Chapter 2.14
The Design Space of Ubiquitous Mobile Input

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ABSTRACT

The mobile phone is the first truly pervasive computer. In addition to its core communications functionality, it is increasingly used for interaction with the physical world. This chapter examines the design space of input techniques using established desktop taxonomies and design spaces to provide an in-depth discussion of existing interaction techniques. A new five-part spatial classification is proposed for ubiquitous mobile phone interaction tasks discussed in our survey. It includes supported subtasks (position, orient, and selection), dimensionality, relative vs. absolute movement, interaction style (direct vs. indirect), and feedback from the environment (continuous vs. discrete). Key design considerations are identified for deploying these interaction techniques in real-world applications. Our analysis aims to inspire and inform the design of future smart phone interaction techniques.

INTRODUCTION

Today, mobile phones are used not just to keep in touch with others, but also to manage everyday tasks, to share files, and to create personal content. Consequently, our mobile phones are always at hand. Just as Mark Weiser suggested in his vision of ubiquitous computing, the ubiquitous nature of mobile phones certainly does make them "*blend into the fabric of our everyday lives*" (Weiser, 1991).

Technology trends show an increasing number of features packed into this small, convenient form factor. Smart phones already have eyes (camera), ears (microphone), and sensors to perceive their environment. However, their real power, as Weiser pointed out, comes not just from one device, but from the interaction of all of them. Our interest is in showing how modern mobile phones, which resemble Weiser's "*tabs,*" can be used as interaction devices for our environment. Within this environment, emphasis will be placed on interactions with public and situated displays (O'Hara, Perry, & Churchill, 2004) – what Weiser called "*boards.*"

The range of input and output (I/O) capabilities for modern mobile phones is broad. Keypad, joystick, microphone, display, touch-screen, loudspeaker, short-range wireless connectivity over Bluetooth, WiFi, or infrared, and long-range wireless connectivity via GSM/GPRS and UMTS all provide multiple ways of interacting with our phones. These multiple I/O capabilities have increased our ability to use mobile phones to control resources available in our environment, such as public displays, vending machines, and home appliances.

Could this ubiquity mean that mobile phones have become the default input device for ubiquitous computing applications? If so, then mobile phones are positioned to create new interaction paradigms, similar to the way the mouse and keyboard on desktop systems enabled the WIMP (windows, icons, menus, pointers) paradigm of the graphical user interface to emerge and dominate the world of personal desktop computing. However, before this potential is realized, first we must consider which input techniques are intuitive, efficient, and enjoyable for users and applications in the ubiquitous computing domain.

EXAMINING THE DESIGN SPACE OF INPUT DEVICES

Recent research demonstrates a broad array of mobile phone input techniques for ubiquitous computing application scenarios. To make sense of the cumulative knowledge, we systematically organize the input techniques to give insights into the design space. The design space is an important tool for helping designers of ubiquitous computing applications to identify the relationships between input techniques, and to select the most appropriate input technique for their interaction scenarios. Design spaces can also be used to identify gaps in the current body of knowledge and suggest new designs (Zwicky, 1967).

Looking to Foley, Wallace, and Chan's classic paper (Foley et al., 1984), we find a taxonomy of desktop input devices that are structured around the graphics subtasks that they are capable of performing (Position, Orient, Select, Path, Quantify, and Text Entry). These subtasks are the elementary operators that are combined to perform higher-level interface tasks, and will be elaborated upon in later sections. In this chapter, we structure our analysis of smart phones as ubiquitous input devices using this taxonomy. This analysis builds on classic design spaces (Buxton, 1983; Card, Mackinlay, & Robertson, 1991) and extends our own previous work (Ballagas, Ringel, Stone, & Borchers, 2003, Ballagas, Rohs, M., Sheridan, J., and Borchers, 2006) on the design space of input techniques. In our analysis, we blur the line between smart phones and personal digital assistants (PDAs) because their feature sets continue to converge.

Although Foley et al.'s analysis was completed with the desktop computing paradigm in mind, the subtasks in their analysis are still applicable to ubiquitous computing today. They naturally apply to situated display interactions; however, their applicability is not limited to graphical interactions.

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