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The role of facilitated volunteered geographic information in the landscape planning and site design process

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Abstract Over the last 40 years there has been a movement to increase opportunities for public participation in the decision and policy-making processes for design and planning projects. The emergence of online digital mapping systems and enhancements in Web technology to support sharing and collaboration have allowed the general public to generate their own spatial content via Web applications and other geospatially enabled devices. The resulting data from this recent phenomenon has been called Volunteered Geographic Information (VGI). When facilitated through digital mapping interfaces, VGI can provide landscape architects and allied design professionals with local, detailed and spatial information that can be used to create a more informed design solution. This paper describes several digital interfaces the author has developed to elicit facilitated-VGI (f-VGI) over the past decade, and examines their use in community design projects and their lessons for implementing future f-VGI initiatives.

Keywords VGI · Participation · Planning/Design · Facilitated mapping · 3D · Visualization

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Introduction

The emergence of new online mapping technologies and an interest in involving the public throughout design-making processes has prompted the development and adaptation of digital participation technologies such as Geospatial Surveys, Public Participation Geographic Information Systems (PPGIS) and most recently Volunteered Geographic Information (VGI) (Craig et al. 2002; Sieber 2006; Goodchild 2007). These democratized geospatial tools facilitate the involvement of marginalized and excluded groups, allowing them to contribute their values, ideas and visions regarding the future of their community. Additionally, through the use of collaboration and crowd sourcing, these tools can be used to enhance the information used by professionals and decision makers.

Coined by Michael Goodchild in 2007, the term VGI refers to geospatial data that are voluntarily created by citizens who are untrained in the disciplines of geography, cartography or related fields. This definition implies that for contributed data to be considered 'VGI', volunteers must instigate the documentation of the spatial features of their own accord without invitation or prompting. While this pure form of VGI derived data may have value to the design professional, a variation on this understanding of VGI may be more applicable to the information needs of the design profession. Specifically, an approach to VGI that is more akin to the process of citizens voting on a design proposal, writing comments on a map, or the placing of pins or chips on a site plan during a design workshop may have more relevance in the context of participatory planning and design initiatives facilitated by professional planners and designers.

This variant of VGI, which I term facilitated-VGI (f-VGI), is characterized by the use of online mapping interfaces that allow the public to individually or collaboratively contribute information to be located on a map. This information might be contributed in response to a predefined set of criteria, such as an explicitly defined question, or limited to an established geographic extent. I differentiate an f-VGI approach from other VGI practices because of the way in which the collection of volunteered information is shepherded by a facilitator, as part of a pre-established planning or design process. In f-VGI, the facilitator establishes the parameters of the project and recruits volunteers through advertising in local media or through random sample selection.

Building upon established principles of public participation, the methodology informing f-VGI is not limited to the design profession. It might also be used by local government, state agencies and community-based organizations to harness the local 'wisdom of the crowd' in an effort to improve the quality of decisions, reduce cost and delay, build consensus, increase the ease of implementation, avoid confrontations, maintain credibility and legitimacy, anticipate public concerns and attitudes, and develop a civil society (Creighton 2005). The remainder of this paper will discuss the role of f-VGI in public participation and present several examples of how I have used f-VGI approaches to engage the public by allowing them to share their collective expertise of a local space, assist in the selection of a site, or express their opinion regarding a proposed design. Before describing the development and application of digital mapping interfaces I created to gather and use this f-VGI I begin by positioning these systems amidst broader changes in planning and design praxis.

Shifting modes of participation, digital resources, and emerging VGI practices

Over the latter half of the last century, as the emphasis on the modernist principles of planning and design gave way to postmodernism, there has been increased emphasis placed on the contributions of all members of society and recognition of the multiplicity of knowledge, interpretation and values (Healy 1996). In Sherry Arnstein's classic, *Ladder of Citizen Participation* (1969), she presented a framework of citizen participation that advocated an increased level of public power and control with each rung. The ladder begins with manipulation and therapy, two forms of "nonparticipation," where educational persuasion to garner support of the participants is the primary aim. The middle three rungs, referred to as "tokenism," consist of informing, consulting and placating. These are the first steps to participation and begin with information flowing outward to the citizen. Multi-way communication begins with consultation and placation, and participants have a voice through surveys and public meetings or by serving in an advising role to the final decision makers. The final three rungs represent increasing degrees of "citizen power" through partnership, delegation and citizen control. Within this final set of rungs, the citizen begins to move from simply providing an opinion to actually making the decision.

Since the publication of the participation ladder, many scholars and professionals have expanded or simplified the ladder and moved away from the focus on citizen power. This is particularly the case in community design where the "professional's role is to facilitate the citizen group's ability to reach decisions" while providing professional design service that conforms to the desire of the client (Sanoff 2000). In Kelsey and Gray's *The Citizen Survey Process in Parks and Recreation* (1986), the authors define the role of participation in design and planning as a mechanism to support the identification of the issues, interests, priorities and wishes of those who will make use of the site, as well as those who may be affected by the future development. In his book *Community Participation Methods in Design and Planning* (2000), Henry Sanoff identifies three purposes of participation: information exchange, supplementing design and planning and resolving conflicts. While the focus of these three purposes of participation was targeted to planning and design, they can be generalized and collectively used to establish a framework by which f-VGI can be applied. This framework includes:

(1) Sharing and compiling of factual (and pseudo-factual) geospatial information
(2) Collecting individual or collaborative opinions regarding existing situations or proposed modifications
(3) Identifying potential conflicts early in the process and resolving through education and compromise

