Proceedings of Spatial Knowledge and Information - Canada (SKI-Canada) 2009, February 19-22 in Fernie BC, Canada.

Volume 2

Proceedings Editor
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This is the proceedings of the 2009 conference of Spatial Knowledge and Information Canada, held February 19-22 in Fernie BC, Canada. The intent of Spatial Knowledge and Information Canada is to bring together (digital) Geographic Information researchers and their students from across Canada. We define Geographic Information research broadly as any geographic research in which computation is its main focus. The prime computational platform is Geographic Information Systems although we include Geographic Information Science research, geomatics, remote sensing, geospatial web 2.0, and spatial statistics and modeling. We encourage theory and practice and we invite research on the widest range of applications from GIS-transportation and health to GIS in education and business. We also stress work-in-progress, our reasoning being that the conference would stimulate additional avenues of exploration.

The 2009 conference was held in partnership with the GEOIDE Network Center of Excellence. Over 60 researchers, university faculty, students and interested parties from across Canada registered and attended. While the focus of the organization and conference is to bring together the Canadian Geographic Information community we also invited a small number of international attendees. The conference was composed of 43 scientific papers. We were delighted to have as our keynote speaker, Marie Josée Fortin, who wowed the audience with her lucid explanations of geostatistics. The conference concluded with a conference planning meeting on the final day, where we decided to skip a year due to the Winter Olympics to be held in British Columbia and resume our conference in 2011.

A substantial focus of the conference continues to be the promotion of Canadian student research on Geographic Information. We were excited to have 29 presentations by undergraduate, Master’s, PhD students and postdoctoral fellows. We awarded seven outstanding students substantial awards for their research and presentation quality. First prize went to Jonathan Cinnamon, Simon Fraser University, for his presentation "Injury data collection and analysis in low-resource settings Using Web 2.0 and the Geospatial Web". Three people tied for second prize: Cyrille Médard de Chardon, Simon Fraser University, for his presentation "Real-time Interactive Groundwater Visualization using 3D Cellular Automata", Stine Barlindhaug, UBC Okanagan, for her presentation "Cultural sites, traditional knowledge and participatory mapping; Long-time landscape use in Sápmi" and Gregory Mc Quat, Queens University, for his presentation "3D Cellular Automata and Mobile Terrestrial Lidar: Simple rules for urban geography." Honourary mentions went to Jake Wall, UBC, for his presentation "Elephants Avoid Costly Mountaineering", Andrew Cuff, Memorial University, for his presentation "Improving seabed classification through the use of multiple acoustic frequencies" and Krista Jones, Memorial University, for her presentation "Relationships between Cold-water Corals off Newfoundland and Labrador and their Environment". Congratulations, prize winners and to all our student presenters!

Please enjoy the extended abstracts of student and faculty talks in these 2 volumes, visit the SKI-Canada site and attend the 2011 conference.

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Real-time Interactive Groundwater Visualization using 3D Cellular Automata

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Abstract

Groundwater is an inherently three dimensional concept commonly communicated through diagrams in text books, educational posters or rendered in groundwater modeling software (Cherry and Freeze, 1979; Todd and Mays 2004; Fritts 2002; Schwartz and Zhang 2002; Turner et al., 2006, Li and Liu, 2004). In an attempt to improve existing communication tools we developed an interactive groundwater model prototype designed to encourage discussion and participation of Okanagan Basin (OB) stakeholders in their decision making processes. CABI (Cellular Automata Basin Interface) provides non experts a first glimpse of the relationships between groundwater, wells, and rivers. CABI gives OB stakeholders a 3D interactive experience allowing manipulation of the terrain and placement of wells. Water is implemented using cellular automata (CA) modelling which allows real-time changes in water levels adapting to wells and their surroundings. Testing by 43 participants to discern performance effects due to variations in manipulation controls showed differences in task completion times.

Background and Relevance

The Okanagan Basin (OB), one of Canada's driest regions, has limited water recharge despite the apparent abundance of lake water. With an increasing population and most surface water already allocated groundwater is seen as an alternative. Communicating to OB stakeholders the relationships between groundwater and surface water can help bring consensus and encourage dialogue regarding sustainable growth, water conservation and protection. Public groundwater education methods have largely relied on traditional mediums. This project attempts to bring an interactive sandbox environment to stakeholders by implementing cellular automata (CA) modeling, and geovisualization principles to communicate groundwater concepts. This research project also utilizes CABI to explore the effects of differences in model manipulation and visualization. Cellular automata modelling, created by von Neumann (1966) and popularized by Stephen Wolfram (1983), is a relatively new and powerful method of modelling complex systems. Cellular Automata is a form of aggregate complexity where simple local interaction between components or cells creates a complex system (Mason, 2001).

Methods and Data

This project focuses on the creation of a desktop 3D environment driven by CA engine to control the behaviour of water and uses geovisualization principles for the manipulation and interaction with the model. The resulting sandbox environment allows simple interaction with a seemingly simple but hidden complex system. In addition to the design project, three lab sections of an introductory geography class supplied 43 volunteers for testing. While all completing the same task, half of the participants used version of CABI with constrained visualization controls.

Results

CABI successfully simulates river flow, base flow, and cones of depression due to well placements. All changes occur in real-time allowing target stakeholders to explore interaction between sub surface and surface water in a robust virtual sandbox environment. Statistical comparisons between samples show little measurable change with the exception of significantly faster completion times for participants using constrained versions of CABI.

Conclusions

Using CA to model water behaviour in geovisualization environment brings models commonly used by scientists for research to stakeholders. While primitive and graphically simple the complex system resulting from a CA design allows for an immersive and interactive experience that can bring consensus between expert and non-experts. While testing compared model manipulation controls and found few significant differences, more testing is required to determine the efficacy of CABI relative to classic educational methods. CABI is however an immersive experience that can be enjoyable and foster discussion regarding the connections between surface and sub surface water.

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Perception of Pattern and Process in Seabird Distributions: an Assessment of the Impact of Alternative Visualization Methods

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Abstract

Advances in scientific visualization offer an ever-growing number of opportunities to depict and explore spatial information (DiBiase et al. 1994). However, parallel developments in different fields have limited communication about when and how different visualizations are effective (Gahegan 2008). As a member of an inter-disciplinary group interested in the spatial distribution of seabirds at-sea, the author sought to compare the relative effectiveness and interpretability of a range of visualization approaches. Through the use of an anonymous web-based survey, four different visualizations were evaluated by a small sample of study participants: 2D proportional-symbol maps, 2D interpolated-surface maps, and both static and dynamic 3D maps. There was evidence that the type of visualization impacted respondent's interpretations, with dynamic 3D visualizations stimulating conclusions not reported using any other method. Respondents commented on all four types of visualizations, but the provisioning of a 3D perspective was described as more "precise" and informative. The type of data was also important for determining the intelligibility of the 2D maps, with the more sparsely-distributed Thick-billed Murre more clearly showing hotspots of occurrence. User experience may have influenced the results and lead to more favourable evaluations of the role of interpolation surfaces and dynamic 3D visualizations.

Background and Relevance

Advances in scientific visualization offer an ever-growing number of opportunities to depict and explore spatial information (DiBiase et al. 1994). However, the historical development of visualization systems had proceeded across different disciplines in isolation from each other (Gahegan 2008), resulting in a lack of communication and inter-compatibility between different systems. This situation forces the spatial analyst to choose a system to study and utilize, with little guidance as to which visualization elements are going to be effective (Gahegan 2008). The question of "which visualization method will be most effective for exploring my particular phenomenon of interest?" remains unanswered.

As a member of an interdisciplinary group with different backgrounds and experiences with spatial analysis tools, but a shared interest and concern for the offshore distribution of seabirds inhabiting Canadian Atlantic waters, the author sought to reveal new "truths" about the spatial distribution of seabirds at-sea. But parallel to this main objective a secondary goal emerged: in what way does the type of visualization inform the "end user"? What impact does the visualization approach have on their ability to make inferences? And furthermore, what role do visualizations play in fostering collaboration and generating new research questions?

In this preliminary study the relative effectiveness and interpretability of a range of visualization approaches were compared. In a survey of the seabird literature there was a unanimous tendency for authors to fix the scale and extent of the visualization, and to rely on conventional 2D maps and symbology. Particular elements of symbolization were preferentially employed (e.g., proportional symbols: Certain *et al.* 2007, Serra-Sogas *et al.* 2008), as were uni-dimensional summaries of abundance as a function of distance along a survey track (Durazo *et al.* 1998, Skov and Durinck 1998). Occasionally, predictive models were employed to estimate abundances for particular points (Yen *et al.* 2004a) or entire surfaces (Fauchald *et al.* 2002, Clarke *et al.* 2003, Skov *et al.* 2008), but at 2D scales, extents and resolutions fixed by the authors. This is despite the evidence raised by Weimerskirch (2007) that seabird distributional patterns vary with scale as a result of changes in the nature of the species response. For example, at broad scales distributional patterns reflect prominent oceanographic features (such as the location of seamounts or shelf breaks; see Skov and Durinck 1998, Yen *et al.* 2004b) or constraints imposed by the need to be within tolerable distances to breeding colonies (Yen *et al.* 2004b, Weimerskirch 2007).

At finer spatial scales, distribution is much more sensitive to local combinations of prey abundance, and individual birds will show peculiarities in their daily movement patterns (Weimerskirch 2007), respond to the presence of other species (Durazo *et al.* 1998), etc. Seasonal variation in habitat usage also adds a source of temporal variation in seabird distribution that confounds simple depictions of species occurrence. Fixing the scale and extent of visualizations helps to make the task of interpreting distributions more manageable (Andrienko *et al.* 2006) but may also obscure important patterns. The problem of scale-dependent emergent behavior doesn't just complicate the understanding of animal distribution but represents a major research challenge facing any geovisualization study, methodology, or theoretical framework (MacEachren and Kraak 2001).

Four types of visualization were developed, each of which could be naturally positioned along a continuum of visualization complexity (both in terms of the amount of information communicated as well as the level of interaction required to interpret them). The first two were strictly 2D and involved the use of either (1) proportional symbols, or (2) interpolated surfaces. These closely mimicked the types of visualizations currently employed in the seabird literature, and were of fixed scale and extent. The last two were 3D images, and were either (3) static 3D or (4) semi-interactive, animated 3D. These last two methods were totally novel approaches to representing seabird distributions, with the latter varying scale as well as orientation. All methods shared the same chief objectives, however: provide a synoptic view of distribution that would allow inferences to be made about the way birds were using the marine environment, and to illuminate how seasonality influenced that usage.

Through the use of a small, anonymous sample of colleagues from a seabird research project (the Atlantic Beached Bird Analysis), the utility of each visualization was assessed. Similar to Brunsdon et al. (2007), the following four questions were examined: (1) do the interpretations of spatial trends vary according to the types of visualization technique employed?; (2) is one technique clearly preferred, or is a combination the best way to enhance understanding?; (3) does the suitability of the visualization method depend on the type of data available?; and (4) does the effectiveness of the techniques vary with user experience?

Methods and Data

Observations of seabird occurrence and abundance were gathered during at-sea surveys conducted from March 2006 to March 2008 (Wilhelm et al. 2008). At regular positions along the survey track the presence or absence of different seabird species were noted, as were the numbers observed and the season in which observations were made. For the purposes of this study, "winter" was classified as observations gathered from November to January, "spring" from February to April, "summer" from May to July, and "fall" from August to October

The 2D proportional-symbol maps used symbol size to communicate relative differences in abundance, and their scaling was defined using the following formula:

$$scaling = \frac{k * CV * count}{\max(count)}$$

where k was a constant (defined as 5) and CV is the coefficient of variability of the counts (standard deviation / mean). The visualizations were conditioned on season, with a separate figure generated for each combination. These black-and-white figures are representative of many geographic visualizations that appear in the marine literature (e.g., Certain et al. 2007, Fig. 3a; Serra-Sogas et al. 2008, Fig.4). The figures were generated using the R Statistical Package (Ihaka and Gentleman 1996).

As with the 2D proportional-symbol visualizations, 2D interpolated-surface maps contained information about where (and in which season) seabirds were observed. Through the use of differences in hue and saturation, the four-panel display (one figure per season) was reduced to one single figure. Symbols were of uniform size – indicating at least one seabird observation – with color indicating the season in which the observation occurred. The locations of the survey tracks were added as uniformly-sized grey symbols, constituting a new datum missing from the previous visualization. Additionally, differences in relative abundance were symbolized using a color-graded interpolation surface (with blue = lowest abundance, red = highest abundance). The extent of the study area was also indicated using a dark-grey surface. This visualization was produced using ArcMap (Environmental Systems Research Institute 2006a).

The same information provided by the 2D interpolated-surface maps were also available in the static 3D visualizations, but rather than employ a colour-scaled interpolation surface, symbol height was used to represent relative differences in seabird abundance. Inevitably, the use of 3D perspective reduced the dependence on colour as an information medium and may have helped reduce the apparent complexity of the image.

Being a static display, the vantage point was defined by the map-maker (DJL), with users being presented with only one instance of orientation and scale. This visualization was produced using ArcMap (Environmental Systems Research Institute 2006a).

Lastly, dynamic 3D visualizations were produced to help alleviate some of the previously mentioned limitations. While respondents could control neither the scale nor the orientation of the visualizations, they were presented with a "fly by" panoramic view that took them through the landscape by rotating the surface 360^o counter-clockwise (thereby accommodating different orientations), and which varied the distance to the surface (thereby altering scale). The animations were produced using a series of still images gathered using ArcScene 9.2 (Environmental Systems Research Institute 2006b), and were distributed as large (~40Mb) avi animation files.

A key criterion for the design of this study was the protection of respondents' anonymity. Furthermore, in order to maximize the likelihood of candidates choosing to participate in the study it was necessary to design an interface that would render it as simple as possible for them to observe the visualizations and provide their responses. For this reason, a web-based platform was programmed using a combination of the PHP 4 scripting language (PHP Group 2008) and a MySQL database backend (Sun Microsystems 2008). Users visiting the website were taken on a "guided tour" of each of the visualizations (first for the Northern Gannet, then for the Thick-billed Murre) and provided with an opportunity to submit comments for each one independently.

Results

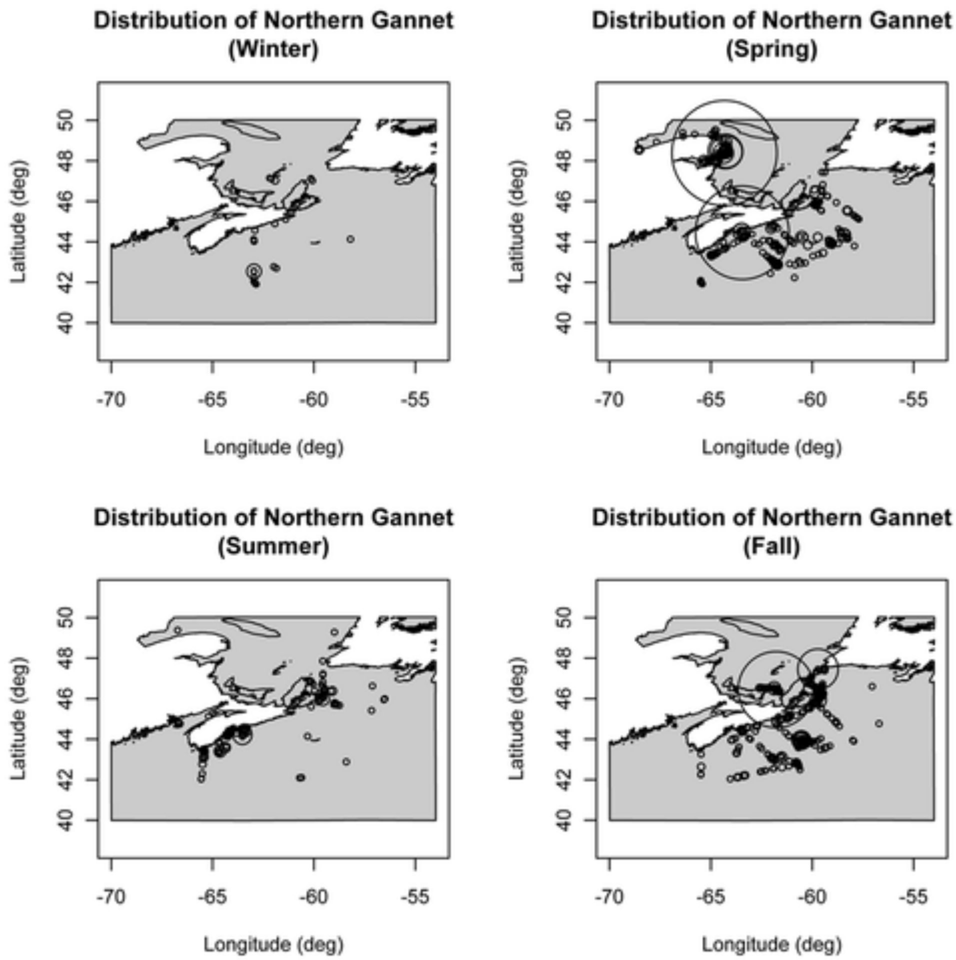
Participant's Prior Experience with GIS

The web interface received records from five participants. When posed the question "have you ever taken a course in cartography, surveying or GIS?", half of the participants who responded to this question reported that they had completed a course in GIS, while one declared that they used GIS but had never studied it formally. Another participant described themselves as having never used GIS.

