T. Kawashima, K. Imamoto, H. Kato, K. Tachibana, M. Billinghurst: Magic PAddle: A Tangible Augmented Reality Interface for Object Manipulation, Proc. on ISMR2001, pp.194-195 (2001)

Magic Paddle: A Tangible Augmented Reality Interface for Object Manipulation

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Abstract

In this demonstration we show a computer vision based Augmented Reality system called Magic Paddle. This system has been designed to support a Tangible Augmented Reality approach in which lessons from Tangible User Interface design are applied to the design of AR interfaces. Magic Paddle is an AR interaction system including virtual object manipulations in table-top environment. User can construct a 3D scene by manipulating virtual objects with a physical paddle as if he manipulates real objects.

Keywords: Augmented Reality, Tangible User Interface, Tangible Augmented Reality, Vision based tracking

1 Introduction

Although there have been many different virtual object manipulation techniques proposed for immersive virtual reality environments, there has been less work conducted on AR interaction techniques. One particularly promising area of research that can be applied is the area of Tangible User Interfaces. The goal of Tangible User Interface research is to turn real objects into input and output devices for computer interfaces [Tangible 2000].

Tangible interfaces are powerful because the physical objects used in them have properties and physical constraints that restrict how they can be manipulated and so are easy to use. However there are limitations as well. It can be difficult to change these physical properties, making it impossible to tell from looking at a physical object what is the state of the digital data associated with that object. In some interfaces there is also often a disconnection between the task space and display space. For example, in the Gorbet's Triangles work, physical triangles are assembled to tell stories, but the visual representations of the stories are shown on a separate monitor distinct from the physical interface [Gorbet 98].

Many of these limitations can be overcome through the use of Augmented Reality. We define Tangible Augmented Reality as AR interfaces based upon Tangible User Interface design principles. In these interfaces the intuitiveness of the physical input devices can be combined with the enhanced display possibilities provided by virtual image overlays. Head mounted display (HMD) based AR provides the ability to support independent public and private views of the information space, and has no dependence on physical display surfaces. Similarly, AR techniques can be used to seamlessly merge the display and task space.

In our augmented reality work we advocate designing the form of physical objects in the interface using established Tangible User Interface design methods. Some of the tangible design principles include:

- Object affordances should match the physical constraints of the object to the requirements of the task.
- The ability to support parallel activity where multiple objects or interface elements is being manipulated at once.
- Support for physically based interaction techniques (such as using object proximity or spatial relations).
- The form of objects should encourage and support spatial manipulation
- Support for multi-handed interaction.

In this demonstration we show a computer vision based Augmented Reality system called Magic Paddle. This system has been designed to support a Tangible Augmented Reality approach in which lessons from Tangible User Interface design are applied to the design of AR interfaces [Kato 2000].

2 Magic Paddle

The Magic Paddle project explores how a Tangible AR interface could be used for virtual object scene assembly. Magic Paddle allows virtual objects to be manipulated within a scene. To achieve this we explored how more complex physical gestures can be used to support more natural interaction.

The physical components of the interface comprise a real book, a cardboard paddle the user holds in their hand, a large piece of paper and a lightweight HMD the user wears (figure 1a). The form of each of these objects reflects their function; the book serves as a container holding all the virtual models, the paddle is the main interaction device, and the large piece of paper is the workspace.

The application is layout of virtual furniture in a room, although the same interaction techniques could be applied to many domains. When the user opens the book on each of its pages they see a different set of virtual furniture, such as a set of chairs, rugs etc (fig. 1b). The 3D virtual models appear exactly superimposed over the real book pages. When they look at the large piece of paper they see an empty virtual room. They can then copy and transfer objects from the book to the virtual room using the paddle.

The paddle is the main interaction device and is designed to be used by either hand to make static and dynamic behaviors. The behaviors recognized by the system include:

Static:

- Object proximity
- Object tilt/inclination

Dynamic:

- Shaking (side to side motion)
- Hitting (up and down motion)
- Pushing (object motion along the ground plane)

To copy an object from the object book onto the paddle the user simple places the paddle beside the desired object and the close proximity is detected and the object copied onto the paddle (fig. 1c). Once a model is on the paddle it can be picked up and viewed from any viewpoint. To drop a model into the virtual scene the paddle is placed at the desired location and tilted until the model slides off (fig. 1d). Models in the scene can be moved around by pushing motions of the paddle (fig. 1e). A shaking motion is used to delete an object already on the paddle, while models already placed in the virtual room can be removed by hitting them.

As can be seen these interactions are very natural to perform with a real paddle, so in a matter of a few moments a user can assemble a fairly complex arrangement of virtual furniture (fig. 1f). Of course what the user is really doing is interacting with a simple CAD program, but instead of using a mouse or keyboard they are just manipulating a cardboard paddle in very intuitive ways.

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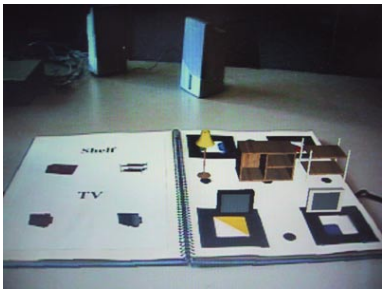
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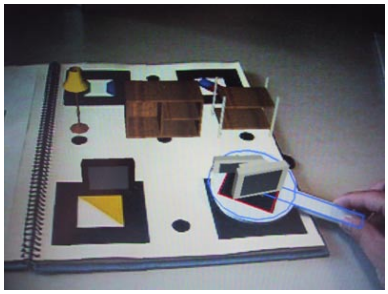
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(a) External view of Magic Paddle interface



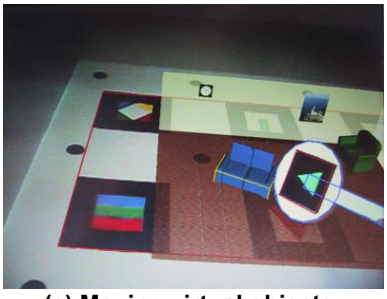
(b) Virtual furniture objects on the real book



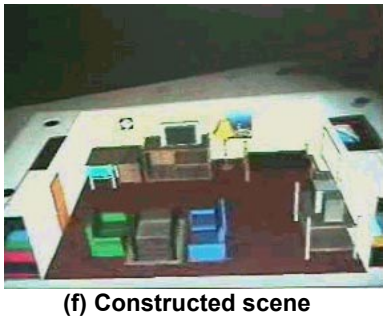
(c) Picking virtual furniture object with a paddle



(d) Placing object in a room by sliding it from the paddle



(e) Moving virtual objects by pushing it



(f) Constructed scene

Figure 1. Magic Paddle Interface