Through this framework, f-VGI can be used to enhance the outcomes of traditional surveys, focus groups, town hall meetings, site tours, workshops and charrettes that are commonly used to engage the public. While these techniques can be generally effective at collecting information, spurring discussion or providing a venue for the evaluation of proposed designs; they do have limitations. For example, public meetings can suffer from either insufficient participation, exclusion of a marginalized population, or an abundance of participation resulting in an overwhelming amount of information that needs to be reviewed and analyzed. Access to meetings or the scheduling of events can also be problematic for many citizens, thus limiting their involvement (FHWA 1996; Sipes 2002). Advancements in Internet technologies over the past decade, along with increased access to broadband Internet have also altered planning and design, creating opportunities for incorporating online participation tools and techniques into the design process (Sipes 2002). These tools include informative Web pages that offer multimedia presentations, public meeting Webcasts, online surveys, opinion polls, bulletin boards, discussion forums, web logging (blogs) and chat technologies (Sanford and Rose 2007). Collectively, these e-Participation tools form a set of information-sharing tools that provide access to information 24/7 in a relaxed atmosphere such as a user's home or workplace, while potentially providing a level of anonymity that makes it easier to vocalize an unpopular position or idea. These tools also provide a means to easily carry on a discussion of a particular topic beyond the limited time allotted during a community meeting.

Although these online e-Participation tools have many benefits, they lack the ability to provide the spatial interaction that is afforded through printed maps. These limitations are gradually diminishing as the second generation of Web-based services, commonly referred to as Web 2.0 continues to emerge. With the ability to "harness the collective intelligence of users," an infrastructure that can support more dynamic participation, social interaction and collaboration emerged (O'Reilly 2005). Among the new Web 2.0 applications, several Web-based and stand-alone mapping applications are now available for public use. These applications include Microsoft Virtual Earth, Google Maps, Yahoo! Maps and Google Earth. In addition to providing mapping and direction services, these tools provide a means for the public to create user-generated geospatial content and share their mapped information over the Internet, unleashing a revolution of VGI.

While the rapid growth of VGI-derived data can be partially attributed to the technological advances of geo-web applications, it is the public's infatuation with online socialization and sharing of ideas, experiences and philosophies that has created a wealth of geo-referenced information. How the geo-professionals utilize this information was the topic of a VGI Specialist Meeting in December of 2007 (VGI Meeting 2007). During the meeting, several questions regarding VGI data were presented: What motivates people to provide data? What level of knowledge does the contributor have on the subject? How is the spatial accuracy of the data validated? Who owns and maintains the data? To what degree is one liable for using the data when making a decision?

While there are concerns about the quality and validity of the geographic data produced (Maue 2007), I contend that two characteristics of f-VGI may negate some of these issues. The first characteristic is one of elimination; the volunteered information should be considered valid only if the volunteer is considered to be local or part of the community. This might be determined by a preset qualifier such as his or her zip code or the number of years he or she has lived in the area. The second characteristic takes into account the quantity of corroborating information and follows the theoretical premise of crowd sourcing or crowd wisdom. Take, for example, a scenario in which residents living next to an underutilized park are asked over the period of a week to map (using GPS) the locations where they would like to see enhancements. During the process, several amateur ornithologists note that they observed what appeared to be an endangered or rare to the area bird roosting in a grove of trees that is scheduled to be removed. While the bird's presence may not have been apparent during a site visit by the design professionals, there are now indications that they may need to reconsider the tree removal after investigating the situation further.

The role of VGI in the design process should be thought of as more than a mechanism for collecting physical site data. By collecting VGI in the design process, designers might be able to collect a community's opinions, its ideas about a particular topic, or its self-described identity. One example of the latter is the CommonCensus Project (http://www.commoncensus.org), where participants enter their zip codes and information such as their favorite sports teams or the metropolitan area to which they believe their hometown is most closely associated (Tulloch 2007). While there is no right or wrong answer, a map can be created from these data, depicting the boundaries of team affiliations or densities of agreement for a particular subject. This effort to gather information contributed by many individuals and to pull out shared definitions or meanings in these data is central to the value of f-VGI in planning and design. Such contributed information can provide a rich source of insights into the range of perceptions, experiences, or wishes of a large group of citizens, as well as a window on shared goals or common understandings and potential sources of disagreement. In the following sections, I demonstrate some of these potentials, drawing empirical evidence from my efforts to develop and implement digital mapping interfaces for gathering f-VGI in planning and design.

Developing interfaces to elicit f-VGI: prototype system design and functionalities

Over the last decade, I have developed a variety of online mapping techniques that demonstrate how spatial tools can be used in the design process to facilitate the collection of the public's shared wisdom in an effort to produce a better design. I have used these tools and techniques in asset and inventory mapping, site programming, preference studies, and design evaluation. I developed these tools and methods by building upon two interactive online mapping prototypes I created nearly a decade ago. Here I describe these prototypes, and then in the following section, explain how I have expanded them to support a broader range of f-VGI applications in planning and design.

My first prototype mapping interface, called 'River Notes', was developed following the completion of a 70-mile river corridor study that included an exhaustive inventory of the views, historic sites, architecture and other points of interest as identified by local citizens and the design team. As part of the site inventory, three public workshops during which participants were asked to write notes on paper maps that stretched across several tables (Fig. 1). The intent was for the design team to transfer the information collected on these maps into a geographic information system (GIS). This proved to be a time-intensive process, hampered by illegible notes and inaccuracies in the placement of features because of scalar differences in the maps and overlap of submitted features. The value of the local knowledge to the planning process was clear, but so too were the limitations of the process in which the information was collected. These observations motivated my development of the River Notes prototype in 1999.

The purpose of River Notes was to combine interactive online maps and Web database technologies to support design projects that required extensive public input. The interface included an aerial photo consisting of a series of tiles as the background image. Participants interacted with the map by dragging and placing a point marker (yellow dot) from the legend and placing the point at the location about which they wished to comment. Once the location marker was placed, participants could type a 'note' about the feature in the text box located below the map (Fig. 2). Pressing the Submit button then sent the information to an online database and presented participants with a new, clean map to which they could add additional points and notes.