In response to the following question "if you are familiar with, and use GIS on a regular basis, please indicate how long you have used these software tools", two of the five reported using it for more than 2 years, while one individual reported using if for more than 6 months but less than 2 years. Two of the five reported that they had never used GIS.

All respondents responded positively to the question "do you enjoy studying and using maps?".

The final question was one of self-assessment: "how would you characterize your GIS and mapping skills?'. Four of the five respondents (80%) described themselves as "informed" users, while one described themselves as a "novice".


Distribution of Northern Gannet
(Winter)
Distribution of Northern Gannet
(Spring)
Distribution of Northern Gannet
(Summer)
Distribution of Northern Gannet
(Fall)
Latitude (deg)
Longitude (deg)
40
42
44
46
48
50
-70
-65
-60
-55
Fig 1a.

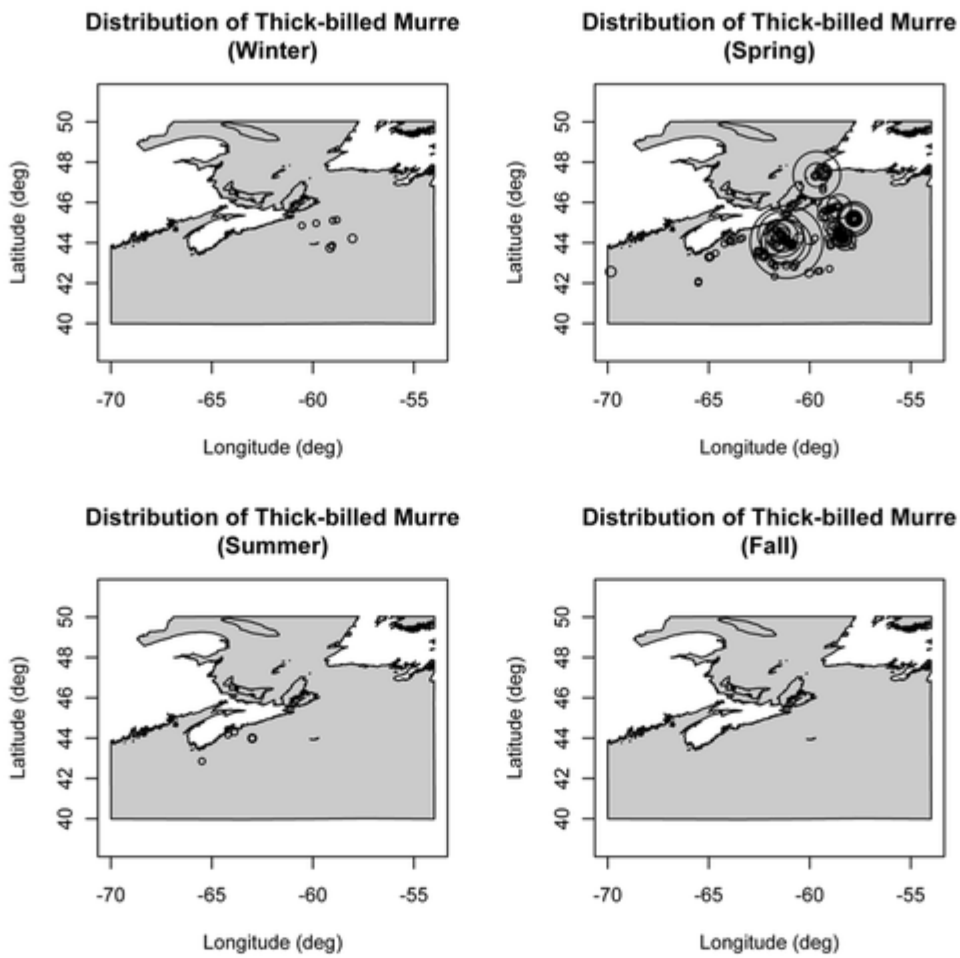


Fig. 1b.

Receptivity to 2D, Proportional Symbols Maps

Participants were first presented with two-dimensional proportional symbol maps for each species (Fig. 1a,b). In these figures, three factors were displayed: (1) locations of occurrence, (2) abundance (proportional to symbol diameter), and (3) season (winter, spring, summer and fall). No attempt was made to present seasonal variation in occurrence and abundance in a single figure; instead, four separate figures were generated, one for each season. This type of figure is representative of many geographic visualizations that appear in the marine literature (e.g., Certain et al. 2007, Fig. 3a; Serra-Sogas et al. 2008, Fig.4).

Referring to the criteria of Williamson and McGuinness (1990), two respondents reported that it was difficult to distinguish relative differences in abundance because the "maps were too small" and points overlapped too much. Overlap seemed most confusing for Fig. 1a, where many individual occurrences resulted in a larger number of uniform symbols. Two respondents expressed a difficulty with distinguishing these smaller points from islands. This seemed to be less of a problem for the Thick-billed

Murre visualization (Fig.1b), as one respondent described the proportional symbols to be "quite effective for showing hotspots". In this case, winter, summer and fall occurrences were uncommon and sharply contrasted with the heavier spring usage. A number of respondents correctly described the seasonal differences in occurrence but were also able to pinpoint such geographic locations as the Halifax Harbour and the Cabot Strait, neither of which were labeled or indicated in the original visualizations. This suggests that prior geographic familiarity may contribute to map interpretability. Some respondents also reported discomfort with the absence of information about survey effort, particularly in the case of Fig. 1b where absences in winter, summer and fall may have been partially attributable to uneven sampling coverage.

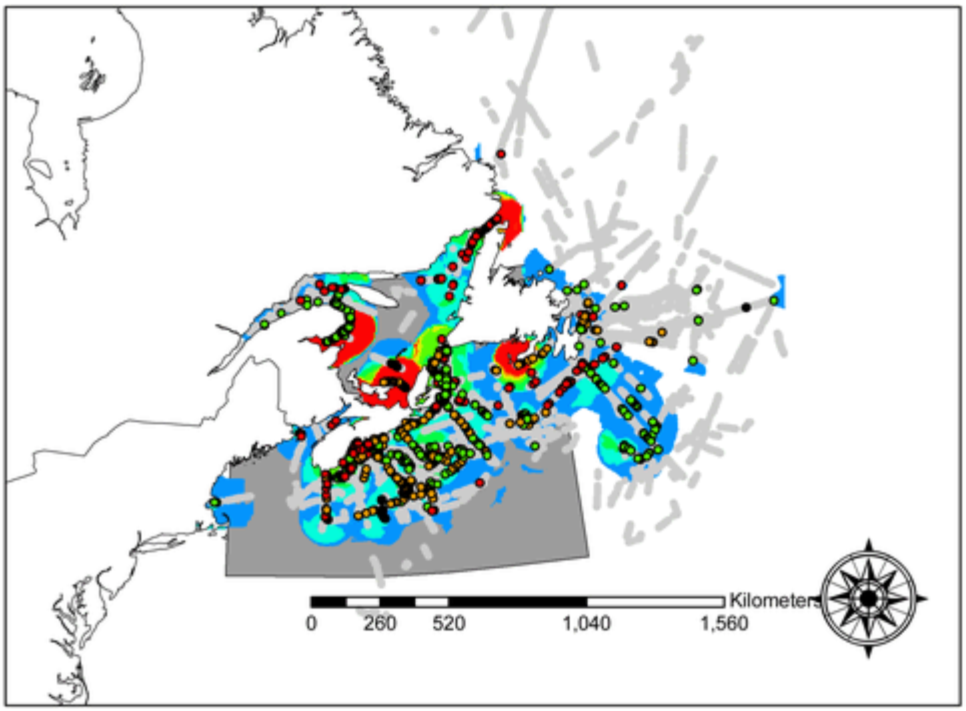


Fig. 2a.

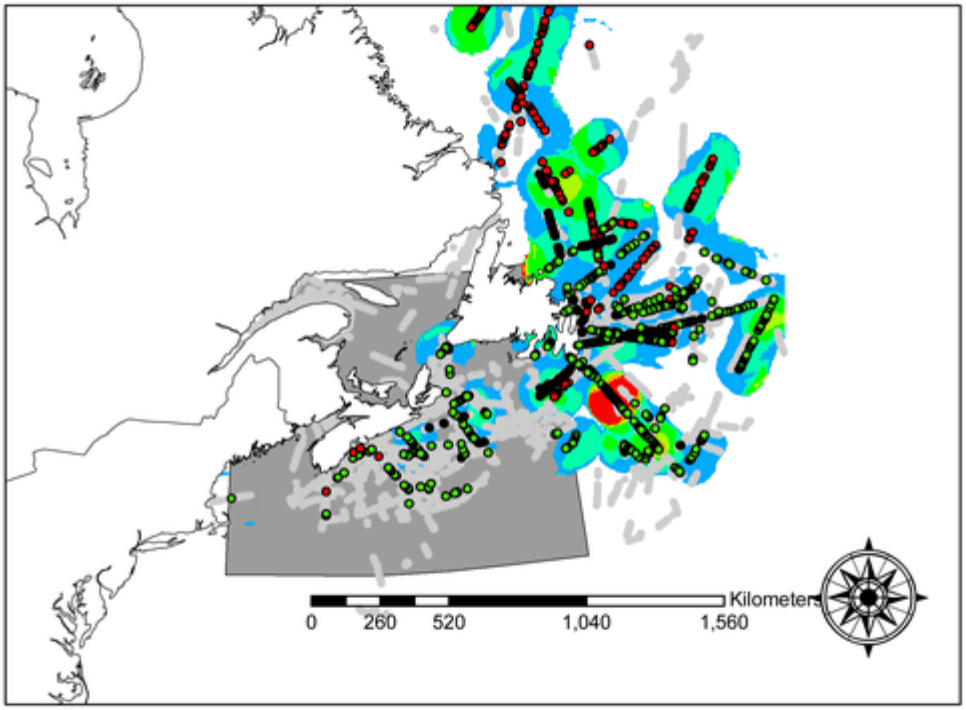


Fig. 2b.

Receptivity to 2D, Interpolated Surface Maps

Figures 2a,b presented two-dimensional interpolated surface maps with all four seasons shown simultaneously. In these figures, four factors were displayed: (1) locations of occurrence, (2) abundance (proportional to the colour gradient of the interpolation surface), (3) season (winter, spring, summer and fall, indicated by solid symbol colour), and (4) survey tracks (light gray symbols). These figures addressed a deficiency expressed for Figs. 1a,b, i.e., the provisioning of survey tracks, but they also used two different colour gradients and one single panel.

Spatial trends were described as "unclear", with Figs.2a,b showing too many colours and too much information. As with Figs.1a,b, three respondents reported that there was too much overlap in the occurrence points, further obscuring spatial trends. One respondent reported a preference for separate seasonal visualizations, while another responded favourably to the use of colour-shaded interpolation. Respondents were comfortable describing the reliance of the Northern Gannet on the shallower water of the Gulf of St. Lawrence, Scotian Shelf and the Newfoundland Grand Banks during most seasons, and correctly described the predominantly Newfoundland offshore distribution of the Thick-billed Murre. Despite expressing reservations about the complexity of the figures, respondents correctly interpreted the seasonal differences in distribution.

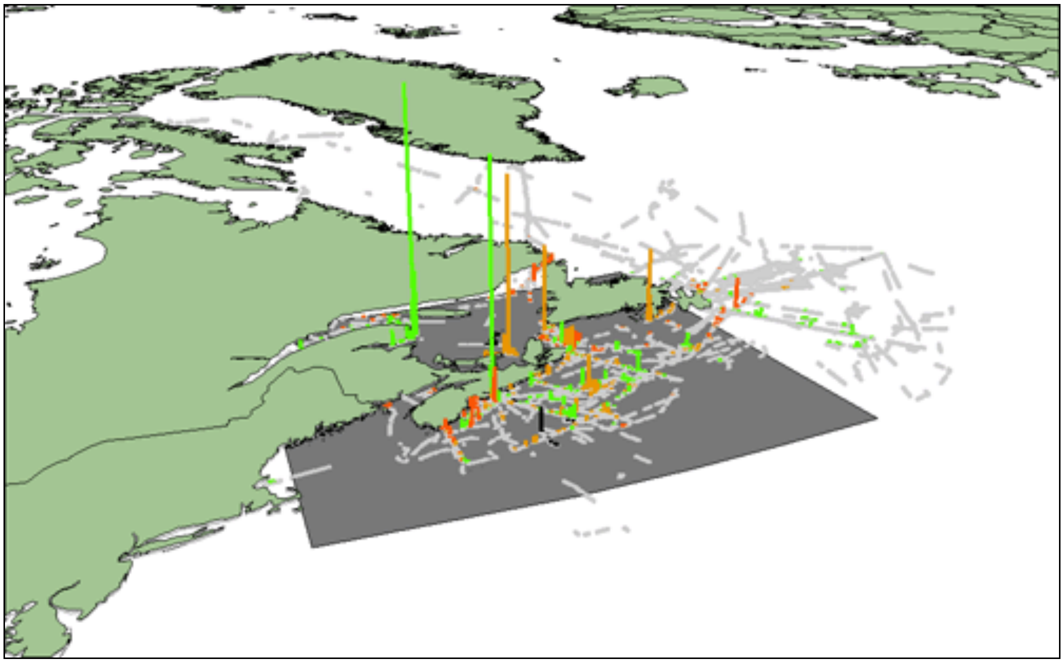


Fig. 3a.

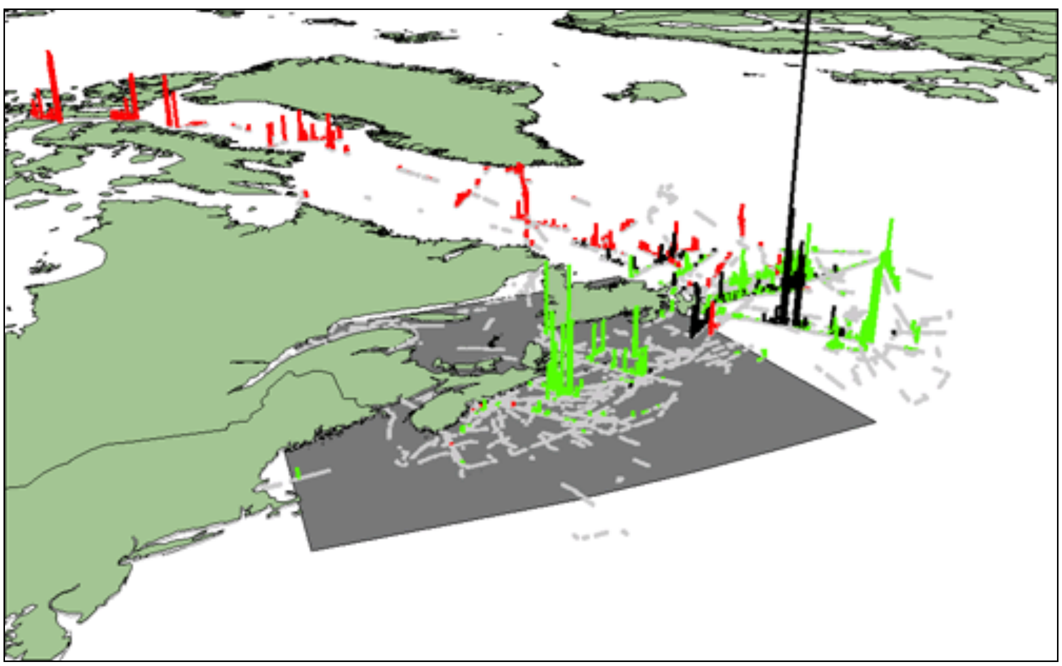


Fig. 3b.

