USING DIGITAL GEOSPATIAL INFORMATION TO LOCATE SAMPLE UNITS IN THE FIELD

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Abstract

Digital geospatial information is now widely available via the Internet, commercial software, and computer-assisted tools. Examples include electronic map and route services, digital photographs, and coordinates obtained from global positioning system (GPS) receivers. Digital geospatial data could be used to increase the efficiency of field staff operations by providing spatial resources in a mobile computer-assisted environment. However, little is known about the effectiveness of alternative formats and how best to present this information to assist field representatives. In this paper, we focus on methods for using digital geospatial information to find sample units. Locating establishments and housing units in the field can be challenging, especially in recently developed neighborhoods, when maps are out-of-date or poorly labeled, or when address information for the sample or reporting unit is inaccurate or incomplete. Field representatives often require additional resources to identify difficult-to-locate units in the field. We will describe preliminary research and a field study design to investigate the effectiveness of digital geospatial materials for locating sample units in the field. The specific goals of the research are to explore the uses and challenges associated with different kinds of digital geospatial data for locating a sample unit and to understand how screen size impacts one's ability to use these resources in a mobile field environment.

1. Introduction

Sample surveys rely on geospatial information to support nearly all components of the survey process. Field representatives, survey methodologists, and researchers use maps and photographs for sample selection, interview workload planning, navigation, listing activities, updates of map information, data collection, and analyses.

Geospatial information such as maps, photographs, and other spatial resources are commonly used in paper form during the survey process. The increasing availability of these resources in digital form is motivating survey methodologists to explore the role of geospatial data in computer-assisted data collection activities. However, little is known about how best to use this type of information in digital form. For example, questions arise about which materials are best for a specific task, how data collectors should use geospatial information in performing a task, and how user attributes such as spatial abilities affect which information is most appropriate for a particular data collector.

Psychologists have long studied spatial cognition in humans (Mark *et al*. 1999). In some investigations, the focus is on expressing and understanding spatial concepts in abstract situations such as a conversation. Other research focuses on specific tasks requiring spatial information. For example, Taylor and Tversky (1992) explore the role of text and map-based information in navigation and in ability to recall routes. They specifically consider the effectiveness of route (egocentric perspective) and survey (bird's eye perspective) information in accomplishing these tasks. The work of Taylor and Tversky (1992) is an example of an emerging research area that focuses on geospatial information theory and cognitive processes in relation to the use of geospatial information. Research to-date primarily focuses on commonplace usages of geospatial information, such as navigation within a zoo or on automobile trips, and much of the research is performed in a laboratory setting. Real world field situations have been explored to some extent, but not within the sample survey context where there is a need to develop protocols that meet levels of standardization required to provide data of consistent meaning and quality.

The broad objective of our research is to explore which forms of geospatial information and interfaces are most effective in aiding users to accurately locate discrete and identifiable sample or reporting units (e.g., housing units, establishments, or sample points on the land). The task of finding a location can be parsed into three phases:

1. *orientation*, where materials are reviewed in relation to the field representative's position and the target location, and a route to the target location (i.e., the establishment) is planned;

2. *navigation*, which involves traveling to the vicinity of the location (i.e., to the corresponding block, within view of the establishment); and

3. *identification* of the specific location of the target unit (i.e., the establishment).

Each of these three phases call for a slightly different set of digital geospatial materials. For example, resources that provide a relatively broad overview are needed during the orientation phase to identify one's own location and the target location on the materials and to plan a route. A closer view of a map may be needed for actual navigation during the second phase. For the third phase, most of the information is derived from the data provided on the establishment rather than on photographic images or maps.