In addition to the interface enabling participants to make notes, an administrator's version allowed the design team to review the submitted data (Fig. 3), viewing either all the submissions or querying the collection to review a subset of the contributions. Clicking on any of the yellow point markers displayed the participant's comment directly below the map. While River Notes was never used on an actual project, it was widely tested and it successfully demonstrated that an easy-to-use Graphical User Interface (GUI) could incorporate spatial content for the purpose of collecting public information, an

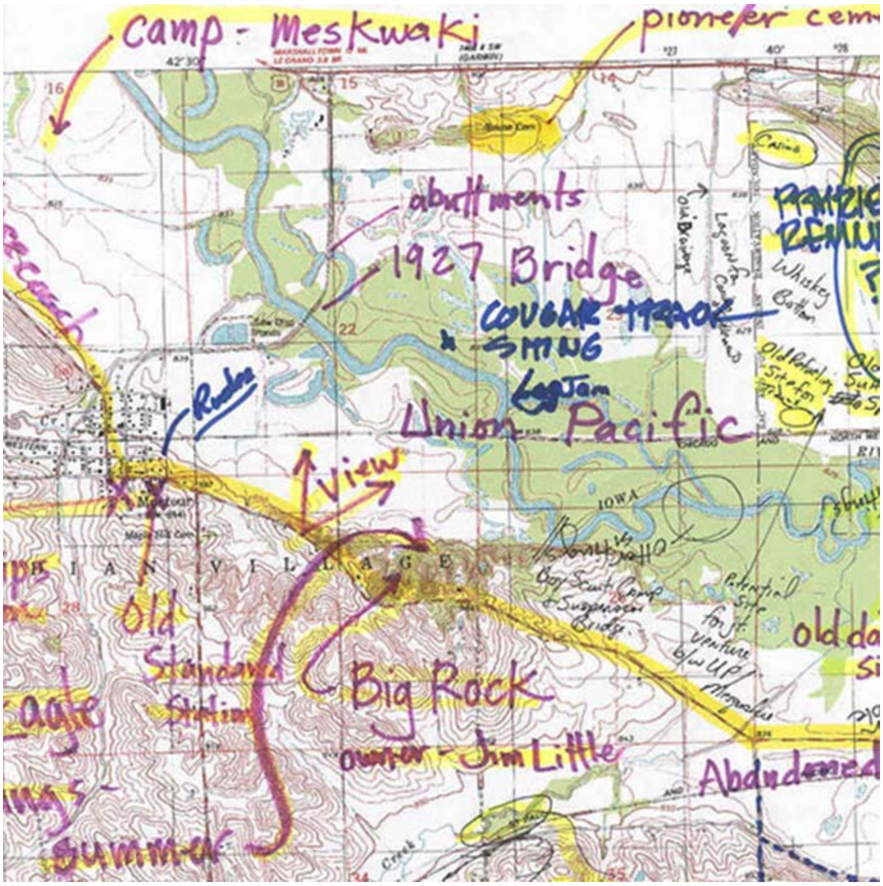


Fig. 1 River corridor site inventory map used to record written public comments

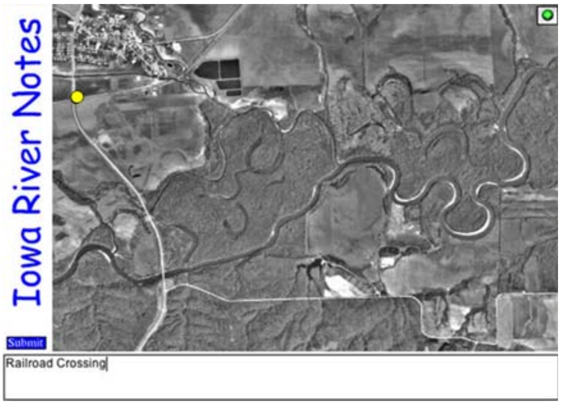


Fig. 2 A dot is dragged onto the map to geo-reference a participant's note along the road south of the town

important finding given the functionalities of e-Participation tools in use at the time.

Building on the framework developed for River Notes, I created another prototype, called the Digital Chip Game (DCG). This application was intended to demonstrate how a geo-enabled interface could be used by participants to locate park program elements such as parking lots, playgrounds, boating and other features by dragging and dropping "iconic chips" from a park activity tray onto a map of the project site. As chips were placed, the participant had the opportunity to enter a comment indicating why the particular location was selected. All placed chips could be reselected and moved until the game board was ready to be submitted to the server.

Like River Notes, the DCG included an administrator's panel that displayed the game results in one of two modes. The first mode displayed each participant's game board individually. This allowed the design team to look at the participant's suggestions one at a time. The second mode allowed the design team to click through and display all records for a selected activity on the screen (Fig. 4). This visualization provided an easy way to discover where the public thought items such as parking, restrooms or swimming activities should be located. The more

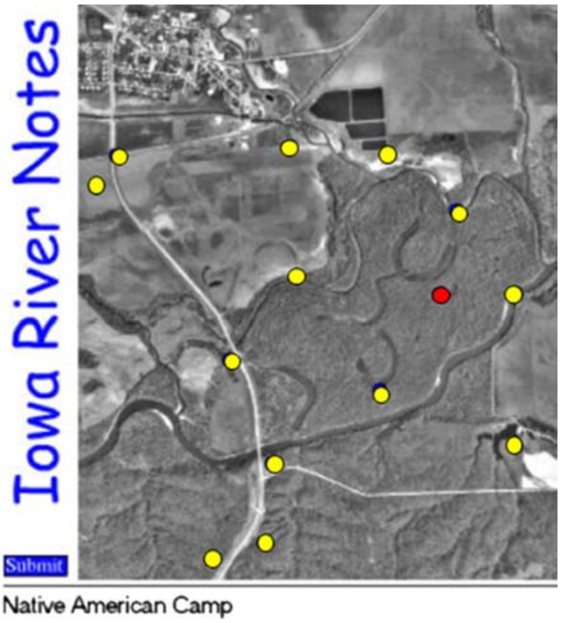


Fig. 3 Administrator's view showing the location of 14 submitted notes with the selected marker's note directly below the map

chips a particular location received, the higher the level of consensus among participants. Both the Digital Chip Game and River Notes were built using Macromedia Flash 4 and a Web-enabled FileMaker Pro Database.

