Chapter 3.19
Mobile Phone Based Augmented Reality

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ABSTRACT

Mobile phones are evolving into the ideal platform for augmented reality (AR). In this chapter, we describe how augmented reality applications can be developed for mobile phones and the interaction metaphors that are ideally suited for this platform. Several sample applications are described which explore different interaction techniques. User study results show that moving the phone to interact with virtual content is an intuitive way to select and position virtual objects. A collaborative AR game is also presented with an evaluation study. Users preferred playing with the collaborative AR interface than with a non-AR interface and also found physical phone motion to be a very natural input method. This results discussed in this chapter should assist researchers in developing their own mobile phone based AR applications.

INTRODUCTION

In recent years, mobile phones have developed into an ideal platform for augmented reality (AR). The current generation of phones has full color displays, integrated cameras, fast processors, and even dedicated 3D graphics chips. It is important to conduct research on the types of AR applications that are ideally suited to mobile phones and user interface guidelines for developing these applications. This is because the widespread adoption of mobile phones means that they could be one of the dominant platforms for AR applications in the near future.

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Traditionally AR content is viewed through a head mounted display (HMD). Wearing an HMD leaves the users hands free to interact with the virtual content, either directly or by using an input device such as a mouse or digital glove. However, for handheld and mobile phone based AR, the user looks through the screen and needs at least one hand to hold the device. The user interface for these applications is very different than those for HMD based AR applications. Thus, there is a need to conduct research on interaction techniques for handheld AR displays, and to produce formal user studies to evaluate these techniques.

In this chapter, we give an overview of the development path from mobile AR to mobile phone AR. We explain in detail how we developed an AR platform suited for mobile phones and discuss the uniqueness of mobile phone interaction for AR. We present sample applications and user studies performed to evaluate interaction techniques and metaphors.

RELATED WORK

The first mobile AR systems, such as Feiner's Touring Machine (Feiner, MacIntyre, & Webster, 1997), relied on bulky backpack worn computers and custom-built hardware. However, it was obvious that what was carried in a backpack would one day be held in the palm of the hand. Feiner showed the potential of mobile AR systems for outdoor context sensitive information overlay, while ARQuake (Thomas et al., 2002) showed how these same systems could be used for outdoor gaming.

At the same time these early mobile systems were being developed, Schmalstieg et al. (2002), Billinghurst, Weghorst, and Furness (1996), and Rekimoto (1996) were exploring early face-to-face collaborative AR interfaces. Billinghurst's Shared Space work showed how AR can be used to seamlessly enhance face-to-face collaboration (Billinghurst, Poupyrev, Kato, & May, 2000) and his AR Conferencing work (Billinghurst & Kato, 1999) showed how AR can be used to create the illusion that a remote collaborator is actually present in the local workspace. Schmalstieg's Studierstube (Schmalstieg et al., 2002) software architecture is ideally suited for building distributed AR applications, and his team has developed a number of interesting collaborative AR systems.

Using Studierstube, Reitmayr, and Schmalstieg (2001) brought the mobile and collaborative research directions together in a mobile collaborative augmented reality interface based on a backpack configuration. Prior to this, Höllerer, Feiner, Terauchi, and Rashid (1999) had added remote collaboration capabilities to the University of Columbia's touring machine, allowing a wearable AR user to collaborate with a remote user at a desktop computer. Piekarski and Thomas (2002) also added similar remote collaboration capabilities to their Tinmith system, once again between a wearable AR user and a colleague at a desktop computer. However Reitmayr's work was the first that allowed multiple users with wearable AR systems to collaborate in spontaneous ways, either face-to-face or in remote settings.

These projects showed that the same benefits that tethered AR interfaces provided for collaboration could also extend to the mobile platform, and new application areas could be explored, such as location based gaming.

Rekimoto's Transvision system explored how a tethered handheld display could provide shared object viewing in an AR setting (Rekimoto, 1996) (see Figure 1). Transvision consists of a small LCD display with a camera mounted on the back. Two users sit across the table and see shared AR content shown on the phone displays. The ARPAD interface (Mogilev, Kiyokawa, Billinghurst, & Pair, 2002) is similar, but it adds a handheld controller to the LCD panel. ARPAD decouples translation and rotation. A selected object is fixed in space relative to the LCD panel and can be moved by moving the panel. Rotation is performed using a trackball input device.

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