

Augmented Reality Based Projection for Interactive Virtual Touch Screen Using Background Subtraction

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ABSTRACT: We propose a large interactive display with virtual touch buttons on a pale-colored flat wall. Our easy-to-install system consists of a front projector and a single commodity camera. A button touch is detected based on the position of hand upon the projected touch screen constituting virtual touch buttons. Each of the touch buttons implemented on the screen corresponds to the device connected as part of home automation i.e. each device can be switched on or off depending on the button touch. The touch detection is implemented using background subtraction. It is used to extract the foreground region. In this method the shadow area is segmented by a brief change of the button to a different color when a large foreground (i.e., the hand and its shadow) covers the button region. Therefore, no time consuming operations, such as morphing or shape analysis, are required. The reference image for the background is continuously adjusted to match the ambient light conditions.

KEYWORDS: Touch detection, Background subtraction, Foreground.

I. INTRODUCTION

In the present world, the consumer grade digital cameras and projectors have become less expensive leading to the introduction of many projector-camera based systems. In particular, since ordinary plain walls can be used as the screen, large interactive displays can be used as information boards in public spaces. Under a projector lighted environment we have two methods of user interaction. One is gesture based and the other is touch screen based. For a gesture interface, users must learn the gestures that correspond to each defined functions and may need training. On the other hand, touching the screen is intuitive and increasingly popular due to the recent spread of touch-based devices such as smartphones. Our aim is to make large, easy-to-install, economical interactive displays; therefore, we use a front projector and a nearby camera. A hand touch on the screen is detected by the area of the shadow cast by the user's hand. The key idea is that the shadow color does not depend on the projected color. Our virtual touch screen system is designed to function in a space where ambient light conditions may change. The camera continually monitors the touch area, and when a large foreground (non-background, a hand or its shadow) covers and stops on the button the processing software detects the presence of hand upon the virtual button and indicates the device that is to be switched on. The background subtraction technique is used to segment the foreground. The reference image for each button, used for background subtraction, is continuously updated to account for changes in ambient light from the hand. Background subtraction is the method for extracting the foreground region even in the projector illumination. It is the method of detecting the moving objects from difference between current frame and a reference frame. The following are three types of reference images that can be subtracted from the camera input image and the method to do so. 1) Real background: by memorizing an image of the screen where a virtual button image is projected 2) Dynamically estimated background: by estimating background pixel values at each pixel position based on the several latest input frames 3) Synthesized background: by predicting the color of each pixel from the mapping relation derived by comparing the projected colors and reference samples taken by the camera during system initialization. We have implemented the concept of augmented reality i.e. the merging of computerized data or graphics on to the real world which is basically the projection of the virtual touch buttons on to the pale colored wall. This system is a blending of augmented reality

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and virtual reality. Virtual reality is a computer technology that uses software to generate realistic images, sounds and other sensations that replicate a real environment. This scheme enables automation thereby easing the task of operating some household devices. Touch based virtual operating mechanism provides more efficient service to users to operate the electronic components easily. The work in this paper is divided in two stages. 1) System Installation 2) Touch detection. The system installation includes a camera-projector interface which is initialized by capturing the virtual button images which will then be used as the reference image for touch detection. Touch detection is done by applying background subtraction which extracts the foreground by utilizing the reference images. Thereafter, devices are operated corresponding to each button touch. Paper is organized as follows. Section II describes the recent studies conducted in the development of methods of augmenting computerized images or graphics onto nearby surfaces thereby implementing graphical user interfaces which helps in reducing human efforts. The proposed model of the system is given in Section III. Section IV presents the installation involved in the system. Touch detection utilized for detecting button touches is explained in Section V. Finally, Section VI presents conclusion.

II. RELATED WORK

A number of studies have been conducted in the field of virtual projection in which text and graphical user interfaces are eliminated by means of augmenting the display of a computer screen on a nearby flat surface or a wall thereby reducing human efforts. Recently a system constituting a camera-projector interface which helps in tracking a mobile screen which then projects the images in rectified form onto a screen was developed. Another scheme referred to as Hand Gesture Recognition in Camera Projector System proposes a vision based hand gesture recognition system which is implemented in a camera-projector system to achieve an augmented reality tool. While this system utilizes gesture based hand localizing techniques, in our system we use shadow segmentation methods for detecting touches of a hand on the projected surface. Another system called User- Centric Design of a Vision System for Interactive Applications illustrates a developer oriented design approach for vision-based interactive systems. Spatial Control of Interactive Surfaces in an Augmented Environment which focuses on techniques and tools for enabling efficient man machine interaction in computer augmented multi-surface environments was also developed recently.