From these prototypes, I have developed other digital spatial tools for eliciting citizens' knowledge and preferences in the design process, and applied these tools in a range of difference empirical contexts. In the following section, I describe these examples and reflect upon their capabilities and limitations.

f-VGI applications in asset mapping, site programming, preference studies, and design evaluation

Since creating the River Notes and Digital Chip Game prototypes nearly a decade ago, I have applied their basic concepts in several other digital mapping applications, which have been used to gather f-VGI in many different planning and design forums. In this section, I describe the structure and functionalities of these systems, and how they were actually applied in practice to gather information from members of the public. These cases suggest that such mapping interfaces may be useful in gathering f-VGI in a diverse range of settings, including asset mapping and inventories, site programming, preference studies, and design evaluation.

In an asset mapping project that required both spatial and non-spatial input from the public to identify specific issues affecting a site, I developed a customized survey tool for gathering this information from citizens. Expanding on the framework originally developed for the River Notes inventory mapping prototype, this interactive geo-survey tool was used as part of the process of developing a master plan for a jointly managed city park and county fairground site. The customized online survey included questions about the existing conditions of the grounds and how they should be improved. The survey asked for demographic information about participants and for information about their experience attending events at the park/fairground. It also included a map of the grounds and allowed participants to indicate on the map where improvements were needed. Like River Notes, the interface was developed using Macromedia Flash and the responses to questions were saved to an online database. Thus, participants' responses could be imported into a GIS to allow for mapping and analysis (Fig. 5).

In another site inventory and analysis application that relied upon such a digital mapping interface to elicit f-VGI, a community held a series of design workshops during which the citizens identified opportunities to improve the green infrastructure of their city. During these workshops, participants were asked to locate resources and points of concern on a series of paper maps. To increase the amount of information collected, the design team incorporated online mapping as part of the participation process. While the River Notes model provided much of the required capability, developing a robust, customized application that could integrate with the design firm's GIS was not feasible. Instead the team used the Google Maps' Developer Application Programming Interface (API) to develop a customized interface that incorporated the GIS base layers while serving as a data collection tool. This dynamic, easy-to-use, f-VGI tool allowed citizens to view GIS data in context with other community features and enabled them to provide their ideas and recommendations for city improvement to the design team (Fig. 6).

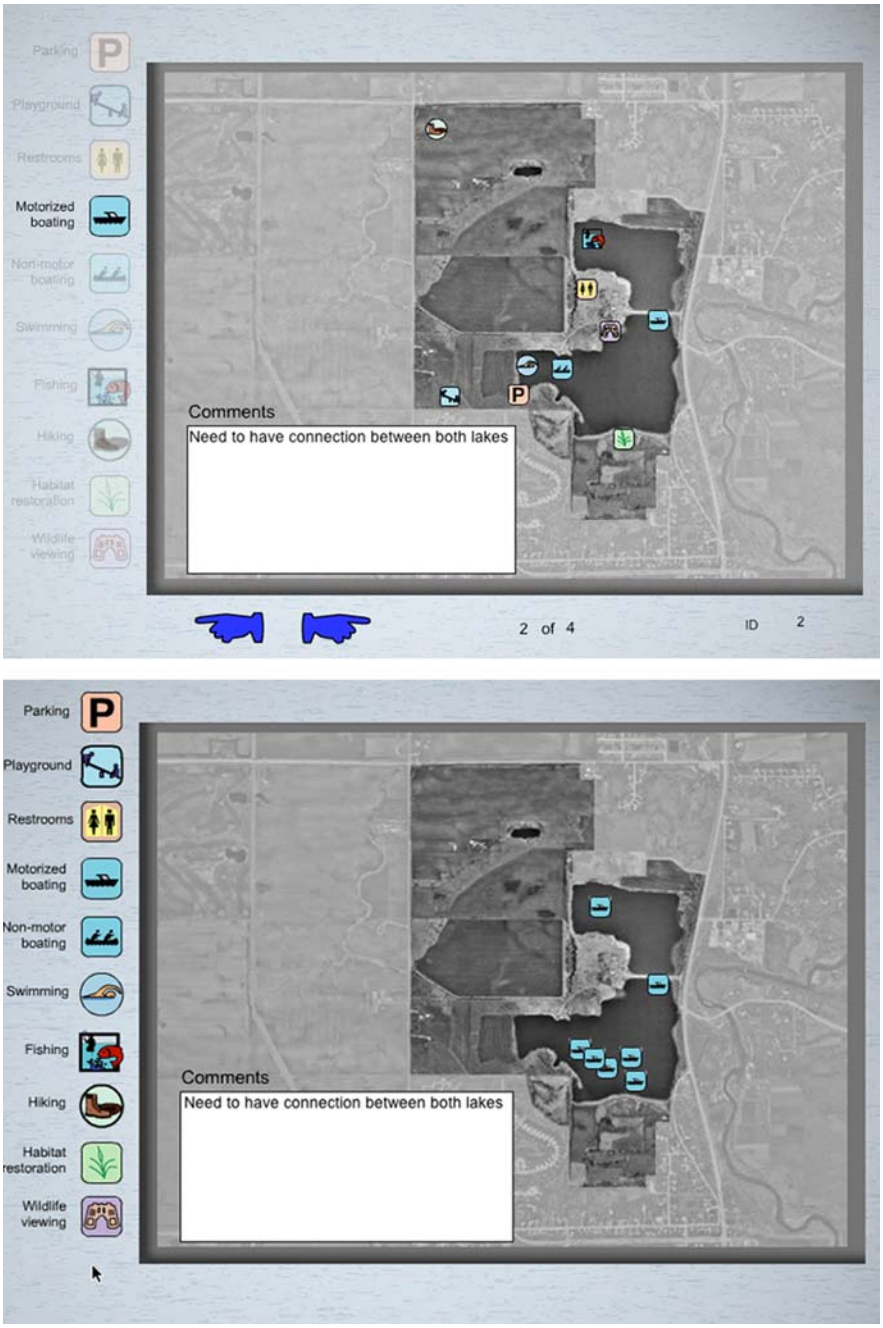


Fig. 4 (Top) Design elements for a proposed park are dragged from the left side of the screen and placed on the map by the participant. (Bottom) The administrator's view displays the location of all motorized boating locations as submitted by the public

