Supporting Interaction as a Secondary Task in Geo-Spatial Applications

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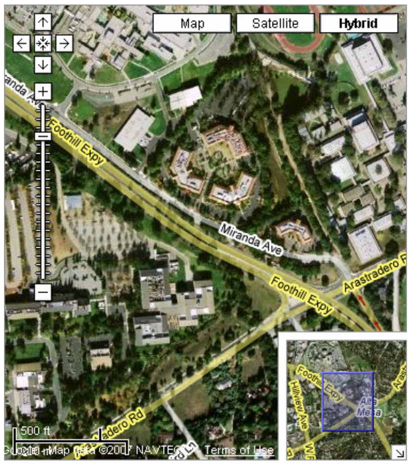
Abstract
Many geo-spatial applications are explicitly or implicitly designed with the premise that the user will be able to devote full attention to the interaction. However, in many situations where geo-spatial applications will be used, there are primary tasks, such as driving an automobile or pedestrian navigation. In these scenarios, the interaction is secondary or supplemental. In this paper, we differentiate between applications and tasks where geo-spatial interaction can be the primary activity, and where it must be relegated as a secondary activity. We examine some issues related to interaction as a secondary task, and discuss whether current techniques that support interaction as a primary task still hold if the task is secondary.

Keywords
Primary and secondary tasks, geo-spatial interaction.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): User Interfaces.

Introduction
Most geo-spatial applications are designed with the premise that the user will be able to devote his/her full attention to the interaction. Since this is true in the

desktop usage scenario familiar to both users and developers, many presentation styles and interaction techniques have been developed that require the user's full attention.



An example desktop geo-spatial application.

While many geo-spatial applications are used on desktop computers to great benefit, mobile access to geo-spatial information can be of even greater utility. Navigational information, tourist guides, and even weather forecast data can be of immediate relevance when a user is mobile and traveling through the world. In this paper, we discuss secondary interaction issues in geo-spatial applications. In the next section, we examine some current usage patterns for geo-spatial applications. In the subsequent section, we highlight several design issues for these applications when considering mobile interaction.

Current Usage Patterns

Geo-spatial applications can include navigation applications, walkthrough and familiarization aids, tourist guides, monitoring and surveillance tools, and surveying and tagging applications. In this section, we discuss a cross section of usage patterns: stationary users at a desktop or laptop, pedestrians using applications on wearable computers and mobile augmented reality systems, and vehicle operators using devices while driving.

Desktop Applications

Perhaps the most commonly used geo-spatial applications are desktop based navigation planning tools like Google Maps, Google Earth, Map Quest, and Yahoo Maps. Other geo-spatial desktop applications include security visualizations that monitor the security status of a large building or facility. Interaction with these applications can monopolize a user's attention since the user is seated and largely focused on the application as a primary task.

Handheld and Wearable Applications

Personal navigation devices are another increasingly popular set of geo-spatial applications. Handheld GPS devices are used for hiking or geocaching, a pastime involving the search for caches of hidden objects known only by their GPS coordinates. A few wearable computer projects have also demonstrated personal GPS based navigation. When using these devices, users make occasional glances at their navigation displays, since staring at the display could cause the user to run into things and trip over rocks or curbs.

Wearable computing research, targeted towards everyday wearable use, has made strides towards realizing application usage as a secondary task. Wearable computer interaction is often characterized by quick glances at a head mounted display and text input is often performed through a one handed, chording keyboard held in the non-dominant hand.

There is also a usage pattern of hybrid applications that overlap the mobile space and the desktop space. These combine mobile data collection in the field and with processing and access on a desktop. Examples include: GPS logging applications that process travel patterns and location tagged observations like field notes or photographs.

Augmented Reality

In tourist guide systems, such as the MARS augmented reality system [1], users typically walk through an area, stopping every so often to bring up information

An example wearable computer usage pattern with head mounted display and one handed keyboard.

concerning the surroundings. Due to this interaction style, there was no strong driver for developing information presentation and interaction techniques that worked while the user was walking. Augmented reality entertainment applications, like AR Quake, require supervision of the players as excited players may focus on the gameplay and fail to notice they are pursuing monsters into a car's path.