Receptivity to Static 3D Maps

Figures 3a,b displayed: (1) locations of occurrence, (2) season (indicated by a solid symbol colour), and (3) survey tracks (light grey symbols). Relative abundance was represented by the degree of vertical exaggeration rather than by a 2D interpolation surface as with figs.2a,b. In this way a third dimension was added to this series of visualizations.

Several respondents described these visualizations as "useful", and declared that trends more easily discernable due to a lack in overlap in the points and the fact that relative differences were easy to see. One respondent reported the scale was too large to make out particular densities. One respondent noted the tendency for the Northern Gannet to occur in the shallower waters of the Gulf of St. Lawrence and in the vicinity of Halifax Harbour. Differences in spring and fall occurrence were noted, as were the tendency for wintering occurrences to be south of the Nova Scotian shelf break. One respondent declared that their interpretations would have been assisted by visualization of the survey tracks by season rather than pooled across the entire period.

Receptivity to Dynamic 3D Maps

Dynamic visualizations were constructed using the same 3D maps presented in figs.3a,b. While users could not directly control the scale or the vantage point for each, the visualizations took the viewer through an automated pan of the entire study area which allowed for multiple perspectives. As with the static 3D maps, locations of occurrence, season (indicated by solid symbol colour), and survey tracks (light grey symbols) were all plotted simultaneously, and vertical exaggeration was used to communicate differences in relative abundance.

The large size of the animation files meant that fewer participants were able to download and view the dynamic 3D maps, but the two who did were both declared the distribution of abundances to be more "precisely" shown and "significantly clearer" than the static 3D displays. These visualizations proved sufficiently stimulating that one participant drew attention to new knowledge not reported elsewhere: for example, the role of coastal PEI as an important area of the Gulf of St. Lawrence for fall Northern Gannet. Confidence in the interpretation of seasonal patterns was enhanced, and was reflected in the volume and quality of the inferences submitted to the website. Attention was drawn to summer occurrences of the Northern Gannet, something not remarked on following the viewing of previous visualizations, in the vicinity of coastal areas of the Gulf of St. Lawrence and Nova Scotia. One respondent attributed the lower summer abundances of the Northern Gannet to be due to birds being tied to their breeding colonies, an explanation/implication not raised in a previous visualization. Some deficiencies were identified: difficulty distinguishing orange and red bars, survey tracks that were not seasonally specific, and the absence of interpolation surfaces like those of figs.2a,b (implying this respondent found them useful).

Conclusions

Based on this small sample of respondents, multiple figures were not considered a drawback, and some users expressed a preference for multiple panels if it enlarged the maps or simplified their ability to discern main trends. The use of two different sets of symbols -- each with their own color classes – combined with a color-graded interpolation surface seemed to overload Figures 2a and 2b. This suggested that there was an upper limit to the complexity that could be effectively communicated using a single image. While the impact of 3D visualizations on interpretation time was not assessed, study respondents appeared to be more confident in their ability to make inferences. Spatial patterns were described for 3D visualizations that were not noted for 2D ones. In assessing the role of visualization in fostering collaboration it can be concluded that they readily provided "talking points" for discussion. Unusual occurrences were readily noted, and the implications of distributions centered, for example, on shelf breaks were highlighted for further inquiry. As part of a wider analysis of seabird distribution it is felt that these visualizations offered a critical, "non-parametric" summary of trends at different spatial and temporal scales.

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Sketch mapping and Geographic Knowledge: What Role for Drawing Ability?

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Abstract

Sketch mapping, a traditional technique for evaluating geographic knowledge, relies in different amounts on drawing ability, spatial ability, spatial memory, and geographic and spatial knowledge. Past research has shown little concern for how non-geographic knowledge and abilities influence the sketch mapping process. For instance, sketch mapping is potentially confounded by drawing ability and non-spatial recall ability. The proposed research employs an experimental design that combines geographic (free-sketch world map, world map labeling from memory and from list) and non-geographic (Rey-Osterrieth complex figures, paper folding, object location memory, and mental rotation) tasks to determine the validity of sketch mapping in world geographic literacy. We also hope to provide some insight into the role of drawing ability in the map creation process. By comparing the three maps with other non-geographic tasks, the relationships among geographic knowledge, drawing ability and spatial memory can be assessed.

Background and Relevance

The primary focus of this research is the influence that spatial ability, spatial memory and drawing ability have on sketch mapping. Sketch mapping is a traditional method for evaluating geographic knowledge of the world (Blades, 1990; Pinheiro, 1998; Taketa, 1996; Saarinen, 1999). It has proven reliable (Blades, 1990), has helped to improve global geographic literacy (Saarinen, 1999), and has been successfully applied in education and science (Golledge, 1985; Kitchin, 1997; Pinheiro, 1998). This research will elucidate the role of drawing or artistic ability in the expression of geographic and spatial knowledge on hand-drawn sketch maps. Unfortunately, very few studies specify the possible impact of non-geographic abilities, such as drawing, on the outcomes of sketch mapping. Sketch mapping involves varying degrees of drawing or artistic skill, and in fact may not rely on drawing at all (Montello, Freundschuh, Gopal, & Hirtle, 1998; UCGIS, 2002; Montello et al., 2003). Although map-like representations, including model building with blocks (Jacobson, 1998), verbal representations (Bell & Saucier, 2004), stated preference (Gould & White, 1974), and multi-dimensional scaling (Golledge, Rivizzigno, & Spector, 1976), might not rely on drawing, they do have some connection to spatial ability, spatial memory, and artistic ability; in addition they have the common goal of communicating spatial and geographic knowledge (cognitive map).

In the past, sketch map evaluation has been split into the subjective or qualitative assessment and metric measurements of, between, and among objects (Montello, Lovelace, Golledge, & Self, 1999). Billinghurst and Weghorst (1995) employ a "map goodness" score as a subjective evaluation, an "object classes" score as a metric count of objects, and a "relative object positioning" score for map assessment. Many researchers advise caution when using metric measurements as a direct expression of the accuracy of cognitive map, while others argue that sketch maps are as accurate as other indirect cognitive techniques (Newcombe, 1985). More recently, the examination of the topological or non-metric representations has also emerged (Rovine & Weisman, 1989; Haq & Girotto, 2003). This approach is beneficial as task completion might not rely on a level of accuracy commensurate with a person's knowledge. It is a combination of accurate and less accurate information rather than the accurate representation of the cognitive map (Kaplan & Kaplan, 1982). Researchers can evaluate sketch maps based on the subjective or qualitative representation, categorical count of information, and varyingly precise measurement techniques.

Sketch maps are used to better understand what is known or how that knowledge is stored, processed, and used (Blades, 1990). Sketch mapping has been applied in geographic education as early as 1973 (Wood, 1973). The Geography Education Standards Project's "Geography for Life" explicitly identifies sketch mapping as one of its six essential elements of geographic literacy, defining the process as "…how to use mental maps to organize information about people, places, and environments in a spatial context…" (Geography Education Standards Project (U.S.), American Geographical Society of New York, Association of American Geographers, National Council for Geographic Education, & National Geographic Society (U.S.), 1994, 34).

Methods and Data

Participants completed a test packet consisting of 8 tasks. They were instructed to work individually, to not look forward or backward through the test packet (except where indicated and only during the completion of an individual task), and to proceed to the next task only when instructed. Each task will be timed and will be accompanied by written and verbal instructions to ensure that the participants understand each component of the experiment. The total time to complete this test packet is approximately 41 minutes.

Task 1 is complex figure drawing. It is used as an index of non-geographic drawing ability. Participants are told to copy the Ray-Osterrieth Complex Figure within 3 minutes. A perfect score is 36, based on the individual elements identical to the original figure.

Task 2 is freehand world sketch map. Participants are instructed to draw a world sketch map and label as many countries as possible in 8 minutes. This task measures individual knowledge of world geography by counting the number of countries labeled rather than evaluating the accuracy of countries drawn. Logically, one's ability to draw a well-proportioned map indicates better geographic knowledge.

Task 3 is world map labeling from memory. This task consists of 3 regional outline maps – the Americas, Europe and Africa, and Asia – of 221 countries in total. Participants are allowed 8 minutes to label the countries on a list and to move back and forth among the three maps. It is intended to measure the knowledge of world geography (as indicated by the number of countries correctly labeled) independent of drawing ability. Total number of correctly labeled countries, total number of incorrectly labeled countries, percent correct, and total number of countries labeled are scored separately.

Task 4 is world map labeling from list. Participants are given a list of country names in alphabetical order number 1-221. 10 minutes are allowed to write the corresponding number to the correct location on the map. It is intended to measure the knowledge of world geography independent of drawing ability. Scoring method is same as in task 3.

Task 5 is object location memory task, from Silverman and Eals, 1992. Participants are instructed to study the first picture and circle the objects that have changed location on the second picture without looking back. This task intends to test the participant's spatial memory.

Task 6 is paper folding task (VZ-2) by the College Board. Participants are given 3 minutes to circle one correct answer out of the 5 figures on the right that represents the holes being punched when the paper is folded as the figure on the left. The score is a formula of correct answers minus a fraction of incorrect answers. This task intends to test the participant's spatial visualization ability.

Task 7 is Vandenberg mental rotation task. Participants are given 3 minutes to determine 2 correct 3D objects out of 4 that are identical to the one on the far left after being rotated at different angles. Score is given only when both objects are correct. It is another spatial ability test in this experiment.

Task 8 is complex figure drawing from memory. Participants are given 3 minutes to recall the complex figure that they copied in task 1. This task is used to measure spatial memory and as a second drawing ability index.

Data is divided into two categories – those independent of drawing ability (total number of correctly labeled countries, total number of incorrectly labeled countries, percent correct, and total number of countries labeled) and those related to drawing ability – along with descriptive statistics including sense of direction, drawing ability, group, and sex. Non-spatial analysis includes the coding of the labeled countries (correct and incorrect) for examination using descriptive statistics for correlative analysis and analysis of variance. Data will also be digitized into GIS database for spatial analysis. By using ArcGIS, the presence or absence of clusters of correctly labeled countries for each participant will be established. These "knowledge clusters" will help to reveal group differences in world geographic knowledge. The data will further be exported to GeoDa for spatial analysis using spatial autocorrelation and cluster mapping to determine any statistically significant variation in these "knowledge clusters".

Conclusions

Drawing or artistic ability may be correlated with the expression of geographic and spatial knowledge. In this experiment, the free sketch world map task is compared with the complex figure (copying and memory) tasks to evaluate the expression of geographic knowledge through drawing ability and spatial memory. The map labeling (from memory and from list) tasks are assumed to represent geographic knowledge independent of drawing ability.

The free sketch map task requires both geographic knowledge and drawing ability. This task is compared to the two non-geographic tasks – complex figure copying and memory. A positive correlation between the free sketch world map and the two complex figure drawing tasks (copying and memory) indicates that those people who can draw a complex figure more accurately will include more countries on their sketch map of the world. This result supports the conclusion that one's artistic ability influences their ability to express geographic knowledge.

The map labeling (from memory and from list) tasks do not require any artistic skills, but do require accurate geographic knowledge. The map labeling from memory task requires participants to recall country names from memory (as in the free sketch map) while providing the spatial cue of world location and country shape (as in the map label from list). No correlation between the drawing tasks and these two labeling tasks would further support the hypothesis that the drawing component of sketch mapping is related to one's ability to communicate what is known about the world or an environment. Inasmuch as the free sketch map task includes both a drawing component and a geographic knowledge component, having it positively correlated with the drawing tasks and the labeling task but the labeling tasks NOT correlated with the drawing tasks would be a strong support for our hypothesis that drawing ability can confound or support one's ability to communicate what is known about the world on a sketch map (depending on whether they are drawn well or drawn poorly).

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Designing Public Geovisualizations to Improve Tsunami Education in Ucluelet, British Columbia

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Abstract

The aim of this research is to develop and evaluate less conventional forms of geovisualizations which communicate spatial risk of a local tsunami scenario. The term geovisualization (geographic visualization) refers to the visual representation of geographic space. This includes conventional, two dimensional maps, as well as two dimensional animations, three dimensional maps, and interactive virtual spaces (Slocum 2005). New technologies need to be investigated to determine their potential to produce increased spatial cognition (Shelton and Hedley, 2002).

Background and Relevance

Residents on the West Coast of Vancouver Island are vulnerable to both telegenic and local tsunamis (Anderson & Gow 2004). If a strong earthquake occurs in the Cascadia Subduction Zone, located approximately 100km west of Vancouver Island, mathematical models indicate that due to bathymetry and probable ocean displacement, a locally generated tsunami will hit Ucluelet, British Columbia. It is estimated that approximately thirty minutes after the earthquake a maximum run-up of 20 meters will occur. Due to the short arrival time of the local tsunami and the severe damage the earthquake will cause on local infrastructure, citizens need to rely on their own knowledge and situational awareness to make prompt, safe and educated decisions for tsunami evacuation of inundation areas.

Current research indicates that in Canada, along with several other identified countries, tsunami education programs that attempt to prepare the public for tsunamis are ineffective (Anderson & Gow 2004, Haque 2006). These education programs are successful in providing awareness, but fail to promote preparedness (Johnson et al. 2002, Paton 2003). There is a need to provide better tsunami education in communities, especially for the case of a local tsunami (Dengler 2005). To fill this gap, this research explores how to improve tsunami education in Ucluelet, British Columbia using hazard mapping.

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interactive virtual spaces (Slocum 2005). New technologies need to be investigated to determine their potential to produce increased spatial cognition (Shelton and Hedley, 2002).

This applied research is part of a larger Geomatics for Informed Decisions (GEOIDE) funded collaboration between the District of Ucluelet, the British Columbia Provincial Emergency Program, the University of British Columbia Civil Engineering and Simon Fraser University Geography. Facilitated by the British Columbia Provincial Emergency Program, the community of Ucluelet arranged for UBC Civil Engineering to model a worst-case local tsunami scenario and recommend safe havens. Our research in the Spatial Interface Research Lab at Simon Fraser University focuses on how to best visually communicate this new risk information to the population of Ucluelet.

Method and Reasoning in Developing New Tsunami Geovisualizations

The first stage of developing new communication tools involved reviewing current applications of community tsunami risk maps in the USA, New Zealand and Australia. Geovisualizations seem to be entirely limited to static two dimensional inundation maps of communities which, if viewed online, may reference two dimensional and three dimensional animations. However, these animations never refer to the local geographic area in question. This, together with two dimensional static inundation maps may lead users to distorted spatial and temporal presumptions of a tsunami event in their community.

Given these limitations of current tsunami educational products, we are developing public Geovisualizations which directly utilize more spatial information created in the previous modeling stages of tsunami risk assessment. This includes technical two dimensional animations of an inundation scenario in Ucluelet, along with digital elevation models.

Our first prototype geovisualization used ArcGIS to render a set of three dimensional flights around Ucluelet. With Adobe Flash, we designed an interface that allows users to choose and fly to different views of Ucluelet and watch an inundation scenario from each view, thus creating a non-linear geomovie. However, due to limitations within ArcScene, inundation animations needed to be simplified to a linear and continuous sea-level rise rather than visualizing a non-linear rise as predicted by the mathematical model.