In this paper, we describe preliminary investigations and the design of a field study to explore the use of geospatial data in the field to locate sample units. We begin by presenting information on the current use of geospatial materials by Bureau of Labor Statistics (BLS) field staff, as well as their ideas on the types of materials and features that would enhance their effectiveness if offered in a mobile computing environment. Next we describe a field study being implemented to explore the use of global positioning system (GPS) receivers and commercial map software on tablet and handheld computing platforms. In the proposed study, we focus on the task of locating an establishment in the field for the first time. Early results from this study will be presented in our talk, but are unavailable in time for publication.

2. Current Field Use of Geospatial Resources

To increase our understanding of how field staff are using geospatial information, BLS regional field managers were asked to distribute a set of questions to field staff on their experiences with using spatial information. Staff were asked what types of map-based resources they use, what information they obtain from map-based resources to help locate establishments or housing units, when map-based resources are most useful, and what problems are encountered when using map-based resources. After reviewing these responses, a teleconference was held with field staff from regional offices to discuss the results of this survey and to obtain more detailed information on field use of geospatial information for locating establishments.

Written and oral responses indicated that maps of widely varying forms are heavily used by field staff and their managers. This points to the importance of this resource in the day-to-day operations of the field staff. The lack of homogeneity in map-based resources primarily results from the need to augment map resources beyond those provided by national staff.

In large urban centers, field staff commonly use map books that contain gridded maps and multiple reference indices available for identifying a location. Commercial organizations producing the best map products (e.g., ADC, Thompson) vary across regions; a single vendor is not available to provide quality maps for the entire U.S. Web-based products for these companies are very limited relative to the paper map products.

Several staff members also use Internet map resources (e.g., MapQuest) and/or map-based software products produced by Microsoft. This year's version is called Streets & Trips 2001 (http://www.microsoft.com/streets), and comes with a PocketPC / WinCE package for downloading map products to a handheld device running a MS operating system. Field staff noted that Internet maps are not always accurate, and that little is known about how digital map sources are updated by private vendors. No one discussed the use of GPS receivers in their work, although a few staff members had driven cars with GPS-based navigation systems.

To plan field work and to navigate to locations, field representatives rely heavily on spatial resources. Coarse-scale views allow one to consider multiple addresses; focused views to identify locations and determine routes for traveling from point to point. Although map resources often provide information on distance for a route, time is also an important metric for the survey setting. Map software features that may help support navigation include route planning utilities that can be updated when plans change, digital maps with a clear indication of one-way streets, and an interface that can be easily interpreted while driving.

In discussing computer-based tools for navigation and field planning tools, field staff commented on several features that may be useful. For example, it may be possible to use audio instructions to provide a safer interface when driving. However, this has the limitation of only providing route-based (rather than overview) information, making it difficult to find a new route when unexpected situations arise (e.g., construction, one way street) unless the ability to adjust the route has been built into the software. Important landmarks that assist navigation to and identification of a location include schools, churches, cemeteries, shopping centers, airports, and parks. Field representatives noted that labels and icons with varied coloring were needed to distinguish and identify landmarks. The ability to display a map at different scales enables a representative to use the digital maps for different tasks (planning for multiple addresses vs. identifying the location of or a route to a single address). Finally, some packages allow the field user to draw on or annotate an image, and this was also viewed as an important tool for locating and for future uses of the map during revisits.

Field staff use multiple kinds of information to identify addresses and outlets, in part due to variability in the completeness and quality of information provided to the field staff. Further, the types of problems encountered in location information vary across community settings, with the age of the development, and with the difficulty of locating businesses. Map resources may contain inaccuracies due to errors or lack of timely information. Streets for a geographic region may be missing or incomplete (e.g., recent construction), or individual or sets of features may be misrepresented.

The net result is that field staff must "triangulate" among information resources (e.g., map, BLS-provided address, yellow pages, internet) to develop an understanding of the likely ground situation. Boundaries for zip codes and other divisions are useful in helping to resolve inconsistencies in information. One type of information that has not been used by field staff is aerial photography. Many thought that aerial photographs may be too complex for field staff to interpret, unless landmarks (or thermal imaging) could be combined with the photograph to provide the field representative with reference information.

