Title
Location-Based Services, Introduction and Position Papers

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Specialist Meeting on Location-Based Services

Introduction and Position Papers

December 14–15, 2001
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The Global Positioning System and cellular technologies are enabling a new generation of electronic devices that know where they are, and are capable of modifying the information they collect and present based on that knowledge. The Wireless Communication and Public Safety Act of 1999 permits operators of cellular networks to release the geographic locations of users in certain emergency situations, and a range of electronic services are now being developed and offered to assist users in finding nearby businesses and other facilities. A location-based service (LBS) could be defined as an information service that exploits the ability of technology to know where it is, and to modify the information it presents accordingly. The Open GIS Consortium has begun a number of initiatives related to technical specifications for LBS.

The NSF-funded Center for Spatially Integrated Social Science and the University Consortium for Geographic Information Science propose to hold a specialist meeting to explore these new services, and their implications and significance for the social sciences and for geographic information science.

Specific issues to be addressed include:

- the use of LBS to support primary data capture in the social sciences, with emphasis on spatial and temporal components
- requirements for new representations, and for analytic tools to visualize and investigate such data
- privacy and related issues associated with LBS data
- new forms of social behavior enabled by LBS
- new technologies that extend current concepts of LBS
- needs for learning materials, examples, and other resources that could help to facilitate social science research related to LBS
- the use of LBS-derived data for modeling in the social sciences

Position Papers by meeting participants address these issues

The specialist meeting was held December 14-15, 2001 at the Upham Hotel in Santa Barbara, CA, and followed the format of previous specialist meetings organized by CSISS and by the National Center for Geographic Information and Analysis.

Spatial Data Analysis Tools in a Wireless Internet Environment

Position Statement for the CSISS Specialist Meeting on Location-Based Services

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My interest in this specialist meeting on location-based services stems from one of the long term objectives formulated in the strategic plan for the *Software Tools Development* program of CSISS, which I direct. Those goals pertain to the development and dissemination of spatial analysis tools for “new technologies”. Specifically, this entails thinking about what challenges and opportunities recent technological developments such as hand-held computing and a wireless internet pose to the methodology of spatial analysis in general, and spatial data analysis in particular. This has implications both for the types of methods that need to be developed as well as their computational implementation. In the context of this meeting, my interest is on those new technologies that combine locational information with wireless access, not only to designated carriers, but to the whole world wide web. While others in this meeting will undoubtedly address the technologies themselves and their implications for spatial data structures and data base management, my interest is in the spatial analysis techniques (such as exploratory and confirmatory spatial and space-time data analysis) that will be able to be built on top of these structures, and how they will affect empirical research carried out by social scientists. Moreover, I will limit my remarks in this note to purely methodological aspects, and leave addressing ethical and legal issues (such as concern over privacy) to others.

Thinking about the impact of a wireless internet on social science *research* (as opposed to decision support systems and commercial applications) constitutes a considerable challenge. First, “traditional” mainstream social science research is largely based on secondary data sources (i.e., data collected by others) or on survey information gathered at some previous point in time. The wireless location-based internet technologies allow one to move beyond this “historic” perspective to real-time collection of information. Second, not only is the collection real-time, but the “collector” can be given immediate feedback in the form of access to distributed data bases and distributed geocomputational “applets.” In other words, analysis and data collection can be carried out at the virtually the same time, combining multiple distributed resources. Third, the standard “equilibrium” paradigm of analysis in the social sciences (especially in economics), and its predominant focus on “global” modeling (in the sense of encompassing all the data points) are hard to maintain in a setting where information changes on the fly (defying any notion of equilibrium) and the “local” may be more relevant than the global.

In what follows, I present some loosely organized ideas that may provide a basis for discussion. Most (if not all) of these have received very little attention so far in the mainstream social science methodological discussions. They are structured along six broad dimensions.

1. *Data Collection*

The design of frameworks for the collection of spatial information, or *spatial sampling*, has not been central in the methodological debate in the social sciences, in contrast to the attention it has received in geostatistics and physical sciences. However, when technologies such as GPS are used in combination with hand held computing devices (including “smart” cell phones) for social science data collection (e.g., crime locations, land use, shopping trips), they open up new opportunities for adaptive sampling. In other words, the data that are being added to existing spatial data bases can on-the-fly update the characteristics of the sample and be refined in function of such feedback.