In order to have finer control over how temporal and elevation information is visualized and animated, it was necessary to move from ArcGIS to a program environment designed primarily for visualization. Currently we are developing renderings in AutoDesk 3Ds MAX to bypass visualization limitations of ArcGIS. Combining developed 3Ds MAX renderings with Flash will provide users intuitive and interactive access to the temporal and spatial nature of a tsunami in a three dimensional geovisualization specific to the geography of Ucluelet.

Any educational tool which disseminates spatial information needs to be carefully considered. The influences different geovisualizations have on user cognition are still poorly understood (Slocum 2005). Design decisions in the process of developing geovisualization products can vary in many characteristics. These characteristics include: i) the content: spatial, spatio-temporal ii) the representation: two dimensional, three dimensional iii) the degree of interaction between the tool and the user. Geovisualization design could potentially impact how users perceive and understand the nature of the tsunami; therefore it is important to explore how new forms of geovisualization may affect users' spatial knowledge. This presentation shows recently developed geovisualizations and discusses how design decisions were made using guidelines and suggestions from tsunami science literature.

Future User Testing

The primary goal of this research is to compare newly developed geovisualizations to current geovisualizations of Ucluelet which consist of small scale animations and static inundation maps. The two approaches may produce significantly different understanding of the spatial and temporal nature of a tsunami in Ucluelet. Working with the municipal government and schools of Ucluelet, residents will be part of tests that empirically measure effects of the two educational tools. User testing is planned for Spring 2009

Conclusions

Creating new information is no longer the biggest challenge facing areas of high environmental hazard - using already existing information within society poses a larger challenge (Tierney 2005). This research explores how designing intuitive geovisualizations, which utilize more information from the tsunami modeling process, may influence tsunami education.

The geovisualizations resulting from this research aim to provide an educational product for Ucluelet, which can provide individuals with improved spatial decision making and understanding of the nature of a tsunami. Providing citizens with better access to spatial and temporal information may improve not just tsunami awareness but also preparedness within the community.

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Geo-statistical Analysis and Modeling of Residential Fire Risks in Toronto Area to Predict Personal Response and Property Damaged

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Abstract

Fire incidents are still a major risk in residential areas especially large cities. Understanding the spatial patterns of fire risks and factors that contribute to their impacts could improve fire response and therefore reduce human injuries, fatalities and property losses. This is even more important and critical in large urban areas such as Toronto where density of population and activities are very high.

This study aims to develop models that can predict require personal response to control the incident and potential of property damage for residential building in Toronto when fire incidents occur. The results of such models would improve fire response management systems.

More than 9,200 fire incidents of residential building in Toronto for the period of 2001 and 2006 provided by Ontario Office of Fire Marshall have been geocoded and used in this study.

Several spatial autoregressive models using various dependent and independent variables for fire risks (e.g. personal response, and estimated damage) and predictors (e.g. distance to fire stations, responding personnel, type of building, ...) have been applied and the results show that spatial autoregressive models are able to better predict fire risks in Toronto.

Exploring the Deterrent Effect of Marine Pollution Monitoring in Canada's Pacific Region.

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Abstract

Off the Pacific coast of Canada, the number of detected small-scale oil discharges from vessel operations has moderately decreased since 2000 as a result of an increase in surveillance effort by Canada's National Aerial Surveillance Program (NASP). To explore the deterrence effect in the region, we investigated changes in the spatial distribution of NASP monitoring effort between early 1997 and late 2006, and differences between summer and winter seasons, using LISA cluster maps. In addition, we studied the spatial relationships between surveillance effort and different marine vessel traffic distributions, differentiating between seasons, and accounting for the presence of spatial autocorrelation in the variables. With this study we aim to generate hypothesis about the type of vessels targeted by NASP and, therefore, for specific deterrence effects from polluting.

Background and Relevance

Canada's National Aerial Surveillance Program (NASP) is the primary monitoring and deterrence tool for the enforcement of national and international pollution prevention regulations (Armstrong, 2004). Within Canadian Pacific waters, the number of NASP flights has varied since the beginning of the program in the early 1990s. Analysis of data provided by the NASP flight crew indicated that during the 1990s NASP surveillance effort declined reaching the lowest level in 1999/2000 fiscal year, followed by an increase of pollution surveillance hours to its peak in 2006/2007 fiscal year (Fig. 1). The number of detected oil spills per fiscal year also presented a notable decrease until 1999/2000, when it changed to a relatively constant number of detections (Serra-Sogas et al., 2008a).

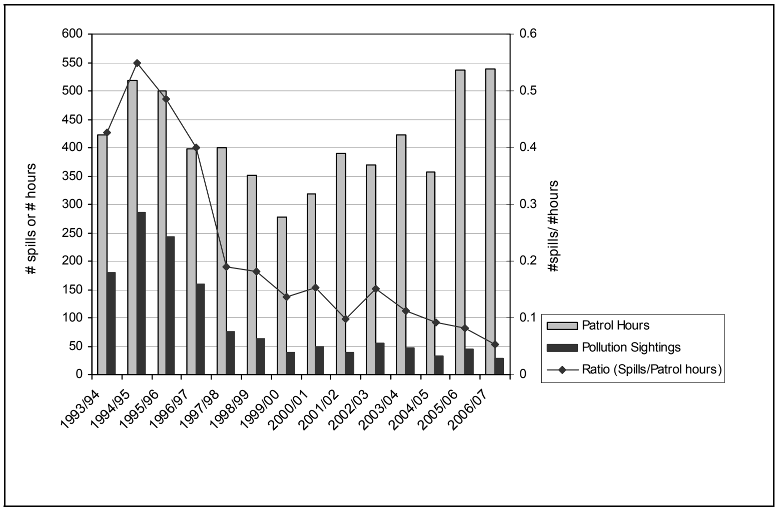

Fig. 1. Trends of total number of patrol hours and observed oil pollution events, and ratio number of spills by number of patrol hours from fiscal year 1993-1994 to 2006/2007 for Canada's Pacific Region.

Studies have shown that generally an increase in monitoring effort leads to a higher probability of detecting potential polluters, followed by an increase in compliance to pollution regulations due to a deterrence effect (Cohen, 2000). In order to investigate the deterrence effect of NASP to marine polluters, we first explore annual variations in the spatial distribution of surveillance effort from 1998 to 2005 in order to determine those areas that received higher surveillance effort and whether they remained the same over time and during different seasons (summer and winter). Next, in a more in depth analysis, we investigate vessels that have a higher probability to be monitored and, therefore, likely to be deterred from polluting, by quantifying the degree of correlation between surveillance effort and marine traffic densities for different vessel types. The analysis will be differentiating between summer and winter to capture seasonal differences in vessel traffic.

Data and Methods

The area considered in this study comprises the area surveyed by NASP between late 1997 and early 2006, and included within the Canadian Economic Exclusive Zone (Fig. 2).

Spatio-temporal information on individual patrol flights from late 1997 to early 2006 was obtained from the NASP flight crew. Surveillance effort was estimated from individual flight routes as the total area surveyed per unit of observation (one unit of observation is equal to 5 by 5 kilometers cell). Relative marine traffic densities for vessels larger than 20 m overall length, divided in type groups (e.g., tugs, ferries, tankers, carriers, cruise ships and fishing vessels) and seasons (e.g., summer and winter) were estimated from 2003 Vessel Traffic Operation Support System (VTOSS) dataset, courtesy of the Marine Traffic and Communication

Services (MCTS) of Transport Canada. 2003 is used as a representative year of shipping densities and distribution for the entire study period, knowing that the intensity of shipping movements in the Pacific Region were reasonably invariable from 2000 to 2006 (Canadian Coast Guard, 2001-2006).

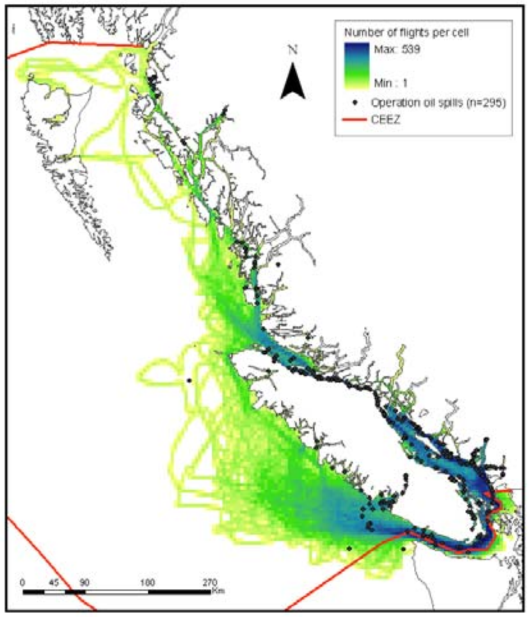

Fig. 2. Map of the spatial distribution of observed oil spills the estimated surveillance flight effort between 1997 and 2006.

Local measures of spatial autocorrelation, such as the local form of Moran's I or LISA, are appropriate to identify the location of high values (hot spots) and low values (cold spots) (Anselin, 1995; Boots, 2002). To estimate spatial autocorrelation indices, a weight matrix, which measures the potential interactions among spatial units, needs to be defined (Anselin, 1995). LISA cluster maps representing high values of surveillance effort per year and per season are constructed with GeoDa using a rook contiguity first order of neighbor's weight matrix (Anselin, 2005).

To explore the relationship between surveillance effort and marine traffic distributions, we quantify the relationship by estimating the Pearson's correlation index. In a previous study, both variables presented positive spatial autocorrelation (Serra-Sogas et al., 2008b). The presence of significant spatial autocorrelation in the variables, however, can affect statistical significance and interpretation of the correlation test (Legendre, 1993). Therefore, when testing the significance of correlation, the presence of spatial autocorrelation needs to be taken into account. Fortin and Fayette (2002) suggest a method that adjusts the number degrees of freedom proportionally to the amount of estimated spatial autocorrelation. This method is known as Dutilleul's adjustment t-test method (1993).

Results

Forthcoming results will provide: first the identification of areas that received higher density of pollution patrol flights and whether surveillance coverage was spatially consistent among years; and second, an understanding of monitoring bias and associated deterrence effects of NASP flights to potentially observed vessel types.

Conclusions

By exploring spatial changes of the NASP surveillance effort off the west coast of Canada and by recognizing bias on their monitoring planning we expect to draw inferences about the causal factors that lead to the observed declining pattern in detection rates. In addition, this analysis expects to provide relevant information for future analysis aimed to specify a model to predict detection and occurrence probabilities of vessel-source oil pollution.

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Making Communities Safer
Participatory Mapping and PGIS in support of Community Risk Assessment

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Abstract

This paper assesses the effectiveness of local community information applied to disaster risk reduction management in a PGIS framework.

Background and Relevance

This paper assesses the effectiveness of local community information applied to disaster risk reduction management in a PGIS framework. Local spatial knowledge has both positive values and drawbacks in CRA for understanding local hazard situations, for analysing their components, and designing community-based amelioration. The focus is on urban communities in developing countries, but includes pertinent rural examples, and from marginalized north cities. The hazards are mainly environmental – e.g. disasters, pollution, implications of rapid climate change, but they also include socio-economic risks.

Methods and Data

This paper is a broad-based critical literature review of PGIS applied to community-level and participatory hazard/risk assessment, vulnerability analysis and coping strategies, resilience and adaptation, (cf. McCall 2008) with a strong focus on the critical functions of local spatial knowledge in PGIS in CRA. (Dekens 2007) To this is added specific findings from relevant recent research studies, such as Peters (2008).

Results

Significant applications of PGIS are found in: mapping people's local knowledge of hazard characteristics; mapping vulnerability assessments; mapping coping strategies, resilience, and adaptation; mapping people's perceptions and priorities in overall risk assessment; spatial planning, such as planning the siting of hazardous materials and structures; spatial planning - the siting of warning systems, relief centres, shelters, escape routes, etc.; mapping urban risks based on LSK knowledge analysis; mapping slow onset hazards as a special category including mapping of experiences of climate change impacts.

Methodological problems include: the integration of local knowledge of frequent hazards with objective, but time-limited data from remote sensing images and other external surveys. How can local people's knowledge cross-check remotely-acquired data, and integrate historical spatial information? What are the appropriate measures of credibility, reliability and scale?

Conclusions

PGIS for mapping direct experiences and historical 'folk memories' of natural and human-induced hazards is essential correlative to scientific assessments of risk. P-mapping & PGIS are functionally suited to extracting lay (local, community) knowledge, needs assessments & problem analysis, local perceptions & attitudes, prioritising, coping strategies, and communicating these to scientists. The clarity and conciseness of 'citizen maps' allows decision makers to take into account citizen inputs which used to be ignored.' (Forrester et al. 2003)

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Participatory mapping in climate change adaptation: the case of three rural communities in the Canadian prairies.

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Abstract

The purpose of this presentation is to introduce a methodological approach called participatory mapping session. The participatory mapping session was created in order to support rural community members to develop a set of community recommendations, relevant to policy-makers, to ameliorate the impacts of climate change on water resources in the South Saskatchewan River Basin (SSRB). A participatory mapping session aims at integrating: (a) the multiple dimensions of vulnerability to climate change (*e.g.,* social, economic, natural); and, (b) the multiple dimensions of knowledge of the vulnerability to climate change (*i.e.,* multiple realities). Participatory mapping sessions were pursued in Taber, Alberta, Cabri-Stewart Valley and Outlook, Saskatchewan. The result of the participatory mapping session is a set of community recommendations regarding climate change adaptation, valuable to policy-makers.

Background and Relevance

This study is one of many components involved in the Institutional Adaptation on Climate Change Project (IACC) Multi-Collaborative Research Initiative (2004-2008) program. The IACC project attempts to address the capacity of institutions in dry-land regions to adapt to the impacts of climate change, focusing on water (Diaz *et al.*, 2004). The IACC is a comparative study of two basins: the South Saskatchewan River Basin (SSRB) in western Canada and the Elqui River Basin (ERB) of north-central Chile. The project seeks to understand the adaptive capacity of rural communities and rural households and the roles played by governance institutions in the development of those capacities (Diaz *et al.*, 2005). For further information on the IACC project refer to www.parc.ca/mcri.

Climate change is predicted to have serious impacts on water availability and quality, particularly in dry-land areas where water is already a scarce resource (Barnett *et al.,* 2004; Cohen and Kulkarni, 2001; Gleick, 2000; Heejun *et al.*, 2002). The sustainability of rural communities in prairie dry-lands, under the forecasted impacts of climate change on water resources, depends in part on the capacity of government institutions to address the current and future vulnerabilities of those communities (Patiño and Gauthier, *in press*). Ideally, a consciously planned response to climate change would require and make use of information and perspectives reflecting the multiple dimensions of sustainability (*e.g.,* social, economic and biophysical) across diverse institutional levels (*e.g.*, formal and informal) and across appropriate spatial and temporal scales (Patiño and Gauthier, 2008). Furthermore, an integrated approach would aim at the development of strategies and policies flexible enough to include local knowledge, values and conditions (Klein and Smith, 2003; Smit and Pilifosova, 2003), and information derived from both qualitative and quantitative modes of inquiry.

Unwin (1992) claims knowledge needs to be socially communicated in a meaningful manner. However, the acknowledgement of multiple realities makes this process of meaningful communication quite difficult. In terms of integrating multiple institutional constructions of vulnerability to climate change, this study focuses on two main institutional levels in the construction of the vulnerability to climate change of rural communities in the SSRB: (a) the rural communities; and, (b) the scientific institutional level. A participatory approach, considering the local community and the scientific community, will build collaborative institutions (Kyem, 2004), as well as support the integration of knowledge (*i.e.*, dimensions of climate change) within a multidisciplinary environment.

Public participatory geographic information systems (PPGIS) emerged as the result of the combination of participatory approaches and technologically based spatial analysis (Weiner *et al.,* 2001; Schlossberg and Shufford, 2005). GIS provides to PPGIS the means of a 'visual language' (Schlossberg and Shufford, 2005), that can facilitate: (a) the representation of different, conflicting and competing expressions of place (Weiner *et al.,* 2001; Warren, 2004; Kyem, 2004); the negotiation of the meaning of data and accuracy (Weiner *et al.,* 2001; Warren, 2004); and,(c) the means to support the process of collaboration, communication and knowledge transfer deemed at different scales of analysis (Sedogo and Groten, 2002; Kyem, 2004).