Ideally, digital spatial resources are loaded on to the computer that the field representative uses for data gathering. Field staff indicated that a palm-size computer would be acceptable for a second computer, but that larger computers would not. Concerns were expressed about the robustness of the smaller computers in extreme environments.

One potential concern is the skill level needed to work with digital geospatial information. However, because of the importance of maps in field work under the current setting, staff must have adequate map skills to successfully complete their work regardless of whether resources are paper-based or electronic. Thus the population of field representatives does not contain persons who are largely unable to interpret maps, although training may be needed to become effective in locating outlets. Basic training in map reading skills is provided to assist in planning and executing location and navigation tasks. This training is tailored by the data collector's supervisor to reflect needs of the specific job. For example, staff are given an introduction to different types of maps, how to set up and interpret a map, how to use a map for a specific task, how to use cross-indices (features, grids, etc.), and strategies for different types of location situations. Areas that field staff have the most trouble with include identifying the cardinal directions (e.g., finding north or the northwest corner) and finding one's current location on the map.

Field staff noted several areas in which they could benefit from better geospatial data. These include:

- To identify the location of sample units for which inaccurate information was provided,

- To support staff members who are unfamiliar with an area because they have been imported from other regions or locations due staffing problems,

- For the address refinement process that yields the address information provided to field staff conducting initiation (finding and contacting an establishment or household for the first time),

- For the initiation process when poor address information is provided to the field staff, and

- For updating routes and strategies when conditions in the field have changed unexpectedly.

Based on this preliminary investigation, we developed a small study to examine the effects of commercial map products and GPS information on the ability of field staff to locate establishments. The specific setting for this study is described in Section 3 and the study design is outlined in Section 4.

3. Study Setting

The target task for this study is locating an establishment in an urban setting as part of the initiation phase of the Commodity and Services Survey (C&S), conducted by BLS to obtain pricing information for the Consumer Price Index (CPI). We focus in particular on more difficult cases of locating establishments. For example, professional service offices (e.g., lawyers, dentists, accountants) may have signage that is not as recognizable as a franchise establishment, or they may be housed within a poorly marked building with other professional service units. These more challenging settings are likely to benefit the most from having accessible digital geospatial information resources.

During the initiation phase of C&S, field representatives must follow established procedures to find an establishment, but they have some freedom to determine exactly how to carry out the procedures. Prior to going out into the field, a field representative typically does some background work to help locate the establishment. S/he may review yellow and white page directories, street maps, and perhaps make a phone call to the establishment to obtain directions. However, office preparation of this type is not always feasible. Indeed, it may be more efficient to have access to digital resources on the road in case plans need to be altered during the day.

The field study will involve providing BLS field staff with alternative supporting resources for the task of finding establishments (also called outlets) during the C&S initiation process.

4. Proposed Field Study

4.1 Objectives

The overall objective of the proposed research project is to explore the potential benefits and challenges of using digital geospatial information, in the form of electronic maps and locations obtained from GPS receivers, to locate outlets in a mobile computing environment. The specific goals of the research are:

- To explore the potential uses and problems associated with commercial-off-the-shelf (COTS) map products for specific tasks associated with locating a sample unit (e.g., planning, navigating, finding unit),
- To study the benefits and usability issues associated with integrating GPS information with COTS map products,
- To investigate the impact of the screen size of a mobile computer on the use of these resources (both the ability to use them and how they are used),
- To improve our understanding of strategies and tools employed by field staff to make best use of multiple spatial resources in finding outlets, and
- To obtain information on the learning process for using these tools to further understand the training issues associated with these technologies.

Addressing these objectives is a crucial step in developing a foundation for the emerging age in which current and accurate geospatial data are increasingly available and in which on-the-fly integration of different forms of spatial data is possible.

