Back to the Future: Revisiting Mouse and Keyboard for HMD-based Immersive Analytics

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ABSTRACT

With the rise of natural user interfaces, immersive analytics applications often focus on novel forms of interaction modalities such as mid-air gestures, gaze or tangible interaction utilizing input devices such as depth-sensors, touch screens and eye-trackers. At the same time, traditional input devices such as the physical keyboard and mouse are used to a lesser extent. We argue, that for certain work scenarios, such as conducting analytic tasks at stationary desktop settings, it can be valuable to combine the benefits of novel and established input devices as well as input modalities to create productive immersive analytics environments.

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Figure 1: Interaction With head-mounted display, keyboard and mouse.

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INTRODUCTION

Immersive Analytics tries to remove barriers between data, people who analyse this data and the tools they use to do so [15]. Researchers combine knowledge from fields such as data visualization, human-computer interaction and mixed reality to create and study new tools and approaches to engage with data. The rise of natural user interfaces as well the introduction of affordable immersive head-mounted displays (HMDs) [7] led to a wide variety of interaction techniques for data and view specification and manipulation [3, 10] including touch, spatial gestures, tangible and gaze interaction and a number of archetypal setups such as large screen collaborative spaces (with or without personal displays such as tablets) or immersive setups (projection or head-mounted display-based) (for an overview we refer to Büschel et al. [6]).

Specifically, HMD-based systems make heavily use of spatial gestures using bare hands or controllers but are typically designed to support free-space interaction, assuