://www.ccg.leeds.ac.uk/slaithwaite/
UK2	Bradford Community Statistics Project	http://www.bcsp-web.org/mapguide_site/maingeo.cfm
UK3	“Openspace” of Salford University	http://www.ties.salford.ac.uk/pg/xiao/openspace-main.html
DE1	„Bürgerbeteiligung Online“ – landscape plan Königslutter	http://thuja.land.uni-hannover.de/entera/mapserv.phtml
DE2	„Vernetzter Bebauungsplan“ – Landkreis Freising	http://fs.mapsailor.de

The *Pilsen Project* was initiated by the University of Illinois at Chicago and community leaders of the Pilsen community. Within this project the resources of a Geographical Information System were combined with the talents of a graphic artist. *Orange County Interactive Mapping* is an application which was developed by the city of Orlando. *The Resource Management Mapping Service* is a project developed by the College of Agricultural, Consumer and Environmental Sciences. The application is based on ESRI technology using ArcIMS 4.0. The *Wyoming Oil and Gas Resource Assessment* (WOGRA) is an interagency project with the intention to provide information oil and gas resources throughout Wyoming. The company C&S developed *Erie International Airport*. This is a facilitated public involvement approach to environmental and community decision. The *Town of Clover* project wants to support managed residential development that will meet the town’s future housing needs. The results of this public participation process are published on the

Internet. *I-Map Delaware River Basin* is an interactive mapping application that gives responses to basic questions of the users about recreational activities in the Basin area. *Virtual Slaithwaite* is one of the most often quoted PP GIS applications. This project was developed by the School of Geography, University of Leeds. It is a model application for public participation in urban planning. The system is based on the open source Java mapping toolkit GeoTools. The *Bradford Community Statistics Project* provides us with statistical information about the community Bradford. *Openspace* PP GIS application developed by Salford University uses a 3D model for the visualisation of the environment. It is created with the adoption of the virtual reality modelling language (VRML) and Java programming languages. One of the two German examples is the *Interactive landscape plan Königslutter* which was developed by two private companies in cooperation with the University of Hannover. The State of Bavaria, Germany, supported the *Landkreis Freising* to publish a set of development plans on the Internet.

3.2 How interactive are PP GIS applications?

In our analysis of interactivity we use the concept of the e-participation ladder as explained above and apply it to the criterion interactivity (figure 1). The following three applications offer one-way communication: *Erie International Airport*, *I-Map Delaware* and the *Bradford Community Statistics Project*. They serve as examples for the lowest stage of the ladder. *Erie International Airport* allows users to view maps of proposed projects, letting nearby residents to see how their properties might be affected. This means that the users are able to observe different planning scenarios, but they are not able to make comments on them. *I-Map Delaware* and *Bradford Community Statistics Project* are simple information systems with no opportunity for the users to take part in the participation process. In this stage of the ladder we could include also numerous GIS applications which simply deliver geoinformation to the users and help them to improve their decision-making processes. A huge number of such applications can be found on the Internet. Most of them are webmapping applications based on the popular ArcIMS map server. In all these examples, the users do not have the possibility to actively contribute to the planning decisions. The applications lack two-way communication and do not allow the users of the application to comment on specific decisions or suggestions presented online on a map.

The majority of the analysed PP GIS applications sample falls into the stages online discussion or map-based discussion. Online discussion level of interactivity is included in five analysed online PP GIS applications. *Orange County Interactive Mapping* offers the opportunity to define user specific areas on which comments can be stated into the map. The result can be mailed in a form of an attached .pdf file to the Orange County Board of County Commissioners. The “*Resource Management Mapping Service*” application allows the users to write comments into the map and mail then a specific map extent to anybody they want to. “*Landkreis Freising – Vernetzter Bebauungsplan*” provides development plans where the participants can have a look at the actual stock and also on the planning proposal. If they want to make comments on the plans, they have the possibility to write a standard e-mail. *Wyoming*

Oil and Gas Resource Assessment Mapper and the *Town of Clover Planning Analyst* also offer the possibility to express opinions in form of e-mails.