Both of these examples of f-VGI in asset and inventorying mapping sought to compile information from as many participants as possible, but to ensure that this information was contributed by participants with some knowledge of the sites in question. In both cases, participants' locations were used as a proxy for such knowledge, assuming that if they lived in the community or had visited the site being designed, they would have sufficient knowledge to provide reliable input. To validate that participants met these criteria, the f-VGI interface included in the first example included a set of questions about participants' zip code, number of years living in the community, and number of visits to the site in the past five years. The system was designed to use this information as a filter, storing a 'validity' code in the

Fig. 5 (Top left) Question interface with point placed on map. (Top right) Administrator view showing several submitted points. (Bottom) Survey responses displayed as symbolized data in GIS

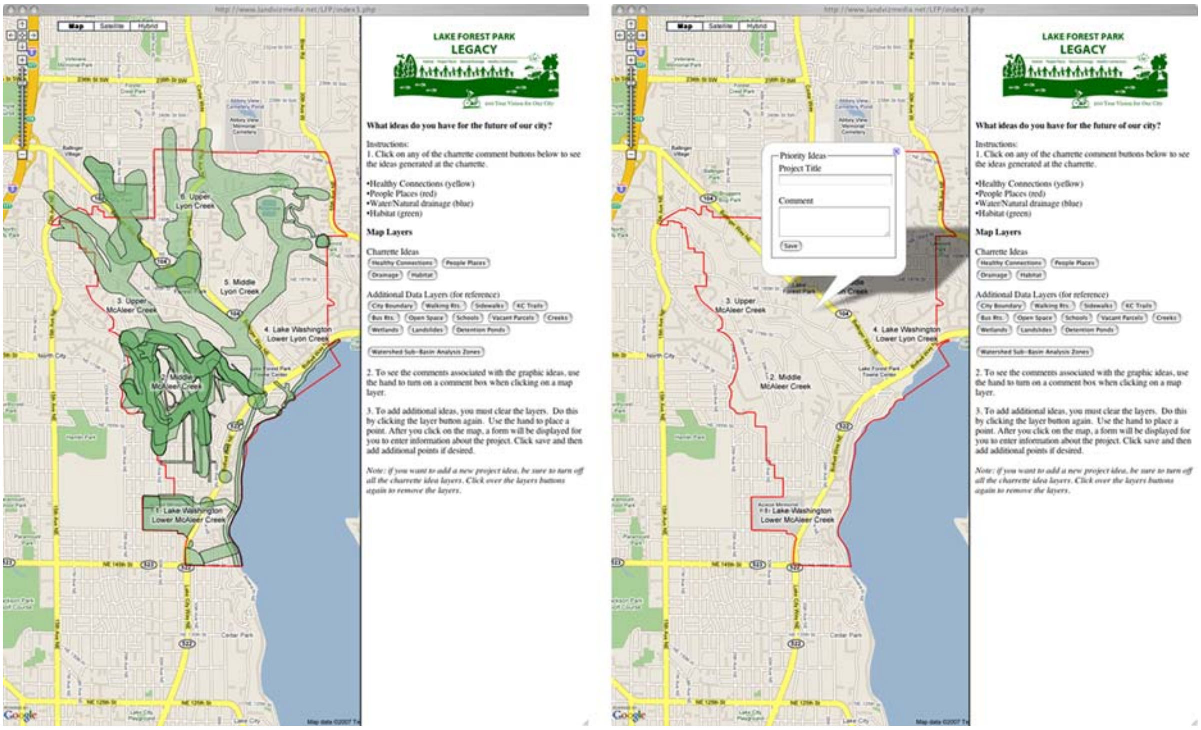


Fig. 6 (Left) The site allowed participants to turn on and off several GIS layers, including sidewalks, trails, schools, parks and vacant lots. (Right) Participant navigates to an area of concern and places a point on the map

results identifying records that were within a specified tolerance of the study area and in compliance with other criteria.

f-VGI also has potential utility in site programming. Building on the first chip game prototype, I later developed an Internet-based version for a park master plan. Dubbed DCG2, the program was a Rich Internet Application (RIA) designed to provide instant feedback, drag and drop exploration of design options, and maximum flexibility in interface content. The RIA utilized the Visual and Spatial Survey Builder (VaSS-Builder) setup wizard, a tool I had created, to develop an application that allowed the facilitator to control the look and feel of the application, including the welcome message, project titles, interface styles, background imagery and the icons used as game chips. A security feature required participants to log in with an account name and password, ensuring that each invited participant could submit only one game board to the server.

As with the original DCG, participants were asked to drag and drop icons or chips representing program elements from a scrollable tray located on the right side of the screen to the map indicating where they thought each item should be located. Also like the original DCG, the application allowed the design team to display and review composite maps of the submitted data. The enabling of this feature was based upon the access privilege assigned to a user's login. The review page allowed the design team to step through each submission or view an entire category as shown in Fig. 7. DCG2 was built using Flash 8, MySQL and PHP. The combination of PHP and SQL databases made the system adaptable, so that the facilitator could create new projects with unique interfaces, customized base maps and corresponding program chips.

