Pockets: User-Assigned Menus Based on Physical Buttons for Virtual Environments

Aubrey Simonson
asimonso@media.mit.edu
MIT Media Lab
Cambridge, Massachusetts, USA

Punit Kunjam
punit17100@iiitnr.edu.in
IIIT-Naya Raipur
Chhattisgarh, Raipur, India

Pattie Maes
pattie@media.mit.edu
MIT Media Lab
Cambridge, Massachusetts, USA

Figure 1: a) Pushing a button while holding a virtual object assigns the object to a Pocket. b) Different objects can be assigned to each Pocket. c) Objects can be retrieved by pushing the corresponding button. Because Pockets use physical hardware, and because we return objects to the dominant hand, we do not need to track their location.

ABSTRACT

We present Pockets, a simple means of organizing and carrying 3D tools and other objects in virtual environments. Previous examples exist of using 3D tools with visually obvious affordances in virtual immersive environments instead of more traditional menus, however, in these applications a 2D menu is still necessary to select 3D tools from. Pockets make use of a belt with physical buttons, that objects can be assigned to. The Pockets design not only enables users to use their muscle memory to store and retrieve objects, thereby making tool use more efficient, but also solves the occlusion problem associated with state of the art approaches such as 2D menus tied to the body or to world space.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Haptic devices.*

KEYWORDS

proprioceptive menus, menus, 3D tools

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1 INTRODUCTION

A common way to have an abstract effect on a virtual immersive environment, such as switching applications or changing settings, is to use a 2D menu in a 3D space.

These menus can be tethered to a specific location in the environment, to the viewport of the user, or to some part of the body. When tethered to world-space, as a flat panel, they need to be oriented towards the user in order to be usable. A user moving around the space also disrupts this orientation. World space menus can be arrayed in an egocentric fashion or turned to always face the viewer, but this, like screen-space tethered menus, occludes a large portion of the environment. Menus tethered to the body, most often the hands, have to be small in order to avoid becoming unwieldy. Previous work has explored the selection method, transparency, and position of 2D widgets in 3d space as a means of alleviating these issues[Salyers et al. 2019]. Prior work which tethers menu items and tools to more and other parts of the body include[Azai et al. 2018].

Prior work has explored the use of 3D tools, rather than 2D menus, as a means of interacting with virtual environments. Excellent examples of this include [Zielasko et al. 2015][Costa et al. 2019][Moore et al. 2015]. However, when 3d tools are used, they are still often selected from a 2d menu, for example in [Greenwald et al. 2017], which uses an egocentric menu, or [gra 2021], which uses a menu attached to the hand.

2 IMPLEMENTATION

Pockets are a means of interacting with virtual environments which minimize the necessity of 2D menus in 3D space. Pockets are a highly modular, user-assigned menu based on physical buttons. The hardware involved in Pockets is any set of buttons which are able to convey that have been pressed. This could hypothetically be a keyboard, the buttons on controllers, or more custom hardware. Our current implementation consists of six buttons worn around the

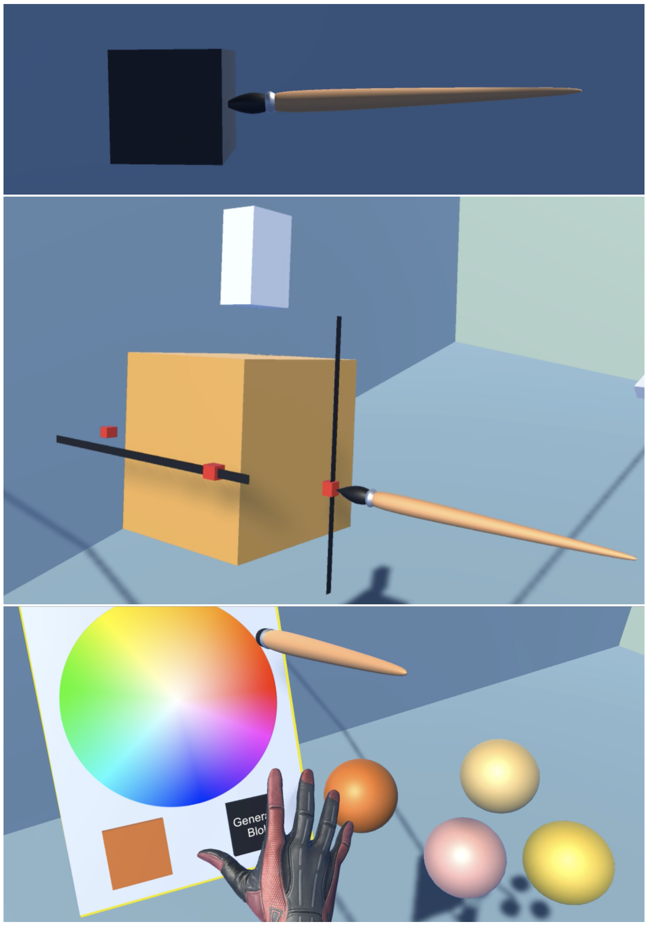

Figure 2: Examples of 3D tools. Top: A paintbrush, which can be used to change the color of paint-able objects. Mid: A tool for generating cuboids. Paintbrushes can be used to move sliders which control the length, width and height of the cuboid. The position of the slider on the generator represents which dimension it controls. Objects can be instantiated by removing them from the generator with the hands. Bottom: A tool for generating "blobs" of paint. These paint blobs can be used to change which color a brush paints, by touching the end of the brush to the blob. This draws from the real-world metaphor of dipping it in a new color of paint.

waist, to draw from the real-world metaphor of a toolbelt. The use of a toolbelt metaphor is inspired by [Mine et al. 1997]'s suggestion that

> The differences between working in a conventional computer environment and working immersed are analogous to the differences between a craftsman at a workbench and one moving about a worksite wearing a toolbelt.

When a button is pressed while holding an object in the hand, the object is deactivated and assigned to that Pocket. Metaphorically, it has been stored "in" the Pocket. If a button is pushed which is already assigned to an object, the object is retrieved from the Pocket, and instantiated at the location of the dominant hand. Because the button is aware of when it has been pushed, and because the hand is tracked, there is no need to track the location of the button in this implementation.

By user-assigned, we mean that Pockets start empty, and users add objects to them as they need to. This means that users never have to learn a pre-made menu. Instead, they develop patterns of keeping objects in the most convenient Pocket for any particular activity, similar to the way we might keep our phones in the same pocket of our pants, unless we are running, in which case we may move them to a more stable arm-band.

By using physical buttons worn on the body, we can take advantage of proprioception and passive haptic feedback to avoid representing Pockets visually in the HMD. A user knows the approximate location of buttons on the body due to having seen them when putting them on, and will likely develop muscle memory over time, in the same way that skilled typists do not need to look at their keyboard when typing. A physical button provides the user with passive tactile feedback to help them understand when they have located and pressed a button.

When worn on the waist, this peripheral hardware serves as a comfortable location to also mount additional cameras, to extend hand-tracking to areas which cannot be seen from the HMD, such as below or otherwise outside of the field of vision. It also provides a more comfortable location to attach additional compute power than worn directly on the HMD.

3 FUTURE WORK

Pockets is currently implemented as six identical physical buttons worn around the waist. Interesting future work could include exploring the optimal number and placement of buttons, as well as the scale and texture of buttons to improve their differentiation while wearing a HMD, and the tradeoff between visually representing Pockets and the occlusion this may cause.

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