4.2 Experimental Factors

We propose to investigate two factors in our study: the size of computer (and thus visual interface) used by the field representative, and the type of geospatial information made available to the field representative.

The first factor to be studied is the type of device, in particular, the size of interface. Personal digital assistants are common palm-sized devices that are extremely portable. The high quality color interfaces now available provide a viable interface for presenting complex visual information such as spatial data. Although map software provides zoom capabilities that enable the field representative to select an image scale that best fits her/his needs for a particular phase of the locating process, a palm-sized device may not provide an adequate interface, for example, to provide overviews during the orientation phase. A tablet computing environment provides a potential compromise between screen real estate needs and mobility, although it still presents ergonomic difficulties. To explore this issue, we will use two types of devices in our study. One will be a lightweight palm-sized computer (Compaq iPaq, Figure 1a, 2 ¼ x 3" viewable screen area, Pocket PC operating system) and the other will be a tablet computer with a larger interface, but heavier form (Fujitsu 3400, Figure 1b, 10.4" diagonal screen size, Windows 98 operating system).

For the second factor, two types of digital geospatial resources will be studied. First, software that creates digital maps annotated with street names and other features will be made available to the field representative. We have selected Microsoft's Streets and Trips because it provides these features and is already used by a small number of field staff on their home computers. One problem with a map is that it can fail to provide the kind of perspective or features needed to understand one's current location. An alternative option is to use a GPS receiver to indicate the field representative's location on the digital map. Thus, the second type of spatial resource will be a GPS receiver that indicates the field representative's location on the digital map. Examples of the two levels proposed for the geospatial resource factor are presented in Figure 2.

The Streets and Trips software can be run on both Pocket PC and Windows 98 devices, so the interface will be roughly uniform across computing platforms. However, the PocketPC version does not support GPS, so the GPS treatment will only be applied on the tablet level of the device factor. Thus the treatment conditions will be as follows:

- Handheld with map software,
- Tablet with map software, and
- Tablet with map software and current position from GPS receiver displayed on map.

Each field representative that participates in the study will be given several outlets for each treatment. The treatments will be ordered to reduce the difficulty of introducing experimental materials to the field representative.

The usual initiation procedures employed by field staff will also be observed as a benchmark or control condition. This will be done prior to administering the experimental conditions so that a clean assessment may be made.

4.3 Identifying sample outlets

The August 2001 C&S sample was reviewed in order to identify primary sampling units that have a sufficient density of hard-to-find outlets. The "type of business" code was used to identify such establishments. For the PSUs selected, business types include legal services, lawn and garden services, housekeeping, furniture reupholstery, and home-based repair services.

Our goal is to gather information from two to four primary sampling units, pending the availability of experimental resources. The number of outlets per control or treatment condition will depend on the number of hard-to-find outlets available in the PSU.

4.4 Field operations

Prior to training, the field representative will be given a short questionnaire to complete. The preliminary questionnaire includes diagnostic question sets for spatial strategies and abilities; prior experience with computers, GPS, establishment initialization, and the layout of the initialization area; and demographic information such as age and gender.

The field representative will then initiate four to eight control outlets using their usual procedures and asked to record observations on this process. Following the control outlets, the field representative will be trained to use the map software on the tablet (field staff have used the tablets in the past), and will be given three or four new outlets to locate using the tablet and the map software. Field staff will then be trained on use of the handheld device, which has the same map software, and asked to initiate an additional set of outlets. Finally, the field representative will be shown how the GPS link works on the map software on the tablet platform, and an additional set of outlets will be done. The field representative will be given a questionnaire after each treatment session to record information on their experiences with the treatment setting. Questions include which features were used, for which components of the locating task were materials used, how effective the resources were, what types of problems arose, and additional features or resources that would have been helpful. The investigators plan to observe all aspects of the use of these materials.

In order to allow the field staff to become familiar with the equipment and software, the materials will be left with the field representative for initiating additional outlets over the subsequent one or two months. A final field visit will be made by the investigators to assess the efficacy of these materials when the field representative is more familiar with them.

