An Adaptive Color Marker for Spatial Augmented Reality Environments and Visual Feedback

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ABSTRACT

This demonstration presents an adaptive visual marker optimised to improve tracking performance in Spatial Augmented Reality environments. The adaptive marker uses a color light sensor to capture the projected light color from a SAR system. The color information is used to select the optimal tracking color that is displayed on a diffused Red, Green, Blue Light Emitting Diode marker attached to a user's finger. We have selected to use the visible light spectrum for the marker since it can be leveraged to present visual feedback to support user interface interactions in addition to the tracking system operation. Our initial results have shown a performance improvement compared to a fixed color passive marker.

Index Terms: H.5.2 [Information interfaces and Presentation]: Graphical User interfaces—Input Devices and Strategies; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

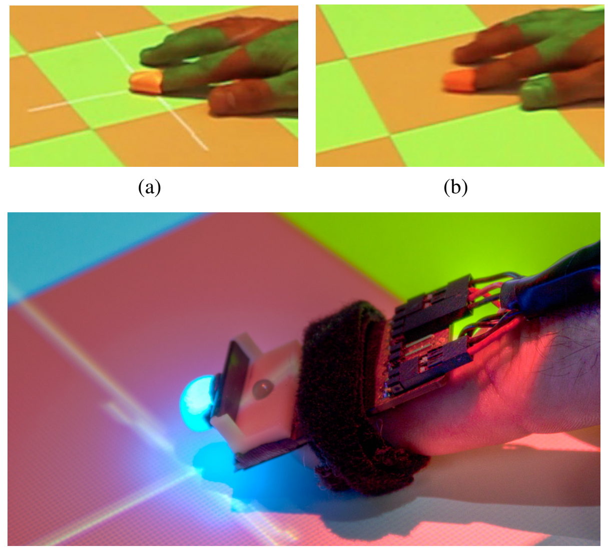
1 Introduction and Motivation

Spatial Augmented Reality (SAR) uses projected light to present perspectively correct computer generated graphics onto physical world objects. Current research has been exploring how SAR can be leveraged to support industrial designers during mock-up prototype development [1]. The appearance of simple white physical prototypes is augmented with projected light to provide detailed and compelling graphics for design. Additionally, user interface functionality is incorporated into the designs without the need to install electronic switches, dials or displays. This is achieved by using the projected light to present a visual interface and a tracking system to capture the finger gestures allowing interactive controls to be provided in software.

One approach to capturing the finger locations is to use passive colored markers attached to the users fingers. Porter et al. employed orange thimbles worn on the users index finger [1] to allow the 3D position to be captured using stereo cameras. Although this technique is successful in many conditions, when the color of the projected light from the SAR system is the same color as the passive marker the reliability of the tracking is decreased. This problem is demonstrated in Figure 1(a) where the orange passive marker is operating correctly under green projected light and Figure 1(b) shows the tracking system failing when operating under orange projected light.

2 Adaptive Finger Marker Demonstration

We have been exploring how the performance of markers under the projected light of a SAR system can be improved by using an active marker. We have constructed an adaptive marker that can detect the environmental lighting conditions and change its own color and be tracked in real-time. The adaptive marker uses an Avago ADJD-S371-Q999 RGB color sensor with a dome lens to capture the color of the environmental light. The captured RGB color is then converted into the Hue Saturation Value (HSV) color space which places colors on a virtual color wheel. We select the optimal marker color by moving 180° from the environmental color to find the opposite color. The tracking software is also configured to search for the new color which is now easily identified since the contrast between the environmental light and the marker is maximised.



(a) (b)

(c)

Figure 1: (a) Orange passive marker performing well in green projected light. (b) Orange passive marker failing in orange projected light. (c) Adaptive marker detecting the red projected light and selecting blue as the opposite color to optimise tracking.

The active marker uses a diffused Red, Green, Blue Light Emitting Diode (RGB LED) to identify the marker in a video stream. The visible spectrum was selected rather than IR since it can also be leveraged for visual feedback. For example, when operating virtual SAR buttons the state of the button can be displayed on the finger worn marker. This overcomes occlusions of projected light and can still be utilised for tracking during operation.