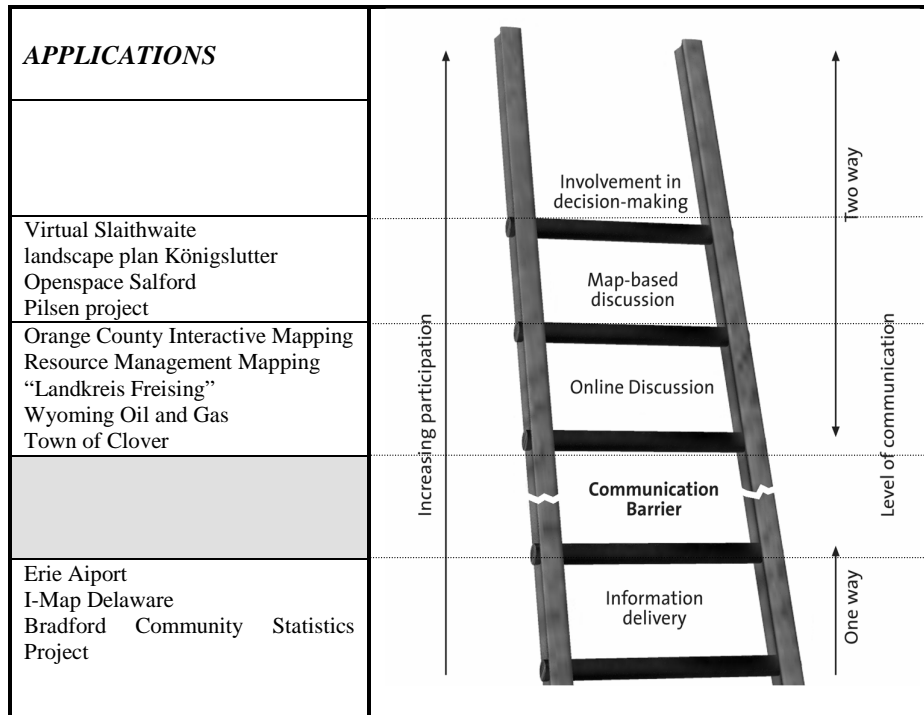


Fig. 1. Interactivity of the selected PP GIS applications

Map-based discussion is provided within four of the selected PP GIS applications. The *Virtual Slaithwaite* application enables the participants in planning to write their own ideas in a separate window on the basis of selected features and then submit them to the responsible persons. “*Openspace*” of Salford University lets the user either walk or fly through the virtual city. The application enables exploration of different viewpoints and walking speeds. The participant can also submit a comment at any spatial location. Within the application *Landscape plan Königslutter* the users can work on self-defined map extents which means that they can draw polygons into the map, comment the planning situation and send their opinion and analysis results to the planning authority. Although only parts of the *Pilsen project* are realized by now, we were able to classify the project regarding a project description of Al-Kodmany [1]. This project allowed participants to truly participate in designing revitalization projects in their neighbourhood.

3.3 Which GIS functionalities are included in PP GIS applications?

Table 3 shows the results of the GIS functionality analysis for the selected online PP GIS applications. Vertical column include topological overlay, query, information retrieval, data selection, zoom and pan, and distance measure function. Lines represent the PP GIS applications from table 2. “x” implies that a particular PP GIS application offers the respective GIS operation.

Table 3. GIS operations included in PP GIS applications

	US 1	US 2	US 3	US 4	US 5	US 6	US 7	UK 1	UK 2	UK 3	DE 1	DE 2
Topological overlay		x	x	x	x		x		x		x	x
Query		x	x				x					
Information retrieval		x	x	x	x		x				x	
Data selection		x	x				x	x	x			
Zoom and Pan		x	x		x		x	x	x	x	x	x
Distance measure		x	x				x					x

Only three applications include all six GIS functionality categories identified in this paper. These PP GIS applications are the *Resource Management Mapping Service* (US1) application, the *Orange County Interactive Mapping application* (US3) and the *I-Map Delaware River Basin* (US7). This type of application provides general GIS functions like zoom and pan or the user is able to identify objects and to query the attributes of the respective object. Basic navigation functions like zoom and pan are included in all analysed applications but only these three applications provide the powerful “Query” functionality. The *Pilsen project* and the *Town of Clover Planning Analyst* have not been considered in this analysis, because the *Pilsen project* was not consistently available online throughout the analysis and the *Planning Analyst* was not categorized as to be an online GIS application.

We conclude that nearly all selected online PP GIS applications fulfil primary functions like topological overlay and navigation functions, but most of them lack querying, selecting and identifying options. The majority of applications do not provide attribute information to their users. In the next step of our analysis we will link the interactivity and GIS functionalities criteria and observe the complexity of PP

GIS applications and how it is related to the use in a practical participatory process. This will enable us to study the relation between the needs for interaction and the number of GIS functionalities.

4 Conclusions and further work

In general, we can conclude that currently available PP GIS applications vary strongly concerning their included GIS functionalities and their complexity. Basedow [2] observes that the selection of the GIS functionalities in a PP GIS application depends very much on the application area and the software that is used for the development of the application. A potential danger is that if the GIS functionalities increase in a PP GIS application, also the complexity of a system may increase. High complexity of an application might prevent elderly and less computer skilled people from using it. The range of computer skills of the participants is probably the most important factor for a PP GIS user's requirements analysis [7]. The complexity also strongly depends on the nature of the decision-making process itself and related possible level of interactivity. Technically, PP GIS applications can be designed in a relatively simple way in the cases of one-way communication where the planning authority only informs the participating people about the planned actions. Complexity and needed GIS functionalities is higher in the cases of map-based discussion and involvement in decision-making. There is a lack of practical, user-based testing of such applications where a minimum set of needed GIS functionalities can be defined and tested. Further development of PP GIS applications should be based on the principles of intelligent user interfaces and decision making support systems that offer personalized information and the possibility of communication with the citizens.

Our research dealt in the first step with the comparison of selected online PP GIS applications. The results of our study are partially presented in this paper. The next activities include the development of an online web-based PP GIS application for a study case in the Salzburg region where public participation is needed. We will intensively deal with the user requirements and the usability of a user friendly PP GIS application. We will analyze novel visualization techniques and innovative spatio-temporal communication approaches. Our planned research projects will include different types of media such as outdoor touch screen installations and for example collaborative planning meetings that are monitored with videos or sketch map techniques. Within the evaluation phase these applications will be tested by a large number of expert and non-expert users. We will also analyze sociological issues that are closely related to map-based online public participation with the focus on user-based testing and recommendations for user friendly PP GIS applications.

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