Automotive

In the automotive world, the term "driver information systems" describe the multi-media applications that seek to inform and entertain vehicle drivers and passengers. These systems include audio and video entertainment features as well as advanced navigation systems that provide dynamic traffic information and route guidance. These systems reflect strong requirements for keeping a driver's eyes on the road and leaving a driver's attention free. Drivers are warned by navigation systems not to enter destination points while the vehicle is in motion; this is better left to the passenger. Automotive designers divide a driver's activities into primary (driving related), secondary (car status and navigation), and tertiary tasks (comfort, entertainment, etc.) [4]. This division is reflected in the placement and grouping of devices and controls with which the driver can interact.

Design Issues for Interaction Techniques

Many of the interaction styles used in geo-spatial applications are better suited to the desktop since mobile users must often manage division of attention and cognitive load issues. In this section, we discuss these issues and some examples of design issues that result: information legibility, text entry, and dialog initiative.

Division of Attention

This phenomenon arises because users must continually shift attention between the surrounding world and the geo-spatial application. This has unique effects on how information can be presented. Large changes in display content can disrupt the shifting of attention, resulting in distraction from the primary task. It is prudent to avoid displaying large changes or a great deal of motion on peripheral displays. In contrast, small changes in the application's display may go unnoticed between glances. These small changes may build up over time until the user suddenly notices that the information has changed, while missing the process of how the information changed. In the first author's previous work on spatial cognition aids, users were shown a digital map of their surroundings with their current location noted by GPS. The users could lose track of how they had gotten to their current location because it was hard to remember where they had been on the map. Techniques like drawing bread crumbs to show a user's path over the last few minutes allowed users to perceive progress since the last glance at the map. This enabled users to better understand the spatial layout of the surrounding environment [2].

Cognitive Load Management

When users are making choices, avoiding obstacles, and dealing with dangers, cognitive resources become taxed. Geo-spatial applications may need to determine the cognitive load and attention available and decide if and when a user can be asked for input. Such a system could modify its interaction with the user, delaying dialog, escalating alerts, and diminishing notifications when necessary [3].

An example automotive geo-spatial application: driver navigation.

Design Issue: Information Legibility
Since the interaction will be a secondary focus of attention at best, it is important to present information that is understandable at a glance, makes choices obvious, and makes decision making easy and infrequent. Legibility of displays is important in strong sunlight and against cluttered backgrounds. Requiring shifts in focal distance of the eyes induces mental and physical adaptations, and should be avoided.

Design Issue: Text Entry
Text entry techniques are often employed for entering destinations, location tags, and waypoint names. In mobile applications, text entry is often performed with dials, joysticks, and directional pads. Unfortunately, this adds additional, often untenable steering, visual selection, and visual confirmation tasks to the user, who may already be navigating a sidewalk or street. Virtual keypads on touch screens are also not a complete answer as they also require visual selection and confirmation.

Design Issue: Dialog Initiative
Many desktop applications demand attention from the user through pop up windows, flashing window title bars, and animated icons. These notification techniques bring background events to the user's primary focus of attention and may not be appropriate for secondary interaction. The user may only infrequently glance or attend to the output of the geo-spatial application. The user may also neglect the secondary interaction in times of high stress and high cognitive load, e.g. while walking across a busy street, or merging onto a highway. The interaction dialog between the application and the user must allow the user to control dialog initiative. The user must be able to decide when and if a response will be given. The application should limit requests of the user's attention.

Conclusion
Many of these issues require revised approaches to interaction design. However, when geo-spatial applications are designed with the knowledge that interaction is a secondary task, users will better integrate geo-spatial applications into their lifestyles. Wearable computing and automotive design are two domains where design practices designate interaction as a secondary task. Results from cognitive psychology, particularly involving perception, change blindness, and cognitive load can also provide guidance for designers. The "take home" lesson is that many users of geo-spatial applications are focused on another primary task. Resources like attention, gaze, perception, and even free hands are severely limited. We encourage partnerships between researchers and industrial groups who build geo-spatial applications to develop techniques that support secondary interaction.

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