Under the umbrella of PPGIS, this study develops a methodological approach called participatory mapping session. This methodological approach, understands PPGIS as an integrative perspective to the multiple dimensions of knowledge. A participatory mapping session aims at integrating: (a) the multiple dimensions of vulnerability to climate change (*e.g.,* social, economic, natural); and, (b) the multiple dimensions of knowledge of the vulnerability to climate change (*i.e.,* multiple realities). A participatory mapping session combines sequences of mapping presentations and small group discussions, and uses maps to facilitate and stimulate discussion among participants. It attempts to link the everyday life experiences of rural community members concerning climate related events and water, and information regarding the science of climate change, in order to develop a set of community recommendations relevant to policy-makers.

This research contributes to the fields of climate change adaptation and public participation geographic information systems. It develops a methodological approach aiming at supporting the integration of information regarding the multiple dimensions of sustainability (*e.g.,* social, economic and biophysical dimensions), hence climate change issues. In addition, this research advances the application of public participation geographic information systems, by coupling ethnographic work results and public participation geographic information systems approach. Knigge and Cope (2006) and Mathews *et al.* (2005) have already explored the coupling of GIS and ethnographic work, mainly by incorporating the use of GIS while pursuing ethnographic work. However, this study draws upon knowledge (*i.e.,* main patterns and trends) resulted from ethnographic work, and interpreted, represented and transferred those results through the use of a combination of sequences of maps and small group discussions.

Methods and Data

The participatory mapping session developed in this study ran for approximately 5.5 hours (9:00 a.m. - 2:30 p.m.) and comprised three main mapping-discussion sections. The dynamic of the participatory mapping sessions combined a sequence of mapping presentations and small group discussions in order to facilitate and stimulate dialogue, in an attempt to provide the means for integrating in peoples' minds the science and the everyday life experiences.

The first mapping portion of the first mapping-discussion section constitutes a series of maps representing or reflecting the main patterns and trends derived from the examination of the results of IACC project community vulnerability assessment reports. A consecutive mapping-discussion portion builds upon the latter by providing a visual representation, in map format, of future climate change scenarios constructed by IACC scientists. The third section of the participatory mapping session focused on a discussion on the role of government institutions under potential impacts of future climate change on water. In addition, the third section asked participants to reflect on how government could facilitate community members to adapt to the future impacts of climate change and water. The outcome of this section was a set of community recommendations, valuable to policy-makers, in terms of climate change and water issues.

The material developed for the participatory mapping sessions was primarily derived from the results of two main research components of the IACC project. These were: (a) the community vulnerability assessment reports for Cabri – Stewart Valley (Matlock, 2007), Taber (Prado, 2007), and Outlook (Pittman, 2008), based on participatory vulnerability assessment procedures developed by Smit and Wandel (2006); and (b) the climate change scenarios research component developed by IACC project Ph.D. candidate Suzan Lapp.

The community vulnerability assessment reports developed by IACC researchers were reviewed to carefully select the information to be mapped for each participatory mapping session. These maps were intended to reflect the rural community members' vulnerabilities perspectives to climate change and water, and at the same time, to provide community members with an alternative visual perspective and tool that allow them to spatially and temporally see their own identified vulnerabilities.

Simultaneously, IACC scientists have been developing a range of climate change scenarios. They have also been examining the potential effects of climate change impacts on the above identified vulnerabilities, as well as interpreting the potential impact of those scenarios on water. This component of the IACC project provided the perspective of those scientists to the issue of climate change and water in the SSRB. A number of maps reflecting potential future climate change scenarios on precipitation, temperature and climate moisture indexes where created at the SSRB level, depicting 1961-1990 climatic normals and 2050s scenarios.

The above two components of knowledge (*i.e.,* community vulnerability assessments and climate change scenarios) were used to generate a number of maps that either have meaning mainly for community members and/or for IACC scientists. Rather than portraying specific rates and number figures, maps were used to depict main spatial and temporal trends and patterns. Furthermore, participants were specifically asked to focus on visualizing trends and patterns. Maps and images, and small group discussions were combined in order to facilitate and stimulate dialogue, in an attempt to provide the means for integrating in peoples' minds the science and the everyday life experiences.

The information was mapped for all the SSRB at the municipal level. Most social, economic, and agricultural related information was obtained from Statistics Canada through the University of Regina Data Liberation Agreement: (1) 1996a and 2001a Agricultural Census; (2) 1996b, 2001b and 2006 Census, and; (3) 1996c and 2001c Census - 20% sample data. Saskatchewan oil and gas digital map data was downloaded from the Government of Saskatchewan (2007) webpage. Climate scenario data were provided by Susan Lapp, Ph.D. candidate at the University of Regina, Saskatchewan, and research fellow of the IACC project. Forty to 60 maps were presented in each participatory mapping session. Maps were created using ArcGIS 9.1 geographic information systems from Environmental Systems and Research Institute © (ESRI©).

Results

In general, participants in the three communities called for the development of policies and strategies based on: (a) long-term planning; (b) improve communication between different levels of government (*i.e.* federal, provincial, local); (c) increase funding for agricultural research and technology; (d) improve funding and promotion of conservation programs (including water and climate change); and (e) improve funding to communities and people to allow change (*i.e.* adaptation). Table 1 shows recommendations identified by participants in the three communities.

Table 1. Recommendations identified in the three community session: Taber, Cabri-Stewart Valley, and Outlook.

Long-term planning on climate change, water, and all initiatives.
Improve communication between government levels
Increase funding for agricultural research and technology
Fund and promote conservation programs (including water and climate change)
Fund communities and people to allow change

Table 2 depicts recommendations identified by at least two of the three communities: Taber, and/or Cabri-Stewart Valley, and/or Outlook. These recommendations relate to the federal and provincial levels of government. Table 3 shows recommendations identified by participants only at the Taber, or Cabri-Stewart Valley, or Outlook session.

In addition, the participatory mapping session has enriched the capacity of participants to adapt to future impacts of climate change by helping them to foresee future alternatives/options to reach such a goal, and provide them with the means to develop a set of conscious recommendations valuable to policy-makers in terms of climate change and water issues. Five important components of the participatory mapping session facilitate the development of such recommendations: (a) participants take *ownership* of the session; (b) mapping presentations are *meaningful* to participants; (c) maps *validate* community and participants perspectives; (d) maps support the visualization of *patterns, trends and processes* enriching participants' perspectives, providing context, and promoting discussion; and (e) the combined mapping-discussion sequences are *informative* and facilitate a *progressive learning process*.

Table 2. Recommendations suggested by at least two of the communities: Taber, Cabri-Stewart Valley, and Outlook.

FEDERAL	PROVINCIAL
Long-term planning initiatives.	Cut crop insurance premiums and/or develop useful crop insurance (*e.g*. market neutral crop insurance; re-incorporation of hail into crop insurance).
Support world wide climate change efforts.	Listen to and get involved with the local government.
Increase existing utilization/construction of water storage capacity and associated irrigation operations.	
Fund research and technology, including agricultural research and technology and climate change institutes.	

Table 3. Recommendations identified only by Taber, or Cabri-Stewart Valley, or Outlook participants.

	FEDERAL	PROVINCIAL	LOCAL
TABER	Clear climate change leadership.	Invest in water conservation research.	More water conservation policies.
	Political power to set policies of best management practices for conservation purposes.	Develop water management strategy.	Education in water conservation and use.
	Political power to enforce existing legislation.	Inter-provincial agreements of water crossing boundaries.	
	More input of stakeholder groups in the decision making process.	Fund long-term solutions and balance economic level with environment.	
	Long-term funding for planning and research institutions with climate change mandate.	Need to work with federal government to lesser impact of climate change.	
	Better watershed management.		
	Oil industry best management practices regulations.		
	Provide provincial and local governments the authority to develop change.		
	Resolve outstanding water issues.		
	Measure water resources nationally		

Table 3. Recommendations identified only by Taber, or Cabri-Stewart Valley, or Outlook participants (Continue).

	FEDERAL	PROVINCIAL	LOCAL
CABRI-STEWART VALLEY	Increase utilization of existing water storage infrastructure (Gardiner Dam).	Intensify irrigation operation Increase utilization of Gardiner Dam.	
OUTLOOK	Education for both urban and rural population.	Encourage and fund vegetable production.	More decision-taking to ensure local relevance.
	Support agricultural/climate pilot projects.	Cooperate with federal government to develop agricultural projects.	Encourage better living standards.
	Target and streamline immigration towards rural communities.		
	Fund rural infrastructure.		

Conclusions

The participatory mapping session developed in this study has assisted rural community participants to interpret, discuss and reflect on community vulnerabilities to climate change and water issues, by enabling and opening a dialogue. Such dialogue supported the integration in participants' minds of the science and their everyday life experiences. The participatory mapping sessions assisted community members to reflect on community vulnerability to climate change, and provided the venues to validate, reject, and/or modify participants' perceptions and experiences. Participants were then equipped with knowledge and empowered to provide meaningful recommendations relevant to policy-makers.

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Evolving approaches to Community Mapping in Southwest Nova Scotia

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Abstract

The Applied Geomatics Research Group (AGRG) (www.agrg.cogs.nscc.ca) has collaborated with Agriculture and Agri Food Canada (AAFC) Rural Secretariat (www.agr.ca/policy/rural/contact_e.html) to deliver workshops on the web GIS Community Information Database (CID) (www.cid-bdc.ca) and with local communities to produce maps which demonstrate the value of Geomatics in local planning.

Recent submissions, under the Rural Partnership Development program are designed to expand their toolbox to include community mapping. The geographic focus is Southwest Nova Scotia (five counties: Annapolis, Digby, Yarmouth, Shelburne and Queens) which corresponds to the UNESCO-MAB biosphere reserve (www.snbra.ca) and is also the case study for the Nova Forest Alliance (www.novaforestalliance.com) under the Forest Communities program.

With fiscal uncertainties at the federal level, we have modified our proposal with a reduced number of workshops but an expanded methodology. In the Spring 2009, we anticipate addressing four case studies in sustainable development:

1) Fundy Communities Development Agency (www.fundycommunities.com) on physical infrastructure;
2) Town of Annapolis Royal (www.annapolisroyal.com) on tourism;
3) Annapolis and Digby Economic Development Agency (www.annapolisdigby.com) on biomass supply;
4) Queens County (www.regionofqueens.com) on value added forest products.

Background and Relevance

AGRG , as a research unit within a community college, has a responsibility for community-based research. Given the unique circumstance of a Geomatics research group in rural Canada, there is the opportunity to use our science and technology to address the sustainability concerns of rural Nova Scotia. Within the context of the UNESCO-MAB program, Southwest Nova as a biosphere reserve espouses the values of conservation of biodiversity and sustainable development. With the decline and aging of the rural population, sustainability has many faces. For the citizens of the five counties, concerns include the transfer from a resource-based economy (fishing, forestry, agriculture) to an expanded knowledge economy. AGRG, with government support, works to engage community groups in needs assessment and where appropriate the use of mapping technologies to address particular concerns. Community mapping and

VGI (Goodchild 2008) has the potential to provide evidence based visualization of these community issues (Torjman 2009).

The contribution of this applied research includes:

a) an exploration of action research methodologies within a spatial knowledge context (Banks and Mangan 1999, Reason 2002)
b) the development of customized Geomatics tools which meet the needs of the community;
c) cartographic products , accessible via the Internet, which are useful in support of a community based research network.

Methods and Data

The long term goal is the development of an online sustainable development atlas for Southwest Nova. The four initial case studies will focus on the concerns of particular community groups and agencies

Fundy Communities Development Agency – infrastructure
Annapolis Royal – tourism
ADEDA – alternative energy
Queens County – sustainable forestry.

During February and March, AGRG/SNBRA will host workshops on community mapping. We will model our approach on the work of other practitioners in Canada e.g. Carruthers (2009), Harrington and Stevenson (2005),Lydon (2005). We will modify the Tomlinson approach (Tomlinson 2003), with its emphasis on Information Products, to the web environment. At AGRG we have assembled a team of community facilitator, cartographer, web designer and GIS programmer.

We will facilitate the community group in the collection of their own data by access to GPS and the necessary base maps. . After the data collection phase, AGRG will conduct a second workshop on the use of web GIS for management, updating and visualization. At the end of this workshop, each group will have the capacity to use customized web GIS tools. The exact tool set remains part of other ongoing research evaluating available software: Google, Microsoft, ESRI and open source products.

The third phase will address:

a) the documentation and refinement of the software tools;
b) data access agreements with government agencies and other parties;
c) a sustainability plan for technical support of the online electronic atlas.

Results

This research is a work in progress. At this stage, we can share the context and our overall approach. We will not be able to report, in depth, on the community meetings however we can report on our training materials and updates to their content and availability.

In this type of applied Social Sciences research, key criteria are client satisfaction, ease of use of technical tools, ownership of the spatial data and trust. These criteria are quite distinct from the usual measures associated with other AGRG Environmental Sciences research e.g.flood risk mapping and climate change, LiDAR for forest and snowpack assessment.

Conclusions

Bringing Community Mapping concepts and Geomatics technology into rural Canada is both exciting and challenging. AGRG has a unique advantage in that its research facility is located in the rural Annapolis valley. Our long term success will depend on our ability for action research (Banks and Mangan 1999) and cooperative inquiry (Reason 2002) and our commitment to provide a structure for sustainable technical support. Both of these factors demand the development of community learning centres. These centres will the require the capacity to define their own mapping needs, produce the maps and then update and share them over the Internet with other community groups.

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Cultural sites, traditional knowledge and participatory mapping; Long-time landscape use in Sápmi

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Abstract

The research presented in this paper explores the use of Participatory GIS (PGIS) methodologies in documenting Sámi land use through archaeological surveys. Using a combination of participatory mapping, traditional archaeological surveys and GIS, researchers from The Norwegian Institute for Cultural Heritage Research work together with Sámi elders to map cultural heritage sites, land use management systems, and historical data in new ways.

Background and Relevance

Norway is facing a number of key challenges in meeting its obligations to the Sámi people (the Indigenous People of Norway). The 2005 Finnmark Act recognizes Sámi rights to their traditional land. However, due to persistent Norwegian colonial practices, documentary evidence of Sámi cultural history and land use are scarce. It is becoming increasingly important to develop alternative methods to help identify and record knowledge related to Sámi land use. The Finnmark Act demonstrates that Norway acknowledges this need, however, the government still does little to operationalize a process that overcomes this short-coming.

Methods and Data

The research presented in this paper explores the use of Participatory GIS (PGIS) methodologies in documenting Sámi land use through archaeological surveys. Using a combination of participatory mapping, traditional archaeological surveys and GIS, researchers from The Norwegian Institute for Cultural Heritage Research work together with Sámi elders to map cultural heritage sites, land use management systems, and historical data in new ways. Specifically the research aims to:

- Develop methods to visualize Sámi historical land use through maps and
- Reveal new knowledge concerning continuity, variability and time depth in Sámi land use using GIS tools.

A fundamental aspect identified in PGIS practice, and central to the operation of this project, is that control, access and use of these cultural spatial data need to be kept in the hands of those communities who generated them. In this way PGIS practice can help protect traditional knowledge from external exploitation.

There are very few examples of PGIS research in Norway, and more broadly Scandinavia, involving the indigenous Sámi. Indeed, most research on the social and ethical implications of PGIS practice has been conducted in North America. In response to this, this paper compares research initiatives conducted in Canada and Norway. The paper explores similarities and divergences in the use, adoption and control of participatory mapping and PGIS tools and products by the Norwegian Sámi and the Tlowitsis Nation, a First Nation based in British Columbia.

Ongoing Results

This is an ongoing project. This paper will share some of the initial research findings, particularly in relation to the mapping process, the engagement strategy and the requirements of researchers working on research with Indigenous communities. Furthermore it will explore some of the similarities and differences between working with the Sámi and a First Nation community in British Columbia.