III. PROPOSED MODEL

Our target system is a large interactive display. Virtual touch buttons are as large as a hand and are supposed to be touched with the whole hand. Therefore, we do not rely on the shape and direction of the user's hand for touch detection. To ensure real-time performance, we try to avoid time-consuming operations, such as morphological ones and shape analysis. Therefore, we use an area proportion metric in the button region. The shadow color on the screen can be known in the system by taking an image with the projector off during initialization. However, ambient light may change throughout day. One way to know the shadow area in the touch detection process is to intercept the projected light. So, by altering the color of projected light in the button area, we can find those pixels that do not change color after the projected light changes. As both the button region without interception and the touching hand are affected by the color change, this scheme works out except when the user wears a black or very dark glove. Thus, under the following two conditions, we can achieve touch detection even in places where the ambient light changes. (a) The proportion of the foreground (non-background) area exceeds a threshold.(b) The proportion of shadow is below a separate threshold For condition (a), we utilize background subtraction to extract the foreground. The image of the color button without any object on it is acquired by the camera as a reference image during system initialization and updated continuously. One of the important issues in our scheme is when and how the button color is changed. Another issue is usability. We think that a brief color change of the button may be perceived by users as a response to a button touch. Thus, when a large proportion of the button region is covered by a foreground, we alter the button color for the minimum duration required for the camera to sense the change. Because this scheme does not depend on the shape of touching object (such as the hand), it is not possible to recognize whether more than one hand is simultaneously touching. However, we believe that this is a reasonable limitation for a large interactive display. In addition, simultaneous touch can be reduced by limiting the size of the button, for example, to palm size.

IV. INSTALLATION

Our touch screen requires a projector, a commodity optical camera, a computer connected to these devices, and a screen or a pale-colored flat wall. These devices are easily installed. The projector and the camera must be arranged in front of the screen, but there are few restrictions on their positions; the projector should be able to project the content onto the screen clearly, and the camera should be able to observe the content. It is also necessary to place the camera obliquely from the projector (i.e., off-axis) so that the camera can observe shadows of the hand touching the screen. Preferably, the projector is placed as high as possible so that the projected content can be observed on the screen with minimal blocking of projected light by the user (or users) standing in front of the screen. Figure 1 shows a typical installation of virtual touch screen. The projector is placed on the vertical center line in front of the screen. The camera may be placed at a slant, for example, 50 cm left or right of the center of the screen. Our touch screen is automatically initialized when the system is invoked. First, the relationship between the projector and the camera is calibrated to let the system know the button positions. This task is done by having the camera view a projected chessboard pattern. The second step of initialization is to acquire virtual button images. The touch screen can have more than one touch button, each of a different color. The projector projects the various buttons to their positions on the screen, and the system memorizes each “button-only” (i.e., without foreground) image from the camera input. These images are used as the reference image for the background subtraction in the touch detection process

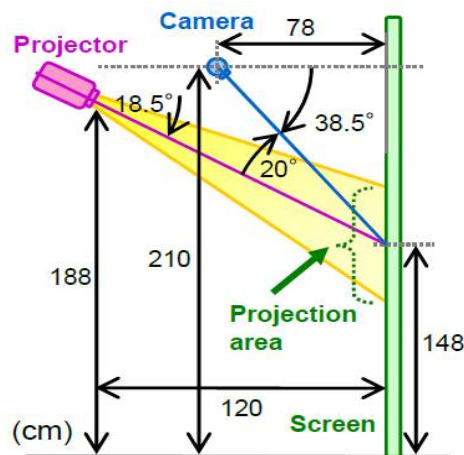


Figure 1

V. TOUCH DETECTION BY SHADOW

One of the characteristics of a projector-based system is that a shadow appears when a user is touching or about to touch the screen, because the hand intercepts the projected light; the camera, owing to its perspective different from that of the projector, sees this shadow. This particular feature can be utilized for detecting a touch. If a front camera can reliably distinguish between a hand and its shadow, a screen touch can be detected by calculating the relative proportions of the hand and the shadow in the camera image. When a hand is about to touch the screen but still hovering on it, the shadow is relatively larger than when the hand is touching. This method depends on accurate separation of the shadow from the hand through the use of only optical color information. The shadow color might be recognized more easily than the hand color because it is not affected by the projected light and is almost the same as the unilluminated screen color. The intensity (brightness) value is often used as a threshold criterion. The pixels with lower intensity value than this threshold are extracted as shadow. However, this simple criterion may falsely accept more than a few non-shadow pixels, and the threshold must be adjusted whenever the ambient light changes.

VI. CONCLUSION

We have implemented a virtual touch screen with virtual touch buttons using a camera-projector interface. Touch detection is implemented using the concept of background subtraction whereby our system is successful in detecting touches of hand upon the projected screen. Our system is thus highly helpful in implementing home automation thereby

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enabling electronic devices to be switched on or off depending on the human hand touches upon the virtual buttons corresponding to each device on the screen.

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