PlayAnywhere and Surface Computing

CS 525

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Table of Contents

Introduction .................................................................................................................. 3
Alternative Devices.......................................................................................................... 3
  Top-Down Projection Systems .................................................................................... 3
  Rear-Projection Systems ............................................................................................ 3
  Touch-Screen Systems ............................................................................................... 4
PlayAnywhere Device ..................................................................................................... 4
  Projector, Camera, and Illuminant ............................................................................ 5
Image Processing ........................................................................................................... 5
  Touch and Hover ....................................................................................................... 6
Visual Codes .................................................................................................................. 6
Page Tracking ................................................................................................................ 6
Flow Move ...................................................................................................................... 7
Conclusion ..................................................................................................................... 7
References ..................................................................................................................... 8
Introduction

This document is intended to give a brief overview of the background, features, and problem solutions for the PlayAnwhere table-top computer-vision system. This system addresses the problems associated with other vision-based interactive systems currently available, and provides alternative methods for touch detection and hand movement. It provides for the tracking of real objects on the interactive surface using visual codes and page detection schemes. Lastly, it tracks the movement of the user to create a framework of true system-user interaction.

Alternative Devices

Alternative approaches to vision-based interactive systems include top-down projection systems, rear-projection systems, and touch-screen devices. These devices all have their advantages and disadvantages, which the PlayAnywhere approach attempts to address.

Top-Down Projection Systems
In Top-Down projection systems, the projector is located above the projection surface and projects directly downward where the user can interact with it. While this provides a direct, perpendicular viewing angle to the entire projection surface, it has some drawbacks that make it unsuitable for consumer adoption. It is difficult to install and maintain in its overhead position, possibly requiring a professional to install it. Once installed, it cannot easily be moved to another location. It also creates an environment where the user can occlude the projected image as they interact with the system.

Rear-Projection Systems
With rear-projection systems, the image is projected onto a surface from behind a diffused interactive surface. This removes the occlusion problems found in overhead projections and creates a system that is self contained in a single unit, but it also has some drawbacks. The table system itself contains the projector, so there is no room for users to put their legs underneath the interactive surface. The resolution is limited because the camera is viewing through a diffused surface. And finally, it requires the use of the dedicated surface; the user cannot move the apparatus to any surface they choose. This device can be quite large and difficult to manufacture.
**Touch-Screen Systems**

Touch-screen systems employ the use of interactive surfaces that have sensors embedded in them to retrieve input from the user. This provides excellent capabilities to detect touch with a high degree of accuracy, but does not provide the ability to model 3D objects on the interactive surface. It is therefore not a viable alternative for the current use scenarios achieved with the other systems.

**PlayAnywhere Device**

The PlayAnywhere Device uses a camera and projector that sit on the interactive surface (slightly raised) to project an image almost horizontally with respect to the device. The user sits at a table with the device sitting on the far side of the table projecting back towards them. This device is self-contained, very portable, and can be used to project images on almost any surface. Therefore, installation is achieved with minimal effort, making it more adoptable by users. Because the camera and projector are contained in a single device, calibration of the two can be done at the factory, removing the requirement that the user do so for every surface they choose to use. The occlusion problem is effectively removed because the projected image is coming from in front of the user – they could stand over the surface and still not block the projection.
**Projector, Camera, and Illuminant**

The projector uses mirrors to cast a 40” diagonal image onto an ordinary table surface from a very short distance. The short distance ensures that the user can sit the projector on the same surface that they interact with, removing the need for difficult installation. This also enables the user to use the device on many different surfaces.

The scene is illuminated using an infrared source and blocks all but infrared light to the camera using a filter. In this way, the scene projected from the device is effectively removed from the input to the camera. A very wide-angle lens is used to capture the entire scene from the same short distance.

**Image Processing**

Due to the short distance between the camera/projector and the user, the scene projected and viewed is read by the device as a very oblique image with distortion attributed to the viewing angle. In order for the image to become useful and accurate, it must be processed to transform it into a square image that matches the true interactive scene.

The four corners of the projected image are found by placing reflective markers (paper) on the surface at the projected locations. This calibration step needs to be performed only once because of the location of the device on the interactive surface – once it is done, the device can be moved to different surfaces and use the same calibrated information. The projected scene and the viewed scene are brought into a one-to-one correspondence so that the rectangular object in the image is the same as the rectangular object in the internal scene.
**Touch and Hover**

The PlayAnywhere device employs a method that determines the appearance of shadows as an object approaches the surface. A finger, for example, touching the surface will cast a differently shaped shadow than one hovering above the surface. The image is binarized to show only the contrast between the surface and the shadows cast on the surface. By analyzing the shape of the shadow, it can determine whether the finger is touching the surface or hovering above it. The system removes ambiguity by analyzing only the shadows closest to the camera, and ensuring that the shadow stretches all the way to the edge of the scene (i.e. an arm of the user extending all the way out of the scene).

**Visual Codes**

The PlayAnywhere device uses a set of visual codes created for the device that allow the use of game pieces to be placed on the visual surface. These codes are printed on a laser printer and glued to circular disks that can be moved about the scene and detected by the camera. The code attempts to balance the goals of creating a system that can easily detected while providing a set of codes large enough to encompass all the potential uses of the code. The code contains strong edges that can easily be detected using fast processing techniques such as a Sobel filter. Surrounding the strong edge is the set of images that illustrate the code trying to be detected. With this method, it can be ensured that it is in fact detecting the actual code being used.

![Sample Visual Code](image)

**Page Tracking**

The PlayAnywhere device attempts to blur the boundary between actual documents and their virtual representations. Documents can be placed on the interactive surface and incorporated into the virtual scene within the device. The device detects the edges of the document using the same Sobel filter, pairing parallel edges together to determine the location and size of the document. As the document is moved around on the surface, the device continually tracks its location, allowing it to project images onto the moving document. Applications such as photo browsing, drawing, and interactive document management can be built upon this foundation.
Flow Move
The PlayAnywhere device uses a frame-to-frame comparison method to track and determine the movement of objects in the scene. By comparing a visual scene with the one before it, it can be inferred what types of movements are being made by the user, thus establishing a framework for manipulating virtual objects in the scene. The user can learn to manipulate objects by performing actions that can be tracked by the system. For instance, the user can separate his hands in order to scale a document, or move one hand up while simultaneously moving the other down in order to rotate an object. The applications for photo browsing or object manipulation can be achieved by building on the concepts provided by the system.

Conclusion
The PlayAnywhere prototype provides a first-step approach to true user-system interaction that is intuitive to the user. It provides a device that can be easily installed and moved at the whim of the user to almost any interactive surface. It provides for touch detection by analyzing shadow shapes to determine the location of the user’s hands without requiring a sensory-enabled surface. It can track objects on the surface using visual codes as well as by determining the location of physical documents. And last, it can determine the movement of the user to incorporate actions into the system. The applications possible for the future are only limited by the imaginations of the developers.
References

PlayAnywhere: A Compact Interactive Tabletop Projection-Vision System, Andrew D. Wilson, Microsoft Research