2. *Data Objects*

The bulk of interest in social science spatial data analysis is arguably focused on “areal” or aggregate data. The nature of the wireless devices suggests a renewed interest in “point” data as well as in ways in which these can be meaningfully aggregated to yield “general” results. The degree of variability in the individual observations may well be so overwhelming so as to require a rethinking of traditional spatial statistical inference.

3. *Framework for Analysis*

Most of the current spatial statistical analysis in the social science deals with cross sectional observations. Although there is a growing attention to space-time data (in the form of panel data), the wireless technology suggests much more complex, near-continuous data settings in which both time and space are equally important and much interest will focus on “flows” rather than “stocks”. Much of the methodological tools to address such issues remain to be developed.

4. *Visualization and ESDA*

Current techniques of geo-visualization and exploratory spatial data analysis are static, based on the availability of large screen real estate and considerable computation power. Moving approaches to identify and visualize clusters, spatial outliers and other spatial patterns to the small screen of the hand held device will require new ways of thinking about ESDA.

5. *Modeling and Spatial Econometrics*

Spatial econometric modeling in a wireless world will allow continuous updating of model parameters, a greater attention to local variability and require a rethinking of inferential paradigms to deal with changing and very large spatially correlated datasets. Immediate access to distributed resources will also provide new opportunities for meta analysis.

6. *Geocomputing Infrastructure*

The division of labor between (thin) clients and distributed servers that provide the infrastructure to carry out geocomputation is an important challenge. As the technologies evolve at break neck speed, it is hard to envisage whether simple extensions of current ideas will be sufficient, or if totally new paradigms (and computing/scripting languages) will be required.

While many of these topics have received attention from technological and commercial perspectives, their implications for spatial social science research remain to be considered.

Contextually Adaptive Mobile Masks and Their Inverses[1]

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A location-based service (LBS) uses information technologies to determine the location of an enabled appliance, and modifies the information it presents to the user in a way that is sensitive to local context and user preferences. Interest in LBS has been spurred recently by FCC stipulations that new cell phone handsets must be able to provide their location, using either GPS or network signal strength, for E-911 use. Additional technology, such as assisted GPS (A-GPS: van Diggelen and Abraham, 2001) is being developed to extend location determination capabilities to areas that are normally inaccessible to GPS signals, such as underground parking garages and inside buildings. These enhancements will soon make it possible for the location of a device to be monitored continuously at high levels of accuracy. This powerful ability, however, has begun to raise important public policy concerns about individual privacy and surveillance (Armstrong, 2001). The purpose of this position paper is to sketch out a general approach that would permit accurate E-911 service provision, and provide context sensitive information to those seeking such services while simultaneously satisfying the conflicting objective of preserving locational privacy.

Though inaccuracies can be introduced for several reasons related to the satellite constellation, atmospheric distortion, physical blockage and receiver health, it is assumed for the purpose of this discussion, that a GPS receiver is able to calculate a three-dimensional coordinate location at high levels of accuracy under a broad range of conditions. To become useful to a LBS, however, a GPS-derived coordinate must be placed into a particular geographic context. This can be accomplished, for example, by assigning the coordinate to its closest link on a street network or to a service area using a point-in-polygon function. Once a location has been established, a link to a contextual database is made and information is either served on request or pushed to the appliance. It is also at this "point" that information can be masked to preserve the locational privacy of an individual using an LBS-enabled appliance. This mask would require, of course, the consent of both a *trusted* location-based service provider and the user. E-911 service would remain unaffected since the "raw" coordinate information is still available for emergency services.

A mask, in this case, is a way of preventing the accurate recovery of a coordinate location. The basic premise of the approach is that a location calculated for a LBS can be masked without substantially affecting the quality of the information provided to a user. Masking can be accomplished using several means (see Armstrong, Rushton and

Zimmerman, 1999) including aggregation and perturbation. For a contextually adaptive mobile mask (CAMM), aggregation seems to hold promise, though a combination of aggregation and perturbation could prove to be superior. The CAMM process would replace a coordinate location with an assigned one or two dimensional object. For example, a point location could first be assigned to a transportation link and then replaced with one or two topologically connected census block groups or tracts. The size of the area used could be a function of local population density (the context), location along a network (e.g. controlled-access highway) or other factors that prove to be important in preserving the locational privacy of an individual. Alternatively, the mask could be made a function of geographic size (area) or population count according to the wishes of the LBS user. In this case, a coordinate would be assigned to an aggregated collection of areal units for which population data are available and if a large population value is set as a parameter (heavy masking) then aggregation of units would continue until a threshold is met or exceeded.