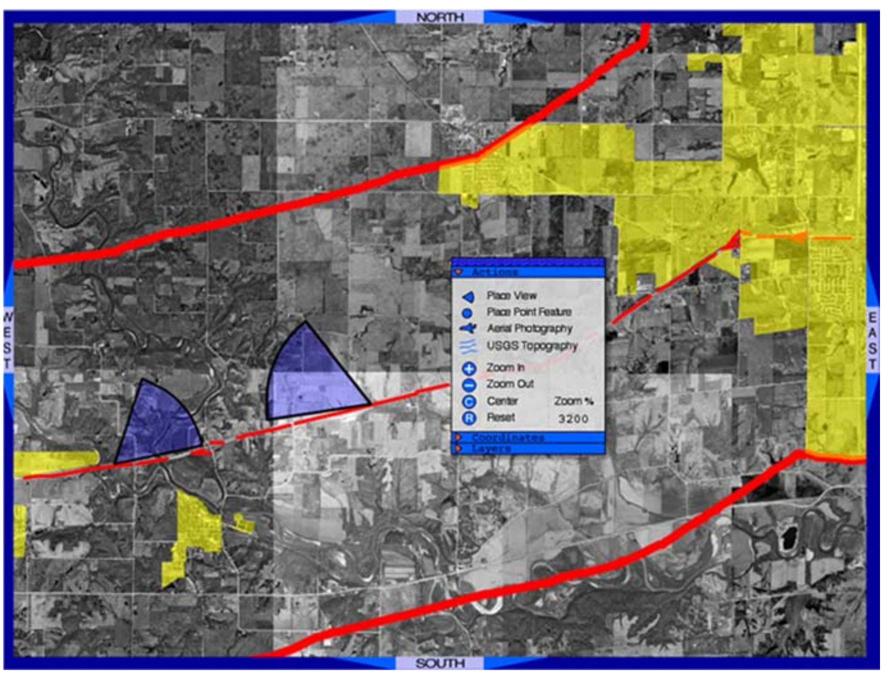
Another useful application of f-VGI is in preference studies in which information may be gathered from many members of the public regarding their preferences for various design options or site locations. For example, identifying the location and quality of views along a corridor is a very subjective analysis that can benefit from having numerous evaluators. In 2002, I developed a system called the 'Viewshed Delineator' to support a highway corridor

Fig. 7 Digital Chip Game participant interface (left) and composite view (right)

study of more than 300 miles of roadway and 2,000 square miles of adjacent land. This visual tool was intended to be used via the Internet or at computer kiosks, however was not implemented beyond the study group. Participants could pan or zoom to a desired location and then draw a 'viewshed cone' on the screen (Fig. 8). With these inputs from the user, the system displayed the resulting view, and a comment box in which the participants could make notes about the view.

Participants could also toggle between aerial photographs and USGS maps, turn GIS overlays on and off, and search for specific locations. The base aerial imagery for the system consisted of thousands of image tiles saved at several resolutions. An internal coordinate system manager tracked the level of zoom and the screen and geographic coordinates of the center of the map, so only the needed imagery was downloaded (plus imagery for areas outside the border of the screen display). Downloading this additional imagery along the borders allows the map to be smoothly panned without having to wait for new imagery to load. This process is very similar to the functioning of Google Maps today. The Viewshed

Fig. 8 The location of viewsheds along a highway corridor



Delineator demonstrates how an f-VGI tool could be used to develop a rich dataset from the preference information contributed by members of the public.

A second preference study example illustrates how f-VGI can be used to help develop safe walking and biking routes for kids to travel to and from school. When developing these routes, it is often useful to understand how the students actually get to school and the routes they use. Developing these data by giving each child a GPS receiver is not a feasible technique, but Internet maps can be used to facilitate the collection of this information. During a recent pilot project, fourth- and seventh-graders and their parents digitized their actual or potential routes for walking or biking to school on a customized Google API map and located and described barriers along these routes (Fig. 9). Typically, the collection and analysis of this type of information is a laborious task, and many planning groups simply forego the process or do it infrequently. Through the use of a digital system for gathering f-VGI, this information can be collected much more easily. In this case, the collected information was later consolidated in an online database and it was used by the planning group to identify where improvements such as sidewalks and crossing lights/guards were needed in the community.

The f-VGI applications described thus far included two-dimensional maps and utilized chips or markers to represent features on these maps. More recently, I developed prototypes in 2008 that take this process a step further by incorporating 3D visualization in the f-VGI process. I have evaluated these systems in the planning process for developing master plans for county fairgrounds and parks, using Google's SketchUp to develop spatially referenced 3D models (SketchUp files) of proposed architectural and site layout changes. Participants can view these models in a navigable virtual environment, and like the other tools previously discussed, insert spatially-referenced