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Towards a socio-economical evaluation framework of Volunteered Geographic Information (VGI)

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Abstract

Neogeography, originally an old phenomenon, but is a new subject matter of this modern digital age with World Wide Web and satellite technology. Volunteered Geographic Information (VGI), using the web 2.0 platform with wikilike initiatives has enriched and is developing the idea of Neogeography in the digital earth. VGI is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals (Goodchild, 2007). Some examples of this phenomenon are Wikimapia, OpenStreetMap, and Google MyMaps. These sites provide general base map information and allow users to create their own content by marking locations where various events occurred or certain features exist, but aren't already shown on the base map. It has a big hope to bring a positive change in the social life and economic sector among the neighbours of our digital neighbourhood. It is introducing a new business, new economics and a new way of thinking about the future of Geographic Information Science (GIScience). This study aims to provide a framework to evaluate the socio-economical value of VGI.

Key Words: Neogeography, VGI, Digital Earth, Digital Neighbourhood, Web 2.0 etc.

Background and Relevance

On the backdrop of the need to asses the socio-economic impact of Geographic Information in the context of Neogeography with the contributions through Volunteer's Initiative, it is necessary to do relevant studies. The ECOGEO project (http://ecogeo.scg.ulaval.ca/) at the Center for Research in Geomatics (CRG), Laval University is launching research work with a view to provide an economical Model of the GI (Geographic Information) sector in the province of Quebec. The study presented here is a part of the ECOGEO project as a PhD research.

NeoGeography in GIScience context: The introduction to *Neogeography* is a recent subject matter of discussion in the field of Geographic Information Science (GIScience), Public Participation GIS (PPGIS), and Volunteers Geographic Information (VGI). In this modern digital age the term "Neogeography" was coined by the fine folks at Platial, where they explained neogeography "*is a diverse set of practices that operate outside, or alongside, or in the manner of, the practices of professional geographers"*.
From my concept, Neogeography is the mapping Mashup, using the web 2.0 as the platform with the help of GI Volunteers. That's not all it also explores the discovery of anything new on the earth. Though neogeography is largely about presenting and reporting information through map-based interfaces, it's more about distributing information than it is about creating it, and therefore, it is a type of GIS.

Volunteer… what is VGI and who are the V in GI? The term "volunteered geographic information" (VGI) refers to GI which is created in collaboration by users who usually don't have special skills in handling spatial data (Cara et al., 2007). Relying only on GIS experts neglects the fact that involving interested users is an important step towards an open and democratic approach for PGIS (Rattray, 2006; Tulloch, 2007). *Christmas Bird count* is a longstanding example of VGI, in effect, Wikimapia is a volunteered gazetteer, produced entirely by individual citizens, and providing richer descriptions of places (Goodchild, 2007).

GeoWeb 2.0 as a platform for the Neogeographers: The geo-bloggers and the Neogeographers are using web 2.0 as their platform to contribute in creating content. Web 2.0 introduce business model through creating places online where people would like to come together to share what they think, see and do. When people come together over the Web, the result can be much more than the sum of the parts. Using Web 2.0 strategy, a company can start by offering a free service, such as a free search capability (Google) or a place to store, organize, access, and share personal photos (Flickr). The next step is then to reach a critical mass of active uploaders or users of the service to create powerful cross-network and social network effects. These network effects then can be mined for advertising and targeted pay-per-click marketing. Who would have thought a great free search web site could make billions of dollars per year! (Shuen, 2008)

Methods and Data

This study will try to provide an evaluation framework to asses the social and economic dimension of Neogeography (and particularly of VGI), where the volunteers are the main contributor of the contents. This research is based on three main components; the Volunteered Geographic information, the GIVolunteers and; the Web 2.0. The economical value of those three components is supposed to meet to a particular and same point and at the same time will perform to build the socio-economic framework of VGI.

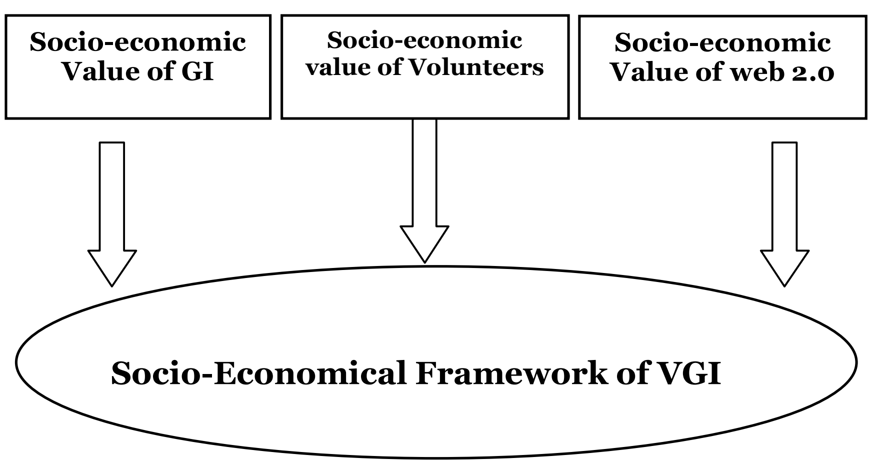

Figure 1: Three main components building the Socio-Economical Framework of VGI

The objectives are in the course of definition, but the project aims to design, develop and test an economic model; likely to help us to evaluate the socio-economic benefits of the initiatives of voluntarily collected amount of knowledge and Geospatial data.

Moreover the main objective of this study is to propose an evaluation framework for achieving socio-economic benefits of the new business model of VGI.
The specific objectives are:

- to improve knowledge about the strengths and the opportunities of VGI,
- to provide an evaluation framework of VGI.

The method to reach the objectives will be in two parts; the first one is theoretical and the second one will be operational. In the first step the theoretical framework – the state of the art will be presented in association with bordering the several components of the research theme. The scope and extent of the research will also be discussed in the first step. In the second step an evaluation framework will be built based on the previous step. The research work will proceed through testing and evaluating the framework.

Results

This research project is ongoing and it is a part of my PhD research topic. There is no result yet since I am on the preliminary stage of the research.

Conclusion

The social and economical value of any voluntary production is praiseworthy and therefore VGI is valuable in the socio-economic view. The users are the creator of the content and they create it willingly. In case of production of Geographic Information without the volunteer, the production of first copy is high because of the collection cost. In VGI the GI is collected without any cost and the volunteers produce the information with their own interest for their own sake. User-Created-Content is becoming an important economic phenomenon with direct impacts on a widening range of economic activates. The social behaviour will be obviously influenced by his impact. Moreover, the social and behavioural changes are interrelated with the change of economic conditions and can never be seen as isolated. So, when there is a change in the economy there is a change in the society and vice-versa. Neogeography, VGI and web 2.0 is supposed to bring a positive effect in mapping science, market of geospatial database and among the users community.

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The GeoWeb 2.0 and the new generation of PPGIS

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Abstract

The Web is peppered with spatial references mapping and location based content is defined under the term Geospatial Web or GeoWeb. This rich melange of spatial data and service offers many opportunities and represent one of the future paths of the Internet Platform. The GeoWeb survey took the last two years as a participatory, following the progress of the phenomenon of Web 2.0. From now on, maps and geolocation content are ubiquitous on Internet and all user can make cartography and create geographic information. Some people do not hesitate to characterize these variation of the Web under different terms such as *Maps 2.0* (Crampton, 2008), *mapping 2.0* (Hay, 2008), *GIS 2.0* (Joliveau, 2008), *neogeography* (Turner, 2006) or *GeoWeb 2.0* (Maguire, 2007). Beyond terminology, the GeoWeb 2.0 is above all other a new dynamic and interactive consultation, management, processing, creation and dissemination of geographic information online. It offers all kinds of audiences, how to superimpose traditional maps, information and services, thus improving substantially the value of the maps. On one side, the technologies and practices converge and space comes together in a complementary perspective. On the other side, this new practice is helping the Web to evolve into a more advanced and more mature socialization tool (Openness - Peering-Sharing and Acting globally) (Tapscott & Williams, 2007). This new form of online mapping where interactivity is as important as the content allows everyone to read but to write the maps. This user generated content is call; Volunteered Geographic Information (Goodchild, 2007a) or Geographic User Generated Content (Goodchild, 2008). The potential impact of this phenomenon is considerable for all professionals in the geographic information, the geospatial industry, local authorities, developers or users of the Internet who are also citizens. The GeoWeb changed the face of geomatics by making it more accessible and understandable to the general public.

Background and Relevance

The first element of this research is based on the idea that there are two cohabiting models of Geomatics. One is more professional, owner base, specialized and is more restricted to experts. It is positioned as management information, as a professional support for decision making or technical communication tool. Another is more personal or public and more open, it composes and shared positions within itself as a tool for communication and multidirectional information (Joliveau, 2008). In the same optic, we can make three types of online digital mapping (Hay, 2007). The first is the model of the GIS mapping where the map is positioned as a tool for planning and decision support. The second is the Webmapping 1.0. In this case, the map is a tool for information and communication. The third model, the mapping 2.0 is characterized by Volunteered Geographic Information (VGI) produced and published by users, and where the map is a tool for interaction and participation.

That was the idea of the map seen as a wiki (Sui, 2008), after having been seen as a communication tool, as a tool of power. These maps are now interactive by and for all users, it is dynamic both in design and in content. Geospatial technologies 2.0 (mapping mashups and APIs, Mapplets services delivered online, GPS) now allow users to learn and map the (their) world. In this context we see the genesis of a process of production, collection, updating and dissemination of geographic information running on a bottom-up approach and based on the model of crowdsourcing (outsourcing), which generalizes in Web 2.0. Examples of crowdsourcing and more specifically geocrowdsourcing increase (Google Maps maker, Open Street Map, locally based services). With services like online mapping GeoCommons, Zee Maps or Navxbeta, any user is able to create, manage and disseminate geographic information. From simple information to the collaboration through consultation or contribution (Arstein, 1969), there are varying degrees of participation.

Over the past ten years, regulatory frameworks for the participation of citizens in local politics are changing. Citizens are increasingly involved in decision-making concerning the management and planning of their territories. With the growing environmental problems and the concept of sustainable development, the public participation is also the generic term for *participatory democracy*. In this context of new demand for transparency, participation and access to information (Cunha & Dao, 2005), new laws are created in different layer of society (international, national and local level). The participation and involvement of citizens are becoming as to access to information is subject to different legal obligations. The institutionalization of public participation in the framework of management and spatial planning (Guay, 2008) requires communities to respect the legal framework in place. They must change and adapt their policies to access and dissemination of geographic information and at the same time offer new tools and mechanisms to involve participation of citizens in the collective decision-making.

The convergence of factors discussed above poses new problems for research both in the field of geomatics and geography. We assume that the phenomenon of Géoweb 2.0 is to consider beyond a simple democratization of geospatial technology by the simple process of extension of customs and practices. A recent study asserts that "*the growth of online mapping highlights the current thinking of communities to Georeferenced data, both for their own use as part of their missions of public interest*" (Jarnac, 2008). We believe that new technologies and practices of Géoweb 2.0 renew the approach the issue of public participation and indeed, that of collecting PPGIS. It is therefore appropriate to identify how these new technologies, new content, but these new practices can act as a link between users, people who adopt, use and develop technologies that were previously only professionals in creating geographic information. And communities who need to bring forward these new expectations for citizens and new legal framework and legislation in the area of public participation planning. Knowledge about the phenomenon of GeoWeb 2.0 is still in development but the interest shown by the scientific community as the geospatial industry is rapidly developing. The phenomenon is too recent for theories to be truly established and a consensus is still to be found in the vocabulary. Many aspects of this phenomenon remain unclear, reactions and positions within the sphere of Internet are growing, so that publications on the subject are beginning to emerge. We can cite as references to this research, the works of Kingston, Nyerges and Elwood about the link between Web 2.0, VGI and PPGIS (Elwood, 2007a ; Elwood, 2007b ;

Elwood, 2008a ; Elwood, 2008b ; Kingston et Smith, 2007 ; Nyerges, 2007). But also the works of Turner about Neogeography (Turner, 2006) and NCGIA about VGI (Goodchild, 2007a, Goodchild, 2007b, Goodchild, 2008, Maguire, 2007, Kuhn, 2007).

Methods

This research is structured in two parts, each with their own methodology. In a first exploratory research follows an inductive type based on the *Grounded Theory*. This methodological approach has the qualitative purpose of generating new theories base on evidence (Glaser, 1992). Empirical data will serve as a starting point for developing a new theory about a phenomenon. Based on findings and observations (readings, web crawling, testing of existing solutions, semi-directed), the objective is to build a new theory on the use of 2.0 geospatial technologies and geographic information in this voluntary geocollaboration processes and participation. To summarize, this first part of the research is divided into five stages. The first is to collect data and observe the facts. In a second step is to combine the observations in points (*code*) that can identify the theoretical anchors. The third step is to combine these codes concepts (*collections*). From this information we go to step four, and are able to train large groups with similar concepts (new practices, new users, new geographic information, new logic of production and distribution). The last step is to achieve a theory that positioned itself as a collection of theory and fact that explain the object of research and also the problems and assumptions. In the second phase of the project, the focus will be on case studies (like laboratory space) in a hypothetical-deductive method. The theories and hypothesis will be produced before facing the ground. These case studies, according to the method proposed by Yin (Yin, 2000), based on a triangulation of sources involving interviews, analysis, speeches and reports, as well as *in situ* observations.

Objectives and research questions

At this stage of this research, I describe the research objectives which are of two types. On one side there are objective of a scientist who focuses on the development of new knowledge about the effects of GeoWeb 2.0 on the interactions between local authorities, citizen and geospatial technologies. Many theoretical and conceptual research questions seem relevant. The news spatial practices based on interaction, participation and networking have most probably an impact on the policies and practices of geographic information of local organizations. Similarly, it seems pertinent to ask whether VGI and other user generated contents are not new ways to involve citizens in less formal than those of PPGIS ? So to what extent these non-organized from the top could not be used by communities to feed their own databases and also use their thoughts on the management and planning of their territory? How the access, availability and widespread use of VGI and geospatial technologies 2.0 can change the relationship between public organization and citizens? News logical and players will they appear in the decision making process? How do these non-factual data can be integrated into GIS-based organizations and used as part of the planning process? And more broadly, virtual globes and maps API they embody new spaces of citizenship?

The second objective is more operational, it aims to synthesize new knowledge on the GeoWeb 2.0 to create a guide for the proper use of GeoWeb 2.0 technologies and *User Generated Geographic Content* to local authorities. The goal is to better inform policy makers and experts on the initiatives put in place (available techniques, possible projects, examples, protocol development, legal point) in order to respond appropriately and consistent with the expectations of citizens for information and participation and also the growing needs of communities in terms of methods and instruments of public participation. This study aims a prescriptive dimension that can only take place after a long period of observation which will materialize in the form of suggestions and recommendations. We believe that the creation of composite applications in order to engage citizens and create the need to have goals in the deployment of tools and good communication on the implementation of these services. Creating a guide that will educate, inform and provide advice to communities that wish to use the potential of GeoWeb 2.0.

Conclusions

The GeoWeb 2.0 changes the logical set; all Internet users can make geomatics. The data that traditionally came from central government are now produced by users who are also citizens. But beyond the size of recreational GeoWeb 2.0 (geocaching, community of POIs, OpenStreetMap), we believe that the potential impacts are more global. The philosophy 2.0 and new the logic of contribution and participation have an impact on decision-making process. It seems important to see how PPGIS will adapt to this new kind of mapping. The GeoWeb 2.0 offers a tool box for a true geocollaboration; the aim is to work in conjunction with geographic information to determine together future of the territory. With the democratization of geospatial technologies and volunteered geographic information, we believe that a new generation of PPGIS is possible.

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Overcoming the Limitations of Participatory Geographic Information Technologies using the Geospatial Web

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Abstract

This paper argues that the Geospatial Web offers a range of applications and capabilities that overcome many of the aspects that have prevented Participatory GIS from becoming as universally applicable as the practice of participatory mapping. It is established that technologies connected to the Geospatial web have the potential to overcome the four major limitations - technological constraints related to the operation of GIS systems, the cost of establishment and maintenance, access to data, and the capacity of GIS to represent local knowledge – that have traditionally been associated with Participatory GIS. The authors have explored this potential by conducting a pilot study of the usefulness of Web 2.0 technologies for engaging North Okanagan residents and visitors in exploring bicycle routes of the region through an online cycle map, and students at UBC Okanagan in creating and using an online campus sustainability map. Insight gained from this study will be applied to a larger land and water use mapping project that is to be used as a tool in regional planning for the Okanagan basin.