The negative impact of masking is that the level of geographical specificity of services with respect to a current location is necessarily degraded. Thus, information about, say, locations of restaurants of a particular type within walking distance (established as a user-set parameter) could be inaccurate. But since users would have control over the level of masking invoked, they could adjust the mask to meet their goals and make trade-offs between the quality of service provided and their desire to maintain locational privacy.

Decloaking - Inverting a CAMM

No mask is perfect. Moreover, there are cases when a mask could be compromised. For example, if a user were to set a small area or population threshold in a sparsely inhabited region, and if the user were to remain stationary, say from 9 PM until 8AM the next day, a sleep location probably could be induced with relative high levels of accuracy. Ancillary information could be used to increase the accuracy of any mask inversion. Areas known to be non-residential (e.g., parks) and even the location of building symbols from USGS topographic maps could be used to establish some masked locations. In a similar fashion, if an assignment of a mobile individual to an area is made, and if a sequence of areas is assembled for that user, it would be possible to induce a route taken, especially, for example, if a limited access highway were used, since uncertainty associated with intersections would be eliminated from consideration.

1. I wish to acknowledge detailed discussions on related topics with Gerard Rushton (Geography, U of Iowa) and Dale Zimmerman (Statistics, U of Iowa) during the summer of 1997 at the Obermann Center for Advanced Study at The University of Iowa.

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Statement of Interest for the Location-Based Services Specialist Meeting
December 14-15, 2001

The next GIS revolution will be hastened by compact GPS receivers, cellular communications, portable web access, reduced size microcomputers, and the next generation input and output devices for the use and display of digital maps. In our work, part of the NSF-funded Project Battuta (www.statlab.iastate.edu/dg), we have designed and built a wearable GIS. A wearable GIS is a GIS contained on the person of the user, with input devices using a hand-free environment, and the display directly into the human vision field. The wearable GIS places extraordinary demands on the human-computer interface. Particular concerns are communications, data bandwidth, Internet access and coverage, high-throughput Internet links, digital library database access, but above all the user interface of such a system. Alternative designs for the mobile ubiquitous GIS user interface are being researched, and include capabilities for in-view augmented cartographic reality. View options include feature frames, three dimensional glyphs, text feature annotation, monochrome feature filters, feature location identification and selection, Internet linkage, haloing, and pointer and navigation aids and mechanisms.

Most GIS applications have been designed for desktop use and do not meet the needs for wearable use. The desktop Graphical User Interface (GUI) is based on the WIMP (Window Icon Menu Pointer) metaphor and assumes that interaction with the computer is the primary task. In contrast, the user of wearable computer applications is most likely distracted by the environment, and the operation of the computer is not necessarily the primary task because the user is doing something else besides interacting with the computer. Some design features for the mobile ubiquitous GIS user interface are feature frames, three dimensional glyphs, text feature annotation, monochrome feature filters, feature location identification and selection, Internet linkage, haloing, and pointer and navigation aids and mechanisms.

A feature frame is the wire-frane equivalent of a three dimensional object. In augmental reality, a realistic depiction is unnecessary, so simplified, stylistic object representetaions are necessary to outline and draw attention to objects. Three dimensional glyphs are solid objects that depict or carry attribute information about the objects that they symbolize. For example, an extruded polygon can be colored, enlarged and annotated with data about a feature. Text annotation is text that is placed intyo the augmented reality view that labels or otherwise communicates information abouty the feature, its name, or its attributes. Feature filters allow augmented reality views to be changed depending on the attributes. For example, features can be shown in black and white on a color image (monochorome feature filter), highlighted with image enhancement such as circles and halos, or pointed to with color or animation.

