Chapter XXXV
Projected Displays of Mobile Devices for Collaboration

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ABSTRACT

Mobile devices have so far been personal tools. With their evolution of increased functionality, however, these devices have begun to be used in a shared fashion by multiple people. This chapter discusses techniques allowing multiple people to share mobile devices by projecting their displays and conducting intuitive manipulations on them. The chapter first shows overviews of systems and technologies related to location-aware projection and several interaction techniques. Then, a system called Hotaru that implements intuitive manipulation techniques on projected displays of multiple mobile devices is described. Hotaru allows a user to annotate or rotate a picture or a document on a projected display by using his finger and intuitively to transfer a file between multiple devices by overlapping their projected displays. User studies of Hotaru indicated that the proposed manipulation techniques could support multiple people in a single location in conducting their tasks. Research issues on projected displays of mobile devices are raised.

INTRODUCTION

Mobile devices (PDAs, cellular phones, etc.) have rapidly penetrated into our society, and many people use them in their daily lives. For example, in Japan, the number of subscribers of cellular phones is 93 million (as of the end of July 2006), which is more than three-quarters of the total Japanese population (Telecommunication Carrier Association, 2006).

One of the recent trends of mobile devices is multifunctionality: they are used not only as a communication tool with another person or as a personal scheduler, but also as a Web browser, a digital video camera, a game console, a music player, a television, a GPS device, electronic wallet, and so on. This trend makes the difference between a mobile device and a personal computer smaller: a cellular phone or a PDA is taking the role of another “personal computer”
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retaining the feature of mobility, although their computational capability is still lower than desktop or notebook computers. Moreover, with the evolution and improvement of mobile devices in their functionality and performance, they have begun to be used by multiple people in face-to-face or colocated situations.

The following example shows how a mobile device is used in a colocated situation. A user takes a photo by using a digital camera built into his cellular phone, and wants to show the photo to all the people around him. However, because of the problem of screen real estate on a cellular phone, it is not easy for multiple people to look simultaneously at the photo on his cellular phone. When he tries to pass the photo to people who have requested it, he needs to conduct unintuitive and bothersome operations on his phone using a limited number of keys; for example, by sending the photo to the other people using e-mail, or transferring the photo using infrared communication between two phones brought close together.

One method for solving this problem is projecting a display of a mobile device in order to make it sharable by multiple people and to allow them to conduct intuitive manipulations on the display. For example, if a projector mountable onto a mobile device is available, a user can easily make a projected display of the device appear in any size on any convenient surface such as a wall, a floor, or a table. When multiple users surrounding the display can conduct manipulations it, such as annotation, file selection, file transfer, and so on in an intuitive way, they can collaborate with each other more smoothly and easily.

Because of weight and power-consumption problems, a projector mountable onto a mobile device and usable for sharing its display among multiple people is not currently available. The Canesta Keyboard (Roeber, Bacus, & Tomasi, 2003) is a monochrome short-distance projection system designed to be attached to a PDA, and used to project a personal virtual keyboard (therefore, its projected display is too small to be shared by multiple people). According to recent news, however, research into portable projectors is in progress, and units mountable onto mobile devices will become available in the near future (New York Times, 2004). On the other hand, a video camera mountable onto a mobile device is commercially available now (e.g., mobile phones with built-in video cameras) and can be used for recognizing users’ manipulations on its projected display.

In this chapter, therefore, we propose a system called Hotaru (“Firefly”) that allows users to conduct intuitive manipulations on projected displays of mobile devices (PDAs in this study) by utilizing currently available technologies. In Hotaru, the displays of PDAs are projected through a projector attached to a ceiling based on their 3-D positions and orientations. A stereo camera installed on the ceiling is used to capture and track the positions and orientations of the PDAs. When a user holding his PDA moves it in 3-D space, he can change the location, size, and shape of its projected display accordingly.

Users’ manipulations on projected displays using their fingers are recognized through a video camera attached to a mobile device. Hotaru allows users to conduct mouse-style operations, such as click, double-click, drag, and to annotate or rotate documents or images (Miyahara, Inoue, Tsunesada, & Sugimoto, 2005). Hotaru also implements a novel and intuitive file-transfer technique between PDAs by overlapping their projected displays (Sugimoto, Miyahara, Inoue, & Tsunesada, 2005).

The chapter is organized as follows: The next section discusses related work to Hotaru. Then, the system configuration of Hotaru and its technological details are described. In the Intuitive Manipulation Techniques section, several manipulation techniques for enhancing colocated collaboration and their user interface issues are shown. In the User Studies section, evaluations of Hotaru are discussed. Finally, research issues to be investigated for a mobile device with a projector and a camera are raised.