InteractiveDisplay: A Computer-Vision-Based Solution to Retrofit Existing Flat Displays into Interactive Surfaces

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***Abstract*- This paper outlines InteractiveDisplay, a novel and cost effective solution to create vision-based interactive surface systems by retrofitting existing regular displays. The proposed solution uses a regular off-the-shelf web camera as the main input device, and the raw image data captured by the web camera are processed using several image processing algorithms such as, background subtraction and skin color detection, to identify foreground objects. InteractiveDisplay's configuration addresses complexity and cost related issues with currently available computer-vision-based interactive surfaces. The proposed system provides an opening for more people to experience a new level of interactions with computing systems using the existing and commonly available technologies. The presented system is capable of responding in real-time for user interactions and provides a cost-effective configuration that requires minimum engineering efforts to set-up.**

I. INTRODUCTION

Keyboard and mouse are the most commonly used input devices for most of the conventional computing systems. These traditional input methods limit the ways of user interactions and increase the space between the users and the computing systems. Commonly used devices, such as mouse, only facilitate single pointer interactions. However, considering these limitations; recently, there has been a major effort in research in the field of Human Computer Interaction to innovate novel ways of interactions with computing systems. One of the major outcomes of the recent research is the ability to closely replicate the familiar hands-on experience of everyday object manipulation. These novel, comfortable and intuitive interactions are used in day-to-day life with interactive multi-touch based products such as, Microsoft Surface [1] and Apple iPhone [2]. They provide increased degrees of control over the traditional input methods and allow a new level of interactions between the computing system and the user that was unattainable previously with the traditional input devices.

This paper presents an alternative method to create an interactive surface with a regular flat display and an off-the-shelf web camera. The presented configuration is cost effective and requires a small number of commonly available hardware devices that address the installation issues that are typical of most interactive surface systems. The prototype that has been proposed is capable of detecting the 2-D positions and colors of circular tangible objects placed on the surface. Further, it identifies the user's hand regions and supports hands-on interactions.

II. MOTIVATION AND RELATED WORK

There are number of systems that use novel interaction methods to manipulate user interface components with natural hand gestures and two-handed manipulation. Most of the tabletop display systems and large wall displays have combined the displaying and sensing techniques together on one surface. Many systems such as PlayAnywhere [3] and WUW [4] have used video projection techniques for displaying and computer-vision-based techniques involving image processing and optical sensing or non-computer-vision-based special sensing techniques such as, capacitive coupling [5] for sensing. PlayAnywhere [3] uses projection for displaying and computer-vision techniques such as, shadow-based touch detection and visual bar code scheme for sensing.

By using systems based on optical sensing have confirmed to be mostly imposing in the richness of data capturing and the flexibility they can provide in processing and detecting arbitrary objects. For example it is possible to identify real world objects that are placed on the interactive surface using generic object recognition algorithms such as, bag-of-visual-words [6] based on SIFT [7]. However, a major drawback with most of vision-based interactive surface systems is the use of infrared based techniques with relatively expensive special hardware devices such as, infrared sensitive cameras and infrared illuminators. Another disadvantage of using infrared techniques is the absence of color information. Since the color information can be used to enhance the interactions with the user, it is considered as an important factor for interactive surfaces. However, one drawback using vision-based techniques is that they demand high computational power for processing, and the use of video projectors as the displaying technique may result in low-resolutions.

Tabletop interactive surface systems such as DiamondTouch [5] and SmartSkin [8] have special sensors embedded underneath the surface to recognize the user input. This method provides more accurate results and consumes low computational power. However, such systems have complex

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