Navigation can also be significantly enhanced through augmented reality. Users can be pointed to locations, or navigational indicators such as magic carpets and floating arrows can be used as aids. Even a disoriented user can be simply pointed towards the correct target. Similarly, locations can be linked directly to web-based information via web hotlinks. The nature of wearable systems may place a premium on security, in which case images placed into augmented reality can be changed to enhance reality. Private features can be blacked out, or access to augmented reality can be blocked at the server side. Such systems may become necessary in the future, or in special environments.

Digital Cities: the ultimate location based services?

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My interest in this specialist meeting is motivated by recent explorations of digital cities, which are web-based representations of real cities offering a wide range of local information, on-line services, and public decision-making support functions. The more specific questions I would like to investigate here concern the requirements (or potential uses) digital cities may have for a variety of location-based services, and the extent to which such services are already available or would need to be provided in the future.

What is the digital city?
The term 'digital city' can mean many different things to different people. For the purposes of this note I adopt the following definition: *the digital city is a comprehensive, web-based representation or reproduction of aspects or functions of a specific real city, open to non-experts.* The definition thus does not cover urban computer games and representations of fictitious cities since they don't represent any specific geographic area. The digital city is also not a traditional GIS representation or urban model, since these are not directly open to non-experts, nor can it be identified with the many useful telematics applications - e.g., intelligent transportation systems - developed to assist urban management or to make some urban function run smoother (these are not representations or reproductions of urban aspects or functions). However, all these urban applications of digital technologies (the games, GISs, computational models, intelligent technologies, and so on) may be integrated into the digital city as considered here. Three characteristics are of defining importance: First, digital cities are 'place-based'; second, they are functionally comprehensive, just as real cities are; and third, they are meant to be accessible to the public in the broad sense rather than to any particular groups of experts, professionals, special interests, or urban managers.

While there have been many locally oriented, web-supported applications around the world, the idea of the digital city as a *comprehensive* digital-age urban resource first crystallized in Europe. In 1996 the European Union launched the four-year European Digital Cities Project (EDC) under the auspices of the Telematics Applications Programme. The purpose of the project was to support European cities and regions in the deployment of new economically and socially sustainable telematics applications, and to identify related future needs and priorities of local authorities. Outside the EDC project, interesting initiatives such as Digital City Amsterdam and Virtual Helsinki have been sponsored in Europe by local authorities and telecoms service providers, respectively. Digital cities have also been proliferating in the USA but here their builders overwhelmingly tend to be commercial interests. Major Internet service providers in particular have developed extensive networks of web sites covering most major

American cities. The site www.digitalcity.com, a division of America Online, Inc., boasts the nation's largest locally focused online network delivering locally targeted news and information, especially on "Entertainment, Shopping, People & More". These digital cities are best described as 'electronic brochures', both in terms of their content and of their conventional organization of the material in thematic 'pages'. A few attempts to emulate the European model of focusing on public services rather than commerce can be found under the Aurora Partnership (www.aurorapartnership.gov), a miscellaneous conglomeration of federal government agencies, universities, GIS vendors and other industrial partners, local authorities, NGOs, and so on. While Aurora's mission is to facilitate "the development and use of spatial decision support tools, services and systems for place-based decision making and management", its focus is not specifically urban. Finally, several striking examples of technologically sophisticated digital cities are from Japan.

A rough typology of digital city functions

The list of functions digital cities are designed to perform keeps growing, with more complex and sophisticated options becoming possible all the time as the technology develops. Some of these are genuinely interactive and participatory in that individuals can affect the course of events within each function. Most have (or could have) a location-based component relating to either the current position of the user or that of the service, persons, facility, or process queried.

- *Information provision* about a specific urban area is the basic and still most common function: maps, news, events, services, entertainment and commerce, accommodation, and so on. Simple services such as booking tickets or hotel rooms are also often offered in that format as an alternative to the telephone. In 1997 these 'electronic brochures' made up some 56% of European city-related web sites. That percentage is quite likely much higher in the USA given the dominance of commercial interests in digital city development.
- *Provision of on-line services* of a more substantial kind, such as civic services (e.g., filing for permits, filling out and submitting complex forms, downloading materials from a city library) is the next step up. Technically these services are simple to provide but they do require considerable effort to set up and maintain. By contrast the p*rovision of real-time information* (and in some cases, short-term forecasts) about transportation conditions, weather, emergencies, and so on requires considerable technological investment. In this case the digital city must be linked to an 'intelligent city' equipped with extensive telematics infrastructure on the ground.
- *Social networking and communication*, though technologically very simple, is justifiably one of the most touted blessings of the Internet. There is no end to the interest groups, special issues groups, neighborhood groups, local politics groups, support groups, activist groups, etc., that can come and go in the real city, and all these can in principle be greatly supported and facilitated through appropriate digital city organization. One of the best known European examples, Digital City Amsterdam (de digitale stad: www.dds.nl/) is primarily an urban social networking and communication engine even though it was initially created for communication between the municipal council and the citizens.

