

Sculpting in Augmented Reality

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Abstract

We present an Augmented Reality (AR) application which allows a user to manipulate a piece of virtual clay using a marker-free unencumbered hand. By removing the need to wear a glove or place markers on the hand the application is made more accessible, allowing users to interact with the environment without special preparation.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Information interfaces and presentation]: Artificial, augmented, and virtual realities

1. Introduction

Augmented reality applications may be used to add information to a scene the user is observing. Applications which actively track the users hands typically use markers or gloves on the hands [BVBC04, IWYY96] to allow the user to control the application. Our work investigates techniques to allow users to manipulate AR environments. In this paper we describe an AR application which allows a sculptor to manipulate a piece of virtual clay using a marker-free unencumbered hand.

2. Application

The user is able to deform a piece of virtual clay, starting from a sphere by using pushing and pulling motions with their hand. The clay is implemented using swirling sweepers [ACWK04] which are a fold-over free, volume preserving surface deformation. Figure 1 shows the starting environment and the wire-frame control sphere, followed by two objects which have been created in the system.

This application uses the ARToolkit AR libraries [KBP*00], with modified tracking to use black/colour markers instead of the standard ARToolkit black/white markers. This change simplifies segmentation by making the markers present in only one of the red, green or blue (RGB) colour channels. This makes it possible to quickly identify between the markers and skin colour, which has values in all three colour channels.

We use two statically mounted calibrated cameras to track the hand of the user. These cameras are mounted on tripods beside the workspace. The background of the workspace is black to aid segmentation. This simple segmentation method with a black background, single RGB channel markers and foreground skin objects, has worked well in our environment. Segmentation in an uncontrolled environment is a complex task. In addition to specific colours being used for the environment, lighting is configured to generate mainly indirect lighting over the workspace to reduce reflections, which saturate local colour to white. The controlled environment makes the task of skin and AR marker segmentation simple and allows effort to be focused on the interaction with the hand.

After segmentation the tip of an extended finger is identified. This application uses some keyboard control so only one hand is tracked for sculpting. The layout of the environment is shown in Figure 2.

The global coordinates of the tracked fingertip are used to place a control sphere, which causes deformation in the clay using the Swirling Sweeper algorithm. Interaction with the clay is performed by moving the finger, with the control sphere attached, near the clay surface. The user selects when interaction is active using the keyboard, allowing the sphere to be placed near the clay before the interaction starts to deform the clay.

A third camera is attached to a head mounted dis-

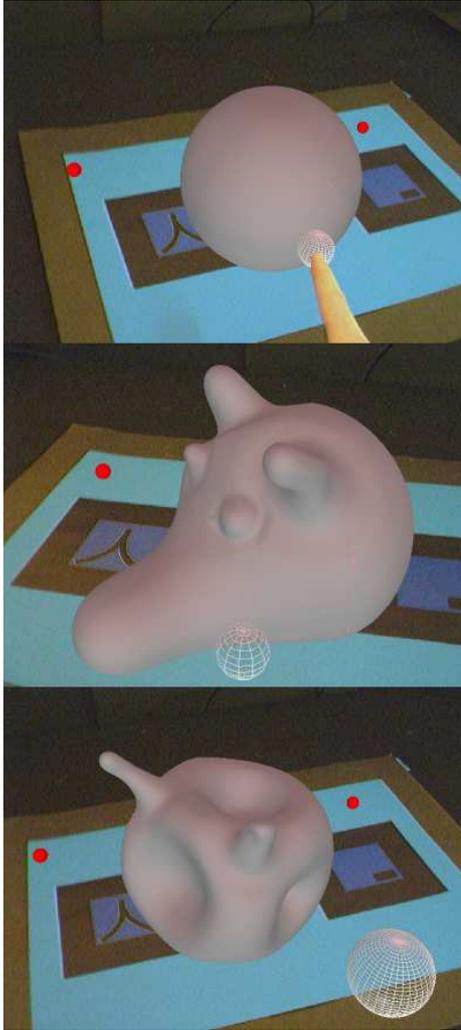


Figure 1: The initial state and two clay creations.

play (HMD) and provides an image of the workspace. The HMD/camera configuration is typical of video see-through AR [MK94]. The ARToolKit calculates the current head position in global coordinates for displaying the AR scene based on this image.