Background and Relevance

Currently, the term 'community participation' is much used because of the widespread and growing recognition that participation of local communities in decision-making is critical to achieving sustainable development (Holmes, 2001; Pratt, 2001). Community participation as an integral component of community planning has gained acceptance because it provides reasonable solutions to the problems of cities and towns, embodying values that, while specific to its efforts, are consonant with the community's values (Hodge, 2008). Within the past 20 years, the use of GIS has proliferated (Obermeyer, 1995) and Leitner et al. (2000 p. 45-47) note that community organizations have become significant GIS users, initiated through their own desire to participate in "building better communities" and influence governmental decision-making. GIS is presently being used as a tool by government, business, NGO's and academia, and Grass Roots Organizations, although less so by local community members themselves. The disproportionate access to GIS by 'professional' groups and organizations has meant that the main focus of research in GIS has been on fine-tuning the technology to suit the current demands of its primary users better. Recent Geospatial technologies associated with the Web 2.0 carry the potential to bridge this gap between technologies that are truly participatory, and end products which can be considered successful. In part, this is because success itself is embedded in the very nature of these emerging technologies, which inherently lend themselves to processes that can enhance "the capacity of individuals to improve their own lives and facilitate social change," (Cleaver, 1999, p.598) through education and community cohesion. This research examines the ways that emerging Geospatial technologies are overcoming the limitations of earlier GIS technologies, lending themselves more thoroughly to participatory processes.

Methods and Data

In order to test the capacity of emerging Geospatial technologies to address the constraints to participation associated with traditional GIS projects, the research team developed an online sustainability map of the UBC Okanagan campus and cycling routes map of the Greater Vernon area in the North Okanagan. The goal of these mapping projects is to familiarize the research team with the process of using emerging technologies to create online maps without previous experience and to provide a framework for engaging user groups in interacting with these new resources. The team experimented with various freely available, open-access online mapping tools, as well as looking to examples of maps that have been developed for other universities and communities. This pilot mapping project involved the creation of base map layers by the research team, as well as a public participation component whereby the researchers sought contributions from students and community members, which were later incorporated into the online maps. In follow up, the research team evaluated the effectiveness of open-source Geospatial technologies to facilitate the process of simply and effectively representing land-use planning information. The next stage of this research will enhance participation by engaging the general public and targeted user groups in using geospatial technologies for contributing towards data layer development on a regular basis.

Results and Conclusions

Through the process of developing two topical online maps and engaging user groups to interact with them and provide feedback, the project team was able to negotiate a mapping process from different perspectives and backgrounds, in order to participate in developing a common vision. It was determined that, by using new Web 2.0 technologies to represent information relevant to land use planning, we were able to overcome many of the limitations associated with cost, ease of use, accessing data, and accurate representation. However, while these constraints are being at least partially dealt with, the use of emerging Geospatial web applications for participatory mapping projects will inevitably generate new concerns specific to these kinds of technologies, such as the degree of censorship that should be applied, and maintaining the integrity of the map so that it remains an accurate and usable tool for community planning. Further research is required in order to assess the capacity of open source Geospatial technologies to facilitate the integration of publicly contributed data into land use planning maps such as the ones discussed in this study.

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Injury data collection and analysis in low-resource settings Using Web 2.0 and the geospatial Web

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Abstract

A pilot study was conducted in Cape Town, South Africa to assess the feasibility of using Web 2.0 tools for the collection, management and analysis of injury data, with a particular focus on the spatial context.

Background and Relevance

The 'invisible epidemic' of injury is one of the leading causes of death in almost every country in the world (Mock *et al.*, 2004), however, low and middle income countries (LMIC) suffer a disproportionate share of the global burden. Of the total worldwide deaths due to injury, more than 90% occur in LMIC (Hofman *et al.*, 2005; Peden *et al.*, 2002). Multiple studies have demonstrated the important role geography plays in the epidemiology of injury, including the relationship with socio-economic and environmental factors (e.g. LaScala *et al.*, 2000; Yiannakoulias *et al.*, 2003). The collection of injury data is rare in LMIC, thus, little is known about its causes and implications, the spatial context, or the populations at risk (Kobusingye & Lett, 2000). As a result, external funding for injury control is disproportionately low when compared with higher profile population health problems (Schultz *et al.*, 2007). Web 2.0, *the second wave of the World Wide Web*, heralds a new age of democracy and equality through its facilitation of information sharing, bottom up decision-making, decentralization, and self-organization (Barsky & Purdon, 2006; Greaves & Mika, 2008). Two traditional barriers to effective data collection and analysis are access to software and availability of trained personnel. With free and easy-to-use Web 2.0 technologies, there is the potential to develop injury surveillance systems and data analysis that can be managed by existing staff in even the lowest-resource settings.

Methods and Data

A pilot study was conducted in Cape Town, South Africa during the month of October 2008 to assess the feasibility of using Web 2.0 tools for the collection, management and analysis of injury data, with a particular focus on the spatial context. Data were collected at a major hospital on the nature of the incident, the type of injury, and the demographic characteristics of the injured person, including their area of residence, and the location where the injury was sustained. Free and simple Web 2.0 tools were used for the project, with the ultimate aim of developing an injury surveillance system which could potentially be translated to other low-resource environments. Google Spreadsheet was used for input and management of the data, while several tools of the geospatial Web including Google Earth and OpenStreetMap were used for georeferencing and basic spatial analysis and visualization.

Results

Google Spreadsheet was useful for managing the extensive epidemiological dataset collected, particularly the capability for multiple people to refine, edit and access the dataset from any Web-enabled computer at anytime. Web-based city maps were used for establishing the incident location and home location when this information was unavailable elsewhere. Free online geocoding tools available proved to be easy-to-use and reasonably accurate. Google Earth and other free geospatial applications were utilized to develop a basic system for analyzing the spatial implications of injury in Cape Town, which may be useful for directing prevention efforts to high-risk areas of the city.

Conclusions

Advanced analysis and visualization available within proprietary GIS and data analysis software is likely unattainable for most low-resource settings. However, the findings of the study suggest that streamlined data collection and management, and simple, useful visualizations and analysis can be achieved using these free applications. This presents an opportunity for hospitals with constrained resources to engage in injury data collection and analysis, the prerequisite for subsequent prevention and control. A major advantage of a lightweight Web-based system is the potential for ongoing refinement and improvement using the built-in sharing and collaboration tools. Ensuring the sustainability of such a system in low-resource settings where funds and personnel are limited is an important area for future research. In addition to the findings, several important issues were illuminated regarding the collection of injury data and its analysis in low-resource settings, including issues of patient privacy and knowledge translation. Overall, this exploratory presents a step towards the development of injury surveillance systems that are appropriate for low-resource settings.

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Mashups, hacktivism and DIY mapping on the World Wide Web

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Abstract

In this presentation we explore the ways in which user-created mapping on the Geoweb is used to represent and collaboratively determine alternative cartographies. We suggest that the informal, open-ended, technically engaged practices of activist mashups and neogeography could be viewed through the lens of hacktivism and the DIY movement.

Background and Relevance

"Mashups" are web-based maps that intermix user-created data with information gathered from multiple online sources. As part of the wave of "Web 2.0" technologies, mashups represent a shift toward distributed authoring and sharing of Internet content, complicating traditional modes of knowledge production. Mashups and neogeography (Turner 2006) involve non-experts using tools other than traditional GIS to create their own cartographies, often in playful, experimental, ad hoc, and collaborative ways.

Early web map mashups, known at the time as "map hacks" (Erle et al. 2005), originated in hacker culture, following the meaning of "hacker" as a curious tinkerer or problem solver, but also containing the transgressive act of remixing existing data sources and services in new ways, sometimes in violation of Terms of Service agreements. In recent years the mashup as a technique has become more mainstream (Scharl & Tochtermann 2007), increasingly sanctioned by data providers and requiring less technical expertise. As a result, mashups and neogeography are frequently judged in comparison to GIS, noting the analysis tools that mashups lack or weighing the accuracy of user-created geographic information. However, the motivations behind amateur mapping and the volunteering of geographic data are clearly multifaceted and remain poorly understood (Goodchild 2007).

Simultaneously, a shift has occurred in the meaning of politically-motivated hacking or "hacktivism". The definition of hacktivism has commonly implied electronic civil disobedience in the from of distributed denial of service (DDoS) attacks, or, its opposite, the illicit acquisition and publishing of information (Jordan & Taylor 2004). However, through a return to the earlier definition of the hacker, the usage of "hacktivism" is shifting away from a specific set of practices to encompass more diverse forms of technologically mediated political activity (von Busch & Palmås 2006). This hacktivist ethic has similarities to the DIY (or Do-It-Yourself) movement, which valorizes self-reliance, independence from corporate control, the acquisition of the skills to fix, modify and build things for one's self. Hacktivism and DIY present the image of a technically literate and politically engaged subject, with an emphasis on process as much as end products.

In this presentation we attempt to re-intersect the discourse of hacktivism with that of mashups and neogeography, in hopes of casting light on the motivations behind and possible roles of these new phenomena. Understanding the intent behind amateur mapping is crucial for scientists interested in using these volunteered data, or for anyone developing sites that solicit public participation in creating geospatial data or applications.

Methods and Data

Taking a broad definition of the political, we examine how the concepts of hacktivism and DIY are at work in a variety of politically-oriented mashups or neogeography projects, operating at a variety of scales and using differing technical approaches and levels of individual participation. Sites examined include mashups monitoring the activities of local government such as ChicagoCrime (later EveryBlock.com), projects supporting the local food movement (from maps of farmers markets to the sharing of gardening space through SharingBackyards.com and community databases of fruit trees at UrbanEdibles.org), the mapping of the experiences of political dissidents in the Tunisian Prison Map (kitab.nl/tunisianprisonersmap), and efforts using OpenStreetMap to remotely map conflict zones such as Baghdad and Gaza.

We present a brief content analysis of these neogeography sites and their surrounding texts, contrasting these case studies with traditional paper cartography and GIS and assessing how each site deals with issues of accuracy, authority and expertise. We ask how "quick and dirty" results and the requirement of technical expertise on the part of the user might be seen as desirable from a hacktivist point of view, producing a critical and technically literate public and more diverse and responsive cartographic representations. Thus, political mashups might be interpreted not only as vehicles for cartographic activism, but as a practice of learning and rewiring the technical substrate of the internet. We also identify problems with the hacktivist stance, observing the elitism potentially inherent in hacking and hacktivism, the possibility of exploitation of volunteered data and labor, and the inevitable technological disparities that remain obstacles to widespread digital literacy.

Conclusions

Mashups and neogeography are often open-ended, mutable, and multivocal, more resembling a process of "mapping" rather than "map making" (Abrams & Hall 2006; Corner 1999; Wood 1992). We suggest that this experimental, knowledge-seeking sense of "mapping" resonates with the concepts of hacktivism and DIY, which contribute to an understanding of how amateur mapping online might operate as a process of political and technical engagement. The implications for individual and community empowerment are undetermined and possibly problematic, and remain open questions for further research. We argue that mashups and neogeography should not be judged solely by the standards of GIS, but rather viewed as complementary knowledge seeking tools and considered in terms of their potential impact on geographic literacy and technical participation, both on the level of the individual and the community.

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An EFFICIENT METHOD for STATIC and TRANSPORTATION FACILITY LOCATION ALLOCATION in LARGE SPATIAL DATASETS

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Abstract

This paper solves a location allocation problem about two types of facilities defined as follows: given a set Loc of locations and a set D of weighted objects located in Loc, we seek to allocate the given number n of static facilities (S) with limited capability and m of transportation facilities (T) to the locations in Loc, which aims to minimize both the average reachability distance from D to S and the maximal transportation reachability distance between D and S through T with consideration of capability constraints. The problem is challenging because two types of facilities are involved and need to cooperate with each other to fulfil the goal. In this paper, we propose a capability constraint facility location allocation algorithm to allocate static and transportation facilities and assign demand points to static facilities with consideration of capability constraints. It first uses capability constraint weighted coefficient assignment to assign demand points to static facility, then uses static facility location searching method to locate the static facilities. Next, it uses transportation facility location searching method to locate the transportation facilities. In addition, to be suitable for time-critical applications, we extended the method to an approximate algorithm that is more efficient with limited scarification on accuracy. An experimental evaluation on real dataset demonstrates the efficiency and practicality of the algorithms.

Background and Relevance

Spatial analysis research is an important research field and has a variety of applications. Facility location problem is one type of spatial analysis which solves problems of matching the supply and demand by using sets of objectives and constraints (Owen & Daskin, 1998) (Longley & Batty 2003) (Jain et al., 2002). The objective is to determine a set of locations for the supply so as to minimize the total supply and assignment cost. For instance, city planner may have a question about how to allocate the facility such as hospitals and fire stations for new residence area. The decision will be made based on the local populations and the capability of the limited resources. Research in single type of facility location problem can be separated in to three categories: the P-Median Problem (Arya et al., 2001) (Zhang et al, 2006), the Center Problem (Daskin, 1995) and the Covering Problem (Daskin, 1982) (Pacheco et al., 2008) (Jia et al., 2007).

In reality, we often face two types of facilities location problem when the distribution of the single type of facility within a service area is inadequate, leading to either suboptimal response times or inefficient use of resources. For example, for emergency medical services, we can locate the hospital locations in such a way that achieves full coverage of a service with the minimum total travelling distance, which usually ends up the hospital locations close to the dense community. However, for the residents in the sparse and remote area, since the number of hospitals is limited, in order to offer fast response time, the ambulance should be located to shorten the time to access medical services. In this application, there are two types of facilities, static facility (e.g. hospital) and transportation facility (e.g. ambulance) need to be located in a region. The service is supplied to the customers by the cooperation of these two types of facilities. In addition, dependency relations usually exist between different types of facilities. Specifically, the locations of transportation facilities are dependent on the locations of static facilities and demand objects. For example, the locations of ambulances will be determined by both residence locations and hospital locations. However, none of current methods can apply to the two types of facilities location problem directly.

The other limitation in current capability constraint facility location algorithms is their capability assignment method. (Wong et al., 2007) propose an algorithm for assignment between facilities and demand points based on mutual nearest neighbour. (Ghoseiri & Ghannadpour, 2007) use an urgencies capability constraint facility allocation method that gives an assignment between a facility and a demand point through urgencies, which is a method to define a spatial relationship between points. However, all of these algorithms only consider the spatial priority for assignment. In this paper, we design a new capability constraint assignment method which considers both spatial relations between demand points and static facilities and the demand attribute of demand points.

The key main contributions of the paper are summarized below:

- We introduce a new type of facility location problem regarding to static and transportation facilities and propose a novel heuristic algorithm to solve the problem. Instead of only minimizing the average travelling distance as traditional facility location problem, we consider the constraint between the transportation facilities and static facilities and minimize the maximum travelling distance of transportation facilities.
- We propose a new weighted coefficient assignment in the step of allocating capacitated constraint static facilities, which avoids assigning demand points to static facility by only considering the spatial relations between them and overlooking the amount of demand.
- To make it more applicable on real time applications, we extended the algorithm to an approximate algorithm which dramatically reduces the execution time and still have a very reasonable accuracy.