- *Participatory decision support* is a function requiring much more sophisticated organization and leadership, and potentially technical resources, than informal communication within groups. It is also the one that comes closest to the ‘Athenian agora’ ideal and is thus very frequently mentioned in discussions of digital cities and ‘digital democracy’ more broadly. Because of the prominence of spatial issues in urban decision making this is an area where planners and GIS experts have already made significant contributions. Making these techniques web-based in the context of a comprehensive digital city structure is an obvious next step.
- *Interactive urban simulations* based on one or several alternative models of urban change would require considerable additional technical sophistication. A wide range of implemented urban process simulation models are available today but have not yet been integrated with other aspects of the digital city, e.g. systematic information provision or social network support. Interactive virtual reality models of the visual appearance of urban change (e.g., in the case of planned large-scale redevelopment) would also be in that category.
- *Integrated urban simulation and public decision support* is finally a further complex function that could become available in the foreseeable future if the digital cities idea is taken seriously by governments and citizens alike.

What I would like to find out:
In principle then the Digital City is the ultimate location-based service, a platform for integrating and enhancing the value of most other kinds of location-based services. The question is what kinds of location-based services are available or needed to properly support the many kinds of functions a digital city could perform, right now or in the near future.

Case Studies in the Deployment of Wireless Emergency Response Systems

Position Paper for Specialist Meeting on Location-Based Services
Santa Barbara, CA December 14-15 , 2001

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Over the past two decades there has been a steady growth in the number, extent and capacity of emergency response systems (ERS) in the U.S. and globally. Also known in North America as 911 systems, they were originally introduced as a means of expediting emergency responses by establishing a single, easy to remember number – 911 – for all emergency calls. All calls to that number would be routed through a central office to the appropriate local emergency response unit. In this form, they had no automated geographic component. However, in the 1990s a second iteration of the system, referred to as Enhanced 911 (or E-911), was introduced. This system automatically provided the emergency operator with not just the number, but also the address of the telephone from which the call was made. In the United States, the implementation this system has involved the massive rationalization and disambiguation of postal addresses, in both urban and rural areas. In urban areas duplicate street names have been changed, and in rural areas there is an ongoing process by which traditional Rural Route and Box numbers are replaced with standard street names and house numbers.

By the late 1990s, some experts estimated that over 50% of emergency 911 calls in the United States were placed from wireless telephones. Unlike the static wired phones, mobile telephones could not be depended upon to reside at a particular postal address. They were, and are, incompatible with the newly enhanced 911 system. In response, the Wireless Communication and Public Safety Act of 1999 mandated a new iteration of the 911 system, incorporating technologies that permit the location of the source of wireless 911 calls.

Our research attempts to understand the implications and effects of these enhanced systems on individuals as they negotiate the structure of daily life. On the basis of our research so far, we believe that these fall into three categories:

First, the intended use of the systems, for public safety, involves as a basic element of those systems the possibility of identifying and (in the newer systems) tracking the locations of households and individuals. This tracking means one thing when the systems are used strictly for their intended purposes, but may mean something else when these systems are used for additional purposes. Second, the broader commercialization of the systems appears to open the way for their use not simply to track individuals, but also to incorporate collected data into larger, pre-existing geodemographic systems. These systems may be used to typify neighborhoods and places. And third, the systems have been associated with a general rationalization of the landscape, with what James Scott referred to as the creation of a newly "legible" landscape.

Much of the policy action and public concern with location-based services such as 911 systems has focused on privacy. That concern has, by and large, focused on the first of the three issues above, that of tracking, and more particularly, the possibility of tracking for commercial purposes. But we believe that each of the three areas that we mention is of social consequence, and that each--but each in a different way--raises issues of personal privacy.