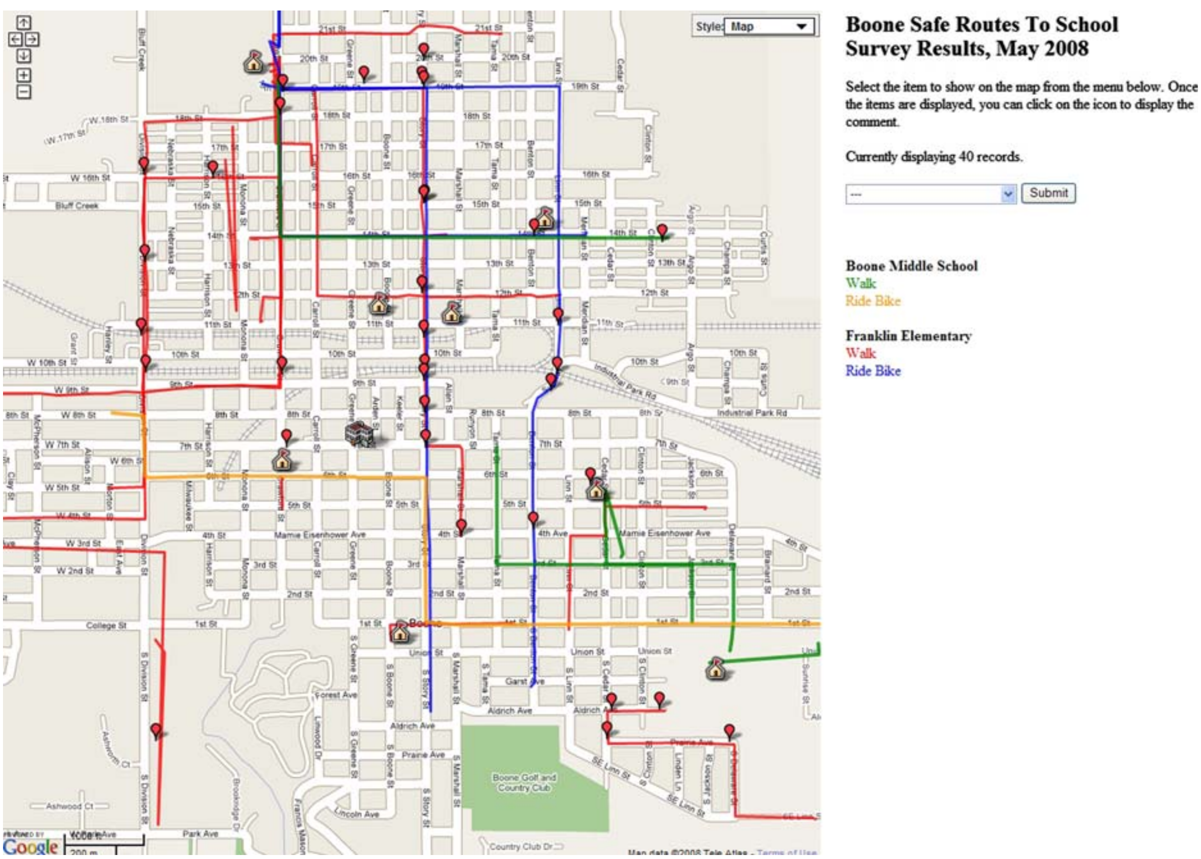


Fig. 9 Selected set of walk/bike to school routes and perceived barriers (red markers) as reported by students for two schools

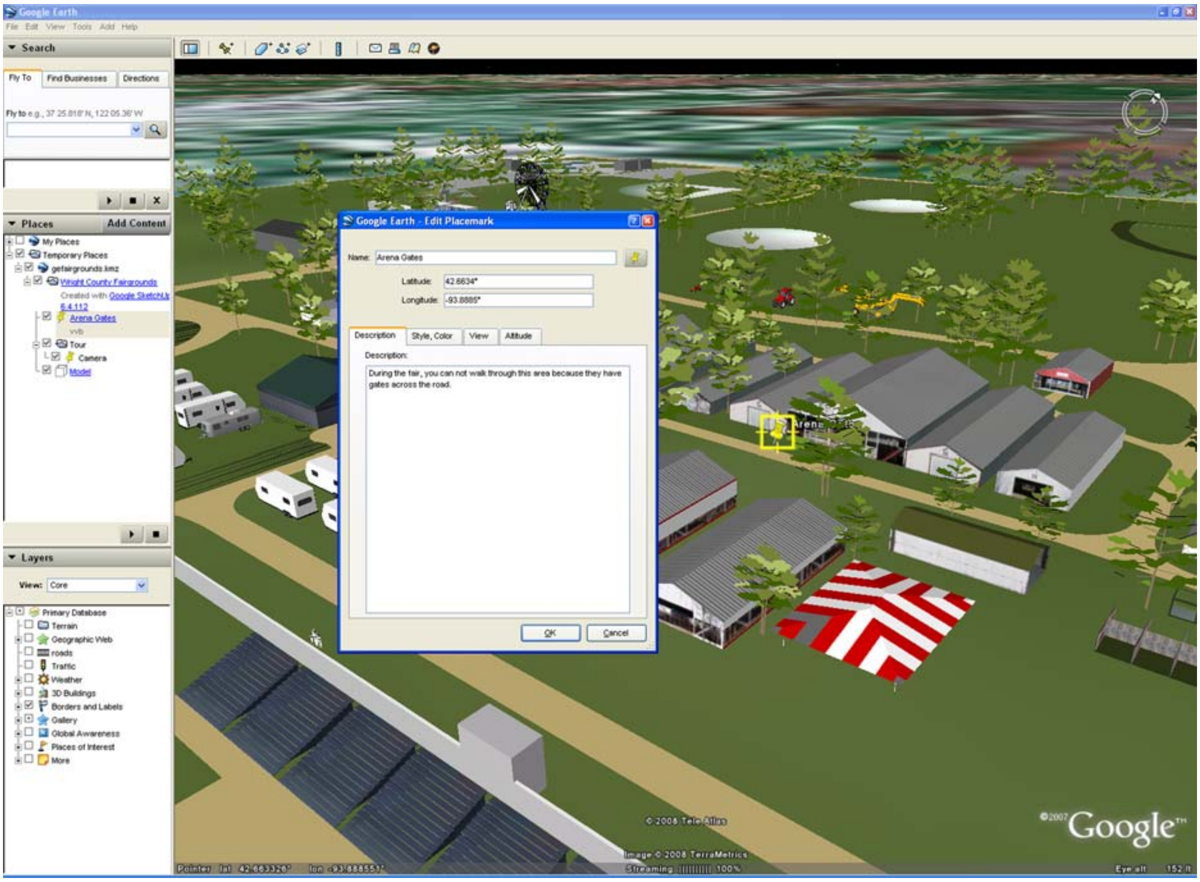


Fig. 10 Google Earth view of 3D fairground buildings with a survey participant's comment geo-referenced to the model and ready to send to design team

comments by placing pins or markers on the map and submit these points to a Web server (Fig. 10). As with the chip game systems, the design team can query the data and view the submitted information, in this case using a commercial version of Google Earth (Fig. 11).