In many AR applications the augmented components are simply drawn over the top of the image captured from the head mounted camera. This makes it more confusing to interact with a scene containing objects that should appear behind the user's hand. A virtual environment which behaves like a real environment should allow the user to move their hand behind and around objects. It should allow the hand to be placed in between two objects, or have an object appear between parts of the hand, such as an object picked up pinched between the thumb and first

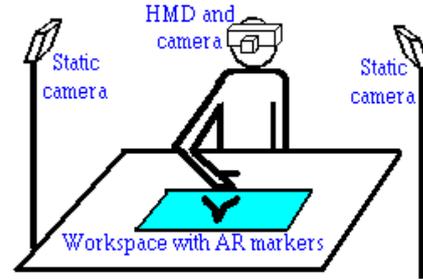


Figure 2: Physical environment.

finger. The accurate representation of depth is important when providing a sense of presence and allowing the user to maintain their suspension of disbelief or immersion while interacting with the virtual world. Unencumbered hand input to augmented worlds cannot use tactile feedback devices making good depth cues even more useful when interacting with the environment. To solve this, the user's hand from the background image is overlaid in front of the virtual objects when the hand is in front of the clay and rendered normally when behind, improving the perceived sense of presence. To display the hand overlapping with an object it may be necessary to draw this overlay several times which may have a performance impact.

An alternative to keyboard control is to use virtual desktop buttons. The application is able to track both hands and use virtual button presses for control information, Figure 3. This system currently requires the user to avoid overlapping the hands. When overlap occurs the silhouette is assumed to be the right hand only and attempts to detect features normally. Two hand tracking resumes immediately the overlap ends.

Calibration is performed using a coplanar calibration method proposed by Tsai [Tsa86, Tsa87]. A calibration mat is placed in the workspace and the static cameras find the centre of each spot to determine their location. The location has an asymmetrically placed red spot which is used to automatically correlate the spots image space coordinates to their world coordinates for calibration. When using the application the calibration mat is replaced with a mat which has the colour markers for AR tracking. The mats are placed in the same position by aligning them to markers on the desktop. This makes recalibration easy to perform and aligning the static and AR coordinates systems automatic. The two mats are shown in Figure 4.

This application has been implemented using common off-the-shelf equipment. Three Fire-i firewire cameras and an i-Glasses HMD are used. The application has been developed in OpenGL under Windows XP due to its good firewire camera support.



Figure 3: Buttons in the workspace to remove the need for keyboard input.

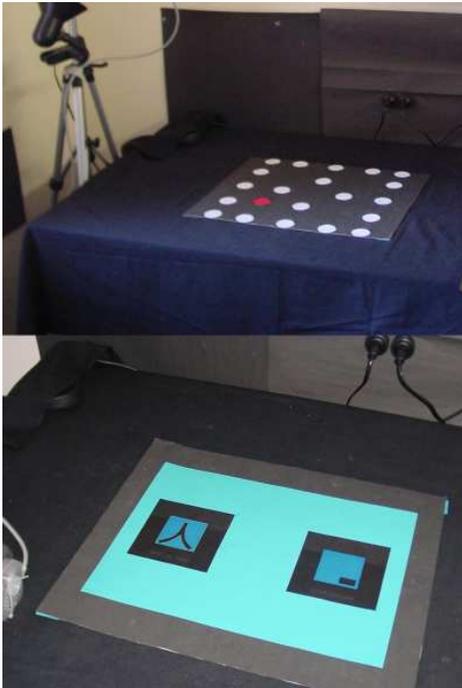


Figure 4: The control mats, spots for calibration and AR markers for virtual world placement.

3. Conclusions and Future Work

The virtual sculpting project combines AR based head tracking with static cameras to provide an interactive virtual sculpting experience without markers or gloves on the hands. The application has been created as a test bed for further investigation of unencumbered hand interaction with AR. The environment had been designed to allow fast changes of the user, with no calibration phase between different users. We have investigated the tracking of the location of the hand

with respect to virtual objects, allowing accurate visual representation of occlusion between the hand and virtual objects in the scene to improve presence and immersion.

The project will continue to develop unencumbered hand input for AR. The next phase of the project will be tracking of two and then three fingertips of each hand to allow more complex interactions, such as clay deformation by pinching the surface and picking up, moving and rotating objects.

4. Acknowledgments

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