The first of these appears the most conventional. There the issue concerns the collection and use of information about individuals. This was an issue with the first, primitive systems; it was more an issue with E-911 systems; and will become even more of an issue with the implementation of the Wireless Communication and Public Safety Act of 1999. Here, though, it might be argued that the issues of transparency and consent, so important to American and European thinking about privacy and data protection, provide a sufficient model for the regulation of the systems and protection of individual privacy.

When we turn to the second issue, of the incorporation of collected data into larger, pre-existing geodemographic systems, rather a different set of issues arises. Here it becomes possible, using the systems, not merely to track individuals, but in addition to use information about their locations and actions for a range of other purposes. It becomes possible on the one hand to associate individuals--and no longer just households--with particular locations, and thereby to characterize the actions of those individuals in a detailed way that defines them as members of particular categories. At the same time, it becomes possible to use those data as means for the redefinition of geographical space, so that traditional, fixed neighborhoods can now be seen as fluid, as changing throughout the day on the basis of the nature of the individuals who occupy them. Conjointly these two possibilities raise the issue (raised in rather a different way by surveillance cameras) of the extent to which it remains possible to engage in private actions within public space; and so calls into question the very nature of public space.

Finally, the development of 911 systems has involved the creation of an institutional underpinning in the form of a rationalization of the address system across the United States. In an important sense, the process begun with the development of the ZIP Code in the 1960s has only now been extended to rural areas, so that the systems have become important to the development of a comprehensive system within which every mailing address and telephone extension, to the level of the office within a building, has been geocoded. If in one sense this is simply an extension of a longstanding process, it raises a series of important social issues. Perhaps most obviously, it increases the extent to which it seems possible to move the locus of authority from the local level to a more centralized location. And there, just to the extent that decision-makers prefer to make their decisions using standard data, and using as much data as can reasonably be brought to bear, it sets the stage for an increase in the collection of individual data, just as it suggests the possibility that traditional, local means of social understanding and control might better be replaced with ones that rely on those standard data. Hence, this third issue, the development of an increasingly legible landscape, feeds back into the first two issues raised by the development of 911 systems. All three issues raise the question of how robust existing laws and systems of privacy protection are in the face of these new challenges.

The applicants are at the halfway mark of a two year National Science Foundation-funded research project[1] which had its genesis at a specialist meeting of the Varenius Project of NCGIA.

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[1] "People and Place: Geographic Information Technologies and Patterns of Individual Identification" *(Grant No. SES-0083271)*. It examines the relation of emergent geographic information technologies to changing patterns of individual identification.

The specialist meeting on location-based services is an ideal opportunity to share with others the first fruits of our current research project. The goals of this project are to specify, empirically and descriptively, the complex socio-technical processes through which geographic information technologies -- including location-based systems -- are imagined, developed, and deployed, and to specify, on a theoretical and prescriptive level, the parameters of the social importance of these systems and services.

The Deployment of Onboard Telematics Systems:
The Case of Car Rental Companies

Position Paper for Specialist Meeting on Location-Based Services
Santa Barbara, CA December 14-15, 2001

Colin Bennett
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Charles Raab
Priscilla Regan

The use of vehicle telematics was introduced to the consumer market in 1996 when the Ford Motor Company unveiled the RESCU (Remote Emergency Satellite Cellular Unit) system in the Lincoln Continental. General Motors made their telematics system, OnStar, publicly available in 1997, and since then, BMW, Mercedes, and Infiniti have introduced telematics devices developed by Motorola that are based on GPS and cellular communications systems. The Magellan Corporation has also developed a telematics system called "NeverLost" that is gaining consumer and industry support.

The case that has caused the most recent controversy, and which provides the starting-point for our analysis, is that involving the use of location-based technologies in rental cars. Earlier this year, this issue was bought to public attention by the Connecticut case of the Acme car rental company which had fined one of its users $450 over the rental contract amount as a penalty for speeding. The location-based device was provided by an Ontario company called AirIQ. In addition to pinpointing a vehicle's exact location, AirIQ customers can set boundaries for their vehicles, enabling car rental companies to track when cars are taken across state or provincial borders. The system can also deactivate a vehicle's ignition if it has been stolen, prohibiting a thief from restarting the car once it has been turned off. It can also track speed.