Reflections and recommendations

Developing the systems described above and implementing them in a diverse range of participatory planning and design processes has afforded me several insights upon how we might develop f-VGI that includes the perspectives of a diverse range of potential participants, is a reliable source of credible information, and is of high quality. While much of my discussion in the previous section focused upon the design of systems for obtaining f-VGI, it is important to note that there are additional issues to address, besides just how to obtain information from members of the public. We must also consider whether all members of the public have had an opportunity to contribute information, whether the contributed information comes from participants who are likely to have credible knowledge, and how to ensure a high level of information quality. In this section, I draw upon the cases described earlier to recommend feasible strategies for addressing these considerations.

In all of the applications described previously, a primary concern was to solicit participation by a broad audience. In trying to do so, I faced three key challenges. First, I sought to ensure that the public was aware of the opportunity to participate. One of the most common approaches is to publish a call for

Fig. 11 Design team's view of submitted information. Comments queried to display only those containing the word "gate"

volunteers using the local newspapers, radio and television stations. While this method works in communities that have all three types of media outlets, in smaller communities only a local newspaper may be available. In these cases, additional methods of notifying the public are necessary to avoid excluding possible participants who do not receive the newspaper. One alternate method is placing signs at local businesses or on the library or post office bulletin board. If the project involves a local committee or board, members can email or call individuals who are part of their social or business networks and tell them about the opportunity. I have used this technique successfully in several recent projects and while it creates an initial jump in participation; this quickly diminishes after the first level of calls or emails is completed. This problem can be alleviated if the initial notice includes a request to notify others about the opportunity. Another alternative is to directly invite select individuals to participate, based upon a random sample of the community. This method generally requires additional facilitation and the VGI application must be designed to differentiate between participants that are part of the random sample and those who may have heard about the project and wish to provide their own unsolicited comments.

Once the opportunity to participate has been widely announced, a second challenge is removing limitations stemming from unequal access to the Internet, since so many f-VGI applications are Internet-based. To accommodate participants who do not have home Internet access, computers at a local library might be used or a series of computer kiosks can be made available at public agencies or in local businesses. A series of Saturday or evening sessions could be scheduled to ensure that individuals unable to visit during regular business hours have an opportunity to contribute. Finally, for those individuals unfamiliar with using computers, it might be necessary to facilitate use of the systems, perhaps pairing these participants with others who have greater familiarity with computers or if necessary relying on paper versions of the maps and then transferring that information manually to the system.

The third issue that can affect participation in f-VGI is the design of the interface used to collect the information. It is critical that the participant's experience is not hindered by difficulties in manipulating the technology, so they can focus on simply entering the information they wish to share. If the interface is not intuitive or is difficult to use, respondents are likely to skip that section or stop participating. When developing f-VGI applications using tools such as Adobe Flash or a developer API, it is imperative that the design of the interface navigation tool adhere to conventional standards used in Web applications with which the participants are likely to be familiar. For example, including familiar looking pan or zoom controls and icons used to save or submit responses will help ensure system usability. The ability to undo an action such as placing a point on the map or moving a marker or line segment after it has been drawn allows the participant the chance to correct an error, potentially resulting in more accurate information.

In addition to ensuring that members of the public are able to participate in the collection of VGI, another consideration is the degree to which these information contributors are knowledgeable about the issues being examined. f-VGI processes provide several opportunities to gather information about contributors, which might be used to validate the extent to which they possess knowledge of the area or are aware of the issues that have prompted the need for collecting public input. In the case of asset and inventory mapping, the purpose is to collect information about a specific site or area, so one might reasonably assume that knowledgeable participants would be those who have lived in the area for more than a year or visited the site on several occasions. For example, in the City Park/Fairgrounds case study, participants were asked where they lived and how often they visited the grounds. While this process of validation does begin to categorize the responses, it is only an indicator of the potential for the participant to provide valid information—it does not indicate the actual value of contributed information. As well, an individual who indicated that s/he recently moved to an area may not have a deep knowledge of the area, but s/he does have a first impression, which can also be valuable to the planning and design process. Another way of validating the knowledge of information from contributors in an f-VGI system would be to include a brief test or self evaluation of their knowledge of the subject matter. For example, if the goal of the project is to locate a new boat ramp and camping area around a lake, such an evaluation might require participants to identify the location of park features on a map, to confirm that they are familiar with the site.

Data quality

Finally, it is important that an f-VGI system provide participants with data and imagery that can aid them in providing high quality information. For example, in order for participants to be able to provide highly accurate geographic information, a useful aid is a good quality base map. Base maps should include both the transportation network and aerial photography, to assist participants in orienting themselves to familiar features. While mapping applications such as Google Maps, Yahoo! Maps, and Microsoft Virtual Earth include access to these data layers, the transportation network data can contain significant errors and the quality of the aerial imagery may not be sufficient for the identification of features. One solution to this issue is to use your own customized imagery for the study area as an overlay.

Conclusions

The wide availability of high-speed bandwidth and the emergence of more mobile devices with built-in Internet access will likely increase opportunities for members of the public to participate by contributing information to planning and design processes. Since I developed the first pilot projects nearly a decade ago, the growth of online geospatial data sources and developer tools from companies such as Google, Microsoft, Yahoo, and ESRI has made it much easier to integrate geographically referenced public information into the design process. As these technologies continue to improve and become more widely adopted, we are likely to see a growing number of processes seek to incorporate VGI, such that local residents can become involved with policy- and decision-making in their communities.

The case studies described in this paper demonstrate ways in which the collection of VGI can be facilitated through digital mapping systems and used as a public participation tool. Additional research is needed to develop recruitment methods that foster diverse participation, ways of validating the expertise of participants and the quality of the information they provide, and appropriate ways of sharing the collected data can be shared beyond its initial purpose. These issues need to be resolved if VGI is to be used at a broader level and implemented as part of spatial data infrastructures to complement the authoritative or 'official' data that make up the backbone of many geographic information systems.

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