Investigating Sensor-based Interaction Techniques for Mobile Map-based Applications

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Abstract—Mobile phones have traditionally relied on keypad and touch-screen interaction. These input modalities are not well suited to browsing map-based information on mobile phones. Sensor-based interaction techniques take advantage of the intrinsic mobility of mobile devices, allowing the user to interact using natural and intuitive gestures. Device tilting and movement have been successfully used to perform panning and zooming in mobile map-based applications. Existing implementations suffer from several limitations, including a lack of controllability. In addition, logic to interpret sensor data is hard-coded into each application. This research will examine how sensor-based interaction techniques can benefit from improved feedback and adapting to users and their tasks. A framework for incorporating sensor-based interaction into mobile map-based applications will also be developed.

Index Terms—Sensor-based interaction, mobile maps

I. INTRODUCTION

MOBILE map-based applications are becoming more widespread. These applications rely on input techniques that are well suited to traditional phone functions such as dialing and text messaging, but are not well suited to interacting with the large information spaces that are typical of mobile map-based applications.

Mobile phones are increasingly being equipped with a range of sensors which allow the context of the device to be determined. A sensor can be defined as “any measurement data source” [1]. Typical examples include ambient light sensors, accelerometers and magnetometers. Sensors allow intuitive sensor-based interaction techniques to be developed, which can support one handed interaction without obscuring the screen [2].

Existing sensor-based interaction techniques for performing panning and zooming in mobile map-based applications suffer from several problems. These problems include controllability and distinguishing between intentional and unintentional device tilting [2, 3].

This research will investigate two aspects of sensor-based interaction techniques. These are:

- Adaptation of sensor-based input techniques according to the user’s behaviour and tasks; and
- Multimodal feedback to improve controllability of sensor-based interaction techniques.

A software framework will be developed to allow sensor-based interaction techniques to be incorporated into mobile map-based applications. The framework will also allow designers to deal with sensor input at a more abstract level.

This paper begins with a discussion of related work regarding mobile map-based applications and sensor-based interaction techniques (Section II). The proposed use of multimodal feedback and adaptation in new sensor-based interaction techniques is discussed in Section III. Section IV will discuss the framework to be developed.

II. RELATED WORK

A. Mobile Map-based Applications

Mobile map-based applications support users in several tasks, namely [4]:

- Locating: Identifying the position of something (e.g. where am I?);
- Searching: Identifying facilities matching certain criteria (e.g. nearest petrol station);
- Navigating: Finding a route between two points or following a route;
- Checking: Determining the condition of something (e.g. operating hours of a business); and
- Identifying: Identifying persons or objects.

These tasks can be broken down into three low-level operations, namely panning, zooming and selecting. For example, a checking task may involve users zooming out to determine their current location, panning to find a certain point of interest and selecting that point of interest to view more details. Traditionally, mobile map-based applications have supported these operations through either keypad or touch-screen interaction. Keypad interaction supports panning using directional keys; zooming using dedicated keys (* and # are commonly used); and selection using another dedicated key. Touch-screen devices support panning in a variety of ways, including dragging the visible map area; scrollbars; and centering the map on a selected point. Zooming is performed using on-screen buttons; a zoom-slider or by drawing a box on the screen [5]. Selection is performed by tapping the screen.

Existing input mechanisms suffer from several problems and shortcomings. Keypad interaction is a binary form of input, making it difficult for users to control the panning speed. Novices often consider the panning speed to be too fast, while expert users perceive the default panning speed to be too slow [2]. Touch-screen interaction techniques require two-handed interaction, result partial occlusion of
the display, and often require users to switch their attention between the map and the user interface controls [6].

B. Sensor-based Interaction

Many mobile phones are equipped with a range of sensors, including accelerometers, magnetometers, ambient light sensors, GPS sensors and compasses. These sensors allow interaction techniques to be designed which capitalise on the hand-held nature of mobile phones. Accelerometers have successfully been used in several domains to detect tilting gestures. Tilt-input has been used to perform panning and zooming in mobile map-based applications [6].

Sensor-based interaction provides a natural means of interacting with mobile devices. Furthermore, sensor-based interaction provides for one-handed interaction. Studies have shown high-levels of user satisfaction with tilt-input [2]. It has also been suggested that tilt-input can help users form better cognitive overviews of maps [7].

Tilt-input currently suffers from several problems and shortcomings. Fine-grained control using tilting gestures is difficult to achieve, with current implementations suffering from overshooting problems [2]. Tilting the device can make the display difficult to view and distinguishing between deliberate and inadvertent tilting is problematic [3].

This research will investigate whether existing interaction techniques can benefit from improved multimodal feedback and by adapting to user behaviour and tasks.

III. NEW INTERACTION TECHNIQUES

A. Multimodal Feedback

Feedback is especially important in sensor-based interaction with mobile map-based applications in order to help the user control panning and/or zooming operations. Feedback allows users to achieve finer grained control by allowing them with to determine whether the system is responding correctly to input [8].

Visual, vibrotactile and auditory feedback have all previously been incorporated into sensor-based interaction techniques in mobile map-based applications [6]. In this research, the use of these three modalities for supporting specific map-based tasks (Section II) will be investigated.

B. Adaptation

Sensor-based interaction techniques could potentially benefit from adapting to the behaviour and tasks of the user. Controllability of sensor-based input could be improved if the system responds in a way the user expects. This research will investigate whether controllability can be improved by calibrating sensor-based input according to the behaviour of the individual user. Furthermore, sensor-based input will be adapted according to the task the user is currently performing. Sensor-based interaction has already been adapted successfully in the domain of photo browsing, with “attractor” mechanisms used to make it easier for users to select a particular photo and prevent overshooting [2].

IV. PROPOSED FRAMEWORK

Sensor-based APIs in major mobile platforms make sensor data available at a very low level [1]. Applications which rely on this information must interpret this data, perform smoothing and identify deliberate user input gestures. The low-level nature of existing APIs has meant that interaction techniques are generally hard-coded into existing applications [6]. As a result, this functionality must be re-implemented every time a new application using sensor-based interaction is designed. A software framework will be designed to allow sensor-based input to be used similar to keypad or stylus input, using an event listener approach. The framework will be designed to allow for flexibility in terms of the sensors used, the smoothing algorithms employed and the gestures to be recognised.

V. CONCLUSIONS AND FUTURE WORK

Traditional mobile input techniques are not well suited to the domain of mobile map-based applications. Sensor-based techniques can provide a more intuitive form of interaction, allowing for one-handed control. Some challenges remain, particularly regarding the controllability of sensor-based input techniques. This research will investigate the use of multimodal feedback and adaptation in order to improve sensor-based interaction techniques.

Future work will involve the development of new sensor-based interaction techniques for performing zooming, panning and selection in mobile map-based applications. These techniques will incorporate multimodal feedback and user and task-based adaptation. The proposed framework to be developed will be used in the implementation of these techniques. The new techniques will be compared to non-adaptive sensor-based interaction techniques to determine whether the new techniques provide benefits for interacting with mobile map-based applications.

REFERENCES


Bradley van Tonder completed his MSc at NMMU in 2008. He is currently pursuing a PhD at the same institution.