Our research[1] seeks to analyze the issues raised by the Acme Car Rental case, and then tries to provide an overview of location-based technologies employed by other car rental companies in Canada, the United States, and abroad with a view to understanding the contemporary practices and standards within the car-rental industry. Comparisons between the major companies, as well as between the countries concerned**,** will be drawn.

These systems raise two rather different sets of issues. On the one hand are conventional information privacy issues concerning the use of data generated through the use of the systems. Potentially, the systems allow an almost unparalleled level of tracking of the users of automobiles; initial media commentary on the *Acme* case has focused predictably on the ‘Big Brother’ potential for these systems. But to what extent is the tracking of automobiles actually occurring within car-rental industry? What sorts of data

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[1] “People and Place: Geographic Information Technologies and Patterns of Individual Identification” *(Grant No. SES-0083271)*. It examines the relation of emergent geographic information technologies to changing patterns of individual identification.

are collected, and to what extent do users of the systems know about this collection and have control over it? Under what circumstances are law enforcement officials granted access to car-rental data? Are data matching and integration occurring, and what are the implications for the possibility of individual privacy and group discrimination?

Beyond concerns about the collection, use and disclosure of the personally-related information associated with onboard telematics systems, there are a range of issues that relate to the dynamic nature of the relationship that is engaged in when one rents an automobile. The practice of car-renting, the role of the car-rental company, and the relationship between the renter and that company have changed in nature and degree as a result of the introduction of location-based technologies. Car rental companies appear to be employing location-based systems to reduce their costs and liabilities. The technology augments their control and decreases their risk. But by what processes are risk categories determined? Are certain clients or certain regions deemed to be riskier than others? To what extent do these systems support existing prejudices about race, ethnicity, and social class? How is the socialization of risk effected? How is cost distributed among newly refined risk categories? Additionally, the social role of the car rental company may be transformed. If restrictions on speeding are included as a contract provision and companies fine customers for violations, might this foreshadow privatization of traffic law enforcement, or at least a closer cooperation between rental companies and police?

At the same time, the technology affects the car-renter in at least two ways. First, location-based systems are likely to be presented to car-renters as means to enhance their safety and convenience. If they get lost in a strange place, someone will know where they are. If they are in an accident, help can be sent. If their rented car is stolen, it will be found. If they are looking for a particular nearby service, its location can be provided. But, at the same time, these systems have the potential to change the social behavior of the renter. Assuming that the renter knows about the location-based device, will her decisions on where and how to drive be constrained by the knowledge that, at least potentially, her movements are being tracked and recorded? What are the implications for notions of place and community as strangers and newcomers rely more heavily on distant databases for knowledge of the local region?

The applicants are at the halfway mark of a two year National Science Foundation-funded research project which had its genesis at a specialist meeting of the Varenius Project of NCGIA. The goals of this project are to specify, empirically and descriptively, the complex socio-technical processes through which geographic information technologies -- including location-based systems -- are imagined, developed, and deployed, and to specify, on a theoretical and prescriptive level, the parameters of the social importance of these systems and services. The specialist meeting on location-based services is an ideal opportunity to share with others the first fruits of this research.

The use of location-based services in distributed collaborative visualization environments

Position Statement

CSISS Specialist Meeting on Location-based Services

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I would like to raise two related discussion points for this workshop that stem from my interdisciplinary research interests in geovisualization, GIScience and cognition, and human-computer interaction. The overall research question I would like to bring to the table is "How can we take advantage of the potential of Location-based Services (LBS) technology to support the design and usability of distributed graphical user interfaces (GUIs) for GIServices?" By GIServices I mean for example geolibraries, Internet Map Servers, augmented, field-based geo-computing, including LBS, as well as collaborative geovisualization tools for geographic knowledge discovery in data rich environments (e.g. of the "same-time-different-place" category).

A pervasive theme among the current geovisualization research challenges is the difficulty to effectively evaluate such kinds of distributed, highly interactive and potentially collaborative graphical tools for knowledge discovery (MacEachren and Kraak, 2001). Within the raised research theme I would like to put forward two related sub questions that I see relevant for the LBS workshop. Firstly, how does one carry out user-centered usability studies for mobile and/or web-enabled interfaces, when evaluators do not have face-to-face access to users to perform task-based usability evaluations? Cases in point are the usability studies of the Alexandria Digital Library Project. Second, how do we evaluate the effectiveness of distributed, collaborative geovisualization tools for group work on ill-defined tasks such as decision-making and knowledge discovery? I believe that LBS in conjunction with eye-movement tracking approaches, typically employed in psychological research, has great potential to address both research questions.

