Direct Manipulation Techniques for Large Displays using Camera Phones

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ABSTRACT

We demonstrate two complementary interaction techniques for electronic large displays that are designed for camera-equipped mobile phones. The first one enables the direct selection of objects on the display by pointing at them. The second uses a visual movement detection algorithm for incrementally dragging objects across the screen. The use of camera phones for large display interaction is particularly beneficial in public environments, such as subway stations or shopping malls. Direct touch-based interaction is less desirable or infeasible in these environments, requiring alternative input mechanisms. To illustrate the interaction techniques, the demonstration features a collaborative jigsaw puzzle game that can be tried by conference attendees. Puzzle pieces can be simultaneously manipulated by multiple persons using individual mobile phones.

INTRODUCTION

Large displays are increasingly found in public places like airports, train stations, shopping malls, and museums. Typically, their content – like current train schedules, information on local events, or advertisements on products to be sold – is related to the environment in which they are situated in. Unfortunately, most of today's large displays are not interactive, making it difficult to capture interesting information and impossible to influence the display's content in any way. In addition, large displays in public places are often inaccessible for touch-based interaction, since they need to be protected from vandalism.

Camera-equipped mobile phones open up new possibilities in this domain, since the camera provides a powerful input channel and the phone can spontaneously connect to the situated display with technologies such as Bluetooth. Additionally, people are familiar and comfortable with using their own devices and have their mobile phones with them most of the time. Mobile phones with integrated cameras are by now in widespread use[1] and continue to gain market share. A more detailed analysis of using personal devices for public displays can be found in [1].

APPLICATION AREAS

Application areas include games, interactive art, digital bulletin boards, and advertising. In the PhotoPhone Entertainment project [7] camera phones were explored to play games in public places, like bus stops and public squares, and to use available large public displays as output. Photos are analyzed or modified by a remote server and the results are sent back to the phone again. However, our direct manipulation approach operates directly on the phones and thus enables a more interactive gaming experience between users and the public display. Other application areas include interactive art installations [3] or public digital bulletin boards like those envisioned in the Plasma Poster Network [2] and Web Wall [4], which provide an outlet for communities to share and disseminate news, announcements, and ideas.

INTERACTION TECHNIQUES

We have developed two complementary interaction techniques: Absolute targeting based on visual code sensing, and relative object movement based on optical flow detection. Both techniques enable selection, dragging, and rotation of objects on a large display. These techniques can be combined into *compound targeting*, where the technique that is used depends on the environment, such as the distance between the user and the display, and on the current task, such as the pointing precision required or the distance an on-screen object needs to be dragged.

In the absolute targeting technique, the user aims the mobile phone to the target on the large display. The target appears on the phone screen, which acts as a view finder and is continously updated as the device moves. Aiming is facilitated by a cross-hair in the center of the device screen. Selection is triggered by pressing and releasing the joystick button. This results in a jump of the cursor on the large screen to the target point. Absolute positioning is implemented using a grid of

[1]Of the 625 million mobile phones that are expected to be sold in 2004, more than a quarter have built-in cameras (in Japan 60%). Sources: CNET News, iSupply, Wikipedia.

Figure 1. A user interacting with the jigsaw puzzle game via a camera phone.

visual codes [5, 6] with known screen positions. As soon as the user selects, the grid is shortly superimposed over the large display contents. The coordinate systems of the recognized visual codes are then used to compute the precise point on the large display that corresponds to the user's cursor on the local phonecam display.

The relative movement technique utilizes optical flow image processing, which involves rapidly sampling successive images from the camera and sequentially comparing them to determine relative motion in the (x, y, θ) dimensions. This enables the camera to be used as an input device with three degrees of freedom. To invoke relative movement, users hold down the joystick button, which acts as a clutch, to indicate to the system that they are actively controlling the cursor, and then they wave the phone in the air to control the (x, y, θ) input. Users can release the clutch button to reposition their arm, which is similar to the way a mouse can be lifted to be repositioned on a desktop surface.

DEMO APPLICATION: JIGSAW PUZZLE

As a demo application for the interaction techniques, we incorporated phone input into an existing jigsaw puzzle application (shown in Figure 1). The puzzle pieces can be individually selected, moved, and rotated. As soon as two compatible pieces are brought in close proximity and their amount of rotation matches, they snap together and form a larger piece. The demo application implements both of the interaction techniques described above. Multiple users can interact with the jigsaw puzzle simultaneously.

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