Results from the initial field visit will be reported on during the conference.

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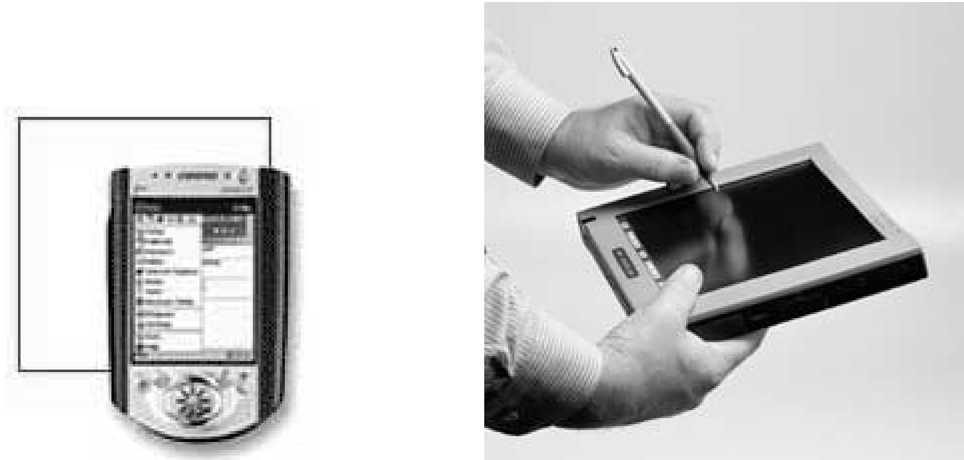
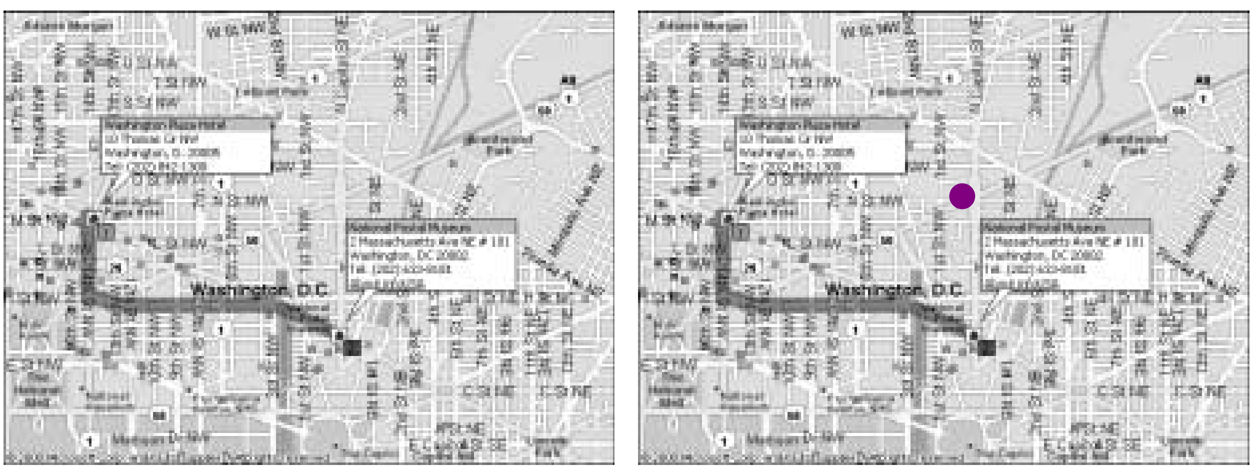


(a) (b)

Figure 1. Devices with different interface dimensions to be used in the field study: (a) Compaq iPAQ and (b) Fujitsu 3400 tablet.



(a) (b)

Figure 2. MS Streets and Trip 2001 map (a) without GPS link and (b) with GPS link denoted by dark circle.