LBS and usability studies of distributed interfaces

On the CSISS web site LBS is defined as "an information service that exploits the ability of technology to know where it is, and to modify the information it presents accordingly" (CSISS, 2001). Besides tracking movement of LBS users in the real world, one can imagine to employ such kinds of location-aware monitoring devices in metaphorical spaces or virtual worlds, such as graphical user interfaces or immersive virtual environments (VE). From a usability evaluation standpoint an investigator might not only be interested in capturing and tracking which user interface elements users are utilizing, and for how long they are using it, but also *where* exactly and for how long precisely on the map display or the remotely sensed image users are focusing.

As with GIS, the recording of process data at adequate spatio-temporal levels of detail is a very important aspect of usability research. Current approaches for distributed interfaces (e.g. user log data analyses) seem to hinder usability data-capture at higher levels of granularity. Eye-tracking software augmented with LBS technology would allow usability evaluators to track fine-grained eye-movement data over distributed networks, thus facilitating the usability assessment of interfaces for WWW-enabled GIServices, mobile technology, or different types of "same-time-different-place" collaborative geovisualization tools. Eye-movement tracking is specifically targeted towards data capture of spatio-temporal events at fine granularity, occurring during graphic display viewing, or graphical user interface use. Eye movement research typically yields a tremendous amount of data, both spatially and temporally at very high levels of detail. One of the pitfalls of early eye-movement research was the difficulty to analyze and comprehend the large volumes of data. Cross-fertilization with GIScience seems appropriate at this point, on several levels. From the cognitive science/social science s perspective GIS is useful as a means to store, manage and analyze large amounts of spatio-temporal data. From a GIScience perspective it is important to develop additional knowledge discovery tools that handle the increase of monitoring data provided by LBS at high levels of spatio-temporal resolution, and to make this data available to human users with limited perceptual and cognitive processing capabilities.

LBS and augmented, collaborative geographic information technology

HCI research has moved from purely visual displays to multimodal interfaces, including more recently gesture, speech and gaze technology. Eye-movement tracking only records where people are looking, but one could envision combining this technology with LBS to trigger events in the interface based on people's gaze. For example, two collaborators sitting in front of the same computer display but at different geographic locations would not only be able to see what button the collaborator is pushing on the display but also which parts of the graph in a display particularly draws the researcher's attention. It is reasonable to think that with LBS technology one would be able to provide additional views at particular gaze fixation points in a display, in real time. This approach might also be applicable to field-based information technology, such as augmented reality type systems and mobile computing. A researcher's gaze through VR glasses can be tracked on elements in the real environment as well as on the VR glasses themselves. With LBS, a person's gaze could be augmented with additional data fed not only into the visual field, but also precisely targeted to the center of attention in the simulated space on the VR glasses.

More recently, researchers in psychology have developed sophisticated software to visualize eye-movement data. Typically, x-y coordinate pairs of eye fixation points are recorded in real time, and can be later played back by plotting them onto the graphic display which is being monitored. Eye-movement data can be displayed using connecting lines between moving eye-fixation points (e.g. scan paths). Other graphic elements reveal for example the duration of eye fixation locations, the magnitude of eye movement saccades, as well as the duration and the length of scan paths (Goldberg and Kotval, 1998).

Eye-tracking software handles temporal visualization quite well, but does not include spatial-analytical tools to analyze the location-based data. Although GIS do not handle temporal visualization well, the development of LBS will foster research in the temporal domain, and lead to better tracking and dynamic visualization software and devices, as to enhance the potential of existing tools such as ESRI's Tracking Analyst for instance. It seems obvious that eye-tracking data can be easily imported into a GIS for further spatial analysis. GISci and LBS on the other hand could benefit from looking across disciplinary boundaries, for example by taking advantage of the sophisticated dynamic visualization tools available for eye-movement research to improve the usability of graphic displays for GIServices.

References

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