In this demonstration participants will be given the opportunity to try the adaptive marker in a small scale projected SAR environment. Users will wear the marker on their index finger and move it through a variety of projected scenes. The marker will detect the projected light color and change its appearance to optimise the tracking performance in real-time.

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3 WEARABLE COMPUTER LABORATORY

The Wearable Computer Laboratory (WCL) was founded by Professor Bruce H. Thomas in 1998. The WCL is located in Adelaide, Australia at the University of South Australia. Since its inception, the laboratory has been exploring Augmented Reality with a focus on user interfaces, input devices and visualisation techniques. Currently there are three primary research focuses; Outdoor Mobile Augmented Reality, Spatial Augmented Reality and Input Devices.

3.1 Mobile Augmented Reality

The Tinmith system is a well established wearable computer system developed at the WCL. Tinmith provides users with the ability to visualize and interact with computer generated worlds in outdoor environments. The current Tinmith wearable computer uses a belt worn system equipped with a PC, GPS, orientation sensor, head mounted display, head worn camera and custom made input gloves. The research has explored how users can interact with the virtual worlds without using traditional keyboard, mouse or touch screen input devices. Figure 2(a) shows how each of the users fingers is mapped to a menu item using custom pinch gloves to capture pinching gestures. The Tinmith system has been used to explore mining visualisations, military training scenarios, virtual weather simulators and sensor management visualisations.

http://www.tinmith.net

3.2 Spatial Augmented Reality

Figure 2(b) is a computer generated vision picture of a custom designed spatial augmented reality visualisation environment. This laboratory has recently been constructed and is now known as the Mawson Institute Visualisation Laboratory (shown in Figure 2(c). It consists of forty ceiling mounted projectors, ceiling mounted scaffolding, white projections surfaces on all walls, ten dedicated server computers with a matrix switch allowing each server to address any projector and two large doors allowing full size cars to enter the room. In this large scale projection area, the WCL team is exploring how projected light can be used to augment large scale items to assist designers during prototype development. We have been developing a variety of interactive physical-virtual tools that are designed to integrate traditional prototype mock-up techniques with modern SAR technologies.

http://wearables.unisa.edu.au/projects/

3.3 Deformable Input Devices

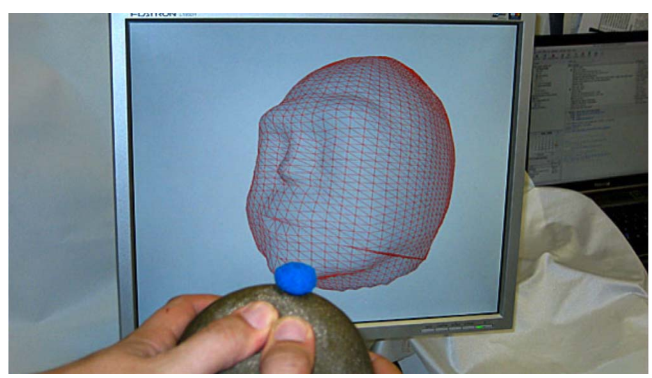
The Digital Foam sensor was developed to explore the use of deformable surfaces for computer interactions. Figure 2(d) is an example of a user sculpting using the Digital Foam deformable input device [2]. As the user deforms the surface of the device the deformations are captured using a custom array of foam sensors allowing the physical sculpting gestures to be applied directly to the virtual model. We are currently exploring how the Digital Foam technology can be incorporated into medical training devices, robotic sensors and interactive sculpting applications.

http://wearables.unisa.edu.au/projects/digital-foam/

(a) Tinmith glove based input description.

(b) Vision picture of a large scale spatial augmented reality laboratory.

(c) Spatial augmented reality laboratory with projected control panels.



(d) Digital Foam deformable input device being used to sculpt a 3D model.

Figure 2: Wearable computer laboratory projects

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