Methods and Data

The heuristic algorithm we proposed is Capability Constraint Facilities Location Searching Algorithm (CCFLS). The algorithm contains three components, weighted coefficient capability constraint assignment method (WCCAA), static facility location searching method and transportation facility location searching method. The work procedure is shown in Fig. 1.

```
CCFLS(D,Snum,Tnum)
  Input: D is a set of demand objects, Snum is the number of the static
facilities and Tnum is the  number of the transportation facilities
   Output: locations for static facilities S, locations for
transportation facilities T.
/* random choose the initial locations for static facilities in S */
  1  S = locateRandomly (D, Snum)
/* static facilities locations searching step */
  2  SearchStaticFacilityLocations (D,S)
/* random choose the initial locations for transportation facilities in
T. */
  3  T = locateRandomly (Q, Tnum)
/* transportation facilities locations searching step*/
   4  SearchTransportationFacilitiesLocations(D,T)
```

Fig.1. Pseudo code of CCFLS

Weighted Coefficient Capability Constraint Assignment Method

As discussed before, current capability constraint assignment methods only considered the spatial locations of demand objects. In this paper, we define a new weighted coefficient which take account of both spatial locations and demand weight of demand objects. The weighted coefficient of a demand point d is defined as:

$$W(d) = (dist(d, SN(d)) - dist(d, FN(d))) * d.w$$

Where $dist(d, FN(d))$ and $dist(d, SN(d))$ are the distances between demand point d and its closest available static facility $FN(d)$ and its second closest available static facility $SN(d)$, respectively. The demand points with higher weight coefficient values are assigned first.

Static Facility Location Searching Method

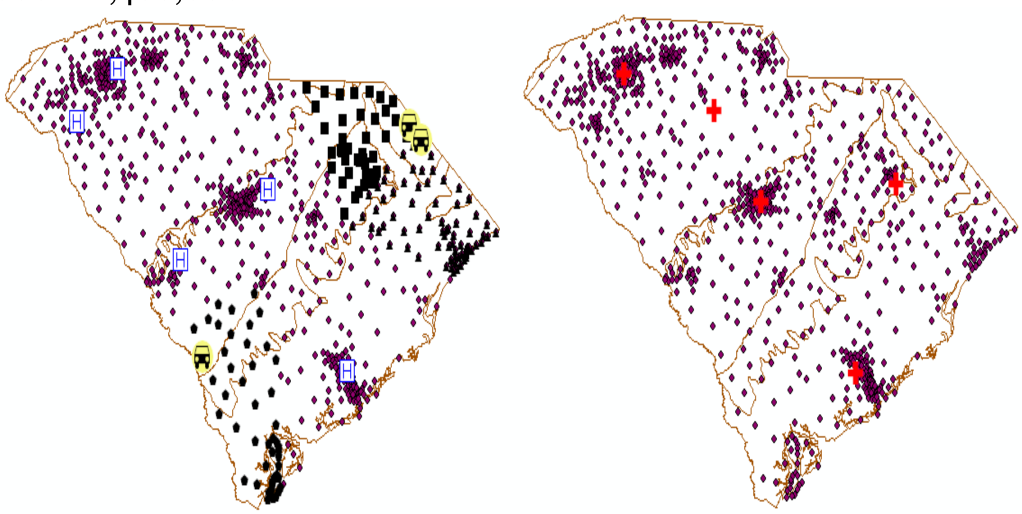
Since usually the number of potential locations for static facilities is very large, it is impossible to allocate static facilities to every potential locations and then pick up a set of optimal locations. So, here we introduce the concept of spatial clustering to reduce the searching space. Spatial clustering is the process of grouping a set of objects into classes so that objects within a cluster have high similarity to one another, but are dissimilar to objects in other clusters (Han et al., 2001). Based on it, we assume that intra cluster locations may be closer to the optimal location of the static facility in the cluster. Thus, in each iteration each static facility and the demand objects assigned to it (by using WCCAA) would be seen as a cluster. Then we search every static facility's optimal location in its cluster and only change one static facility's location to its optimal intra-cluster location which can reduce the average distance most.

Transportation Facilities Location Searching Method

Locations of transportation facilities depend on both locations of demand objects and static facilities. For reducing the computation time, we choose a myopic method in this step. The strategy is that it changes a transportation facility to the location whichever reduces the maximal transportation reachability distance most within each loop and stops if the exchange cannot bring the reduction of transportation reachability distance or the iteration time reaches the redefined times.

Results

This section presents a sufficient-capacity experiment with a real data set, which is to locate five hospitals and three ambulance parking sites in South Carolina. The data set consists of 867 census tracts (Census2000), with each treated as a demand location. The population of a census tract is considered as its demand, which varies from 197 to 16745. The total population (4,212,012) is considered as the overall demand. Centroids of these census tracts are considered as the demand points, which are used to calculate the Euclidean distances among demand locations, hospitals and ambulances. Hospital capabilities range from 800,000 to 1,400,000.



(a) (b)

Fig. 2 Solution to a real dataset : (a) CCFLS (B) Capability Constraint single type facility location algorithm

Figure 2 presents the result of CCFLS (Figure 2(a)) and the result of Capability Constraint single type facility location algorithm (Figure 2(b)). in Figure 2(a) stands for the location of hospital. stands for the location of ambulance parking site. The points marked by ▲, ⬟ and ■ stand for different ambulance parking site's service area. in Figure 2(b) stands for the location of hospital. In Fig 2(a), the average reachability distance is 56.2 km, and the maximal accessibility distance is 260 km. In Fig 2(b), the average reachability distance is 59.7km, and the maximal accessibility distance is 322 km.

Conclusions

This paper proposes and solves two kinds of facilities locations allocation problem. The CCFLS algorithm that separates the allocation process into two steps and alternately uses capability constraint assignment method and local optimal location searching method to find the optimal locations in each step. According to our experimental results, CCFLS performs well in the real dataset.

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Data handling, Interpretation and Visualization for Static and Mobile Terrestrial LiDAR; Qualifying the Problems, Solutions, and Opportunities.

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Abstract

LiDAR (Light Detection and Ranging) technology allows for very rapid acquisition of accurate 3d spatial data. All aspects of LiDAR, from data collection to the dissemination of resulting models, are on the cutting edge of geographic information science. LiDAR data is being used across a wide range of academic disciplines from civil engineering to urban planning to GIScience. We focus on urban applications of LiDAR and in particular on effective ways to bring LiDAR data into existing spatial information environments and the subsequent use of LiDAR data with both available and new tools. The research presented here focuses on what can currently be completed using the existing tools and looks at software created at Queen's University to view small LiDAR data sets in a freely distributable engine. This software focuses on a video game approach to LiDAR software programming, providing a visualization environment and algorithmic interface for research.

Background and Relevance

Currently, urban LiDAR scanning methods are in their infancy. While LiDAR technology was first used for bathymetric scanning in the 1960's (Hickman and Hogg 1969) and on airborne systems in the mid 1980's (Krabill et. al. 1984), urban applications of the technology are just beginning to emerge; new sensors, sensor platforms, and tools for using the resulting data sets are under development by many research groups both within the GI community and within the computer science community. As part of research on high resolution urban models for simulation, researchers at Queen's have collected high resolution urban LiDAR data using the Terrapoint TITAN mobile terrestrial LiDAR system. We collected a dense point based representation of the Kingston city centre. These point clouds were found to be too large for traditional software such as commercial GIS software to handle, and even in specialized software tools for LIDAR processing, pushed the capacities of desktop computers to their limits.

Using software such as Lieca Cyclone in conjunction with Google Sketchup, we were able to produce building and streetscape models from urban LiDAR data, however, this general workflow was time consuming and the resulting models lost some of the accuracy that the LiDAR system provided. Workflow testing led to the conclusion that no current consumer level software could efficiently deal with the immense point clouds generated by systems such as TITAN, and these systems furthermore do not allow the testing of custom algorithms or high quality visualization. Furthermore, these tools are quite expensive, so that distributing LiDAR data to interested parties is impossible. As a result a software project was started to address the problems with LiDAR data processing. The goals of this software development was to create a system that would allow for efficient visualization and algorithm development. In the first phase of this project, described here, we focused on the development of a lightweight, distributable test environment for visualization and algorithm testing.

Methods and Data

The data used in this study was collected using a mobile LiDAR scanner, the Terrapoint TITAN mobile scanning system. TITAN uses precision GPS and an Inertial Movement Unit coupled to 4 Riegl scanners to allow mobile scanning while driving at normal flow-of-traffic speeds. TITAN can scan large areas by driving streets without special requirements for surveying, at up to 5cm accuracy. This scanner has been used in an urban context to collect 3d data for representative sections of Kingston, Ontario, Canada.

The delivered data that Queen's University is using is approximately 4Gb in size, divided into 100-250Mb data tiles. These data tiles can contain up to 30 million data points and as a result the data was subset in order to allow for efficient computation. The subsets of data were approximately one block in size, and contained up to 5 million points. While high-end LiDAR tools are capable of dealing with such data volumes, they are not redistributable and preclude testing of custom algorithms.

In this study, the software development took an approach from the video game community. Using this paradigm the software would be optimized for performance over accuracy, where render speed is paramount. While video game software development can be done in many computer programming languages, this study utilizes the C# language and the Microsoft XNA platform. XNA builds upon Microsoft's Dot Net Framework, a codebase used for its ability to rapidly develop programs. Microsoft XNA provides the programmer with a standard code base to work from, specifically designed to create games for desktop computers and the Xbox and Xbox360 gaming consoles. The software development environment used for this study was Microsoft Visual Studio, a powerful and intuitive program designed for working with the Dot Net Framework.

Once work on the basic software visualization environment was completed, the development moved to encompass an interface for programmatically interacting with the point clouds and to development of algorithms which could find objects within the clouds, such as building walls using computer vision methods.

Results

The program created in this project is able to efficiently view and move LiDAR point clouds. It can load 5 million data points, and manipulate them at 24 rendered frames per second, along highly interactive manipulation of clouds (Figure 1). The visualization is from the first person perspective and allows a user to 'fly' around the data, inspecting it however they wish. Built into the software is an interface to interact with the data and sample algorithms which utilize this interface.

The interface developed for interaction with the data allows researchers to develop their own custom algorithms, and to visually animate the progress of the algorithm. The interface exposes the X, Y, Z and intensity values that the LiDAR data reports and allows access to draw functions in the application window.

The algorithms created in this study focus in the detection of building walls. The algorithms focused on a marching cubes and collision technique. However, these algorithms are still currently being refined.

The visualization system and algorithms are not without certain limitations. The visualization environment is limited by the amount of points that it can display at any given time, by 10 million data points the rendered frame rate drops to 6 frames per second. The algorithms developed suffer from changes in typography and the orientation of UTM grid layout in Kingston.

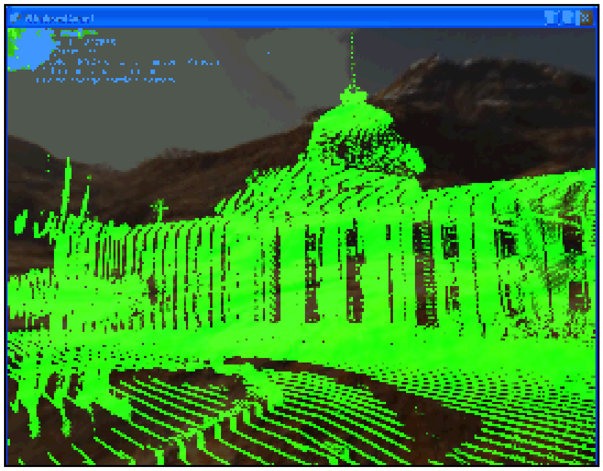

Figure 1. Kingston City Courthouse.

Conclusions

This research contributes to the field of urban geomatics research by addressing the limitations of consumer level software for LiDAR, and providing a new tool for visualization and algorithm development. Specifically, this tool emphasizes interactive performance over data volume handling.

The development approach used in this study has been directly adapted from best practices in the game development community. The result allowed a first person perspective environment to run significantly large data clouds through algorithms at fluent frame rates.

The visualization and research interface software developed in this project proves the validity of using the game technology approach and shows that consumer level computers can scientifically interact with LiDAR data. Although at the current stage of development the tool has limited abilities, the possibilities that can result from a further developed project are exciting. Further development would allow researchers and consumers to be able to use a full complement of visualization techniques and vectorization methods allowing the MTL data to be converted into meaningful, semantically complete, virtual spaces.

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A Decision Framework for Local Indicators for Categorical Data (LICD)

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Abstract

Local indicators for categorical data (LICD) are a spatially local method for quantifying spatial pattern in binary spatial data. In this paper we demonstrate how to apply LICD by developing a framework for their use and providing an example of their application in a study of forest pattern in a landscape heavily impacted by the mountain pine beetle. A dataset representing 2006 forest conditions is employed for evaluating spatial pattern of 'forest' and 'non-forest' components. Our framework outlines research decisions that must be made when implementing LICD. We provide a synthesis of options and implications for each stage. In a forested region LICD are demonstrated to be useful in detecting regions of heavily fragmented forest and deviations from an expected spatial pattern. This research is intended to provide guidance on the use of LICD and introduces a suite of computational tools which aid in their use in a GIS environment.

Background and Relevance

Landscape pattern indices (LPIs) have become the method of choice for quantifying the spatial pattern of landcover features. LPIs are a spatially global method for quantifying spatial pattern, and attempts at 'localizing' LPI measurements have generally employed a fishnet (Riitters et al. 2002) or random window approach (Potvin et al. 2001) with numerous smaller extents. There may however, be a minimum spatial extent when utilizing LPIs due to the formulation of many of these indices (Hargis et al. 1997). Furthermore, there are a number of issues associated with the use of LPIs including; correlation among metrics (Riitters et al. 1995), lack of statistical testing (Remmel & Csillag 2003) and a number of scaling relations (Wu 2004). Local indicators for categorical data (LICD) have been developed as a spatially local method for performing landscape pattern analysis on categorical spatial data which address some of the issues associated with LPIs (Boots 2003, 2006).

We refer to spatial pattern in categorical landcover data as having two primary components: *composition* and *configuration* (Gustafson 1998). Composition is a relatively easily quantifiable entity. Configuration however, is more complex and has been demonstrated to have a known, systematic and often non-linear relationship with composition (Remmel et al. 2002). LICD address the issues of correlation among metrics by incorporating what are believed to be the 5 major components of configuration (Boots 2006). LICD also enable exploratory statistical testing, by testing for significant deviation in local patterns against what would be expected by chance (Boots 2006). LICD address the issue of configurational dependence on composition through direct comparison of only those local windows with the same composition. Scaling issues need to be considered when implementing LICD and we propose a multi-scale approach with clear justifications of scale choices as has been advised for use with LPIs (Wu 2004).

Data and Methods

Landcover information (circa year 2000) has been developed for the entirety of Canada's forested landscapes as part of the earth observation for sustainable development of forests (EOSD) program (see Wulder et al. 2003). Using a change detection algorithm (Han et al. 2007) with Landsat imagery, we update the 2000 data to 2006 conditions. A binary representation of landcover is facilitated with the EOSD data through a nested class hierarchy which can easily be aggregated to two classes: forest and non-forest (Wulder & Nelson 2003).

As part of this research we have developed a decision framework for implementing LICD. This framework identifies the decisions that an analyst encounters when utilizing LICD. We conduct a synthesis of the analysis options available and provide a set of implementation guidelines. We implement LICD in a forested region that has been heavily impacted by the mountain pine beetle and subsequent large-salvage harvest operations. These disturbances have substantially altered the landscape in this region. It is important to quantify the changes in spatial pattern as it is known to impact ecological function (e.g., hydrology (Helie et al. 2005), carbon budget (Kurz et al. 2008) and wildlife habitat (Bunnell et al. 2004)). We focus on quantifying patch scale patterns using LICD. Based on Boots (2006) we implement five configurational LICD and the lone compositional LICD to characterize local spatial pattern in a forest environment following large-scale forest disturbance.

Results and Conclusions

We found LICD to be useful in characterizing regions as fragmented or patchy relative to randomness. An applicable scale for implementing LICD in a forested environment was also determined. Output of this research consists of maps portraying local spatial characteristics for our study area. Inference based on these maps provides insight into the spatial processes occurring across our study area.

We feel that LICD are a readily applicable method for spatially local landscape pattern analysis that has yet to reach its full potential in the peer-reviewed research community. We provide an application of LICD in a forested region that can be used as a reference for future research. We also provide a framework that includes guidelines for implementing LICD. Currently, userfriendly GIS-based software for LICD analysis is lacking. We intend to provide computational tools that will increase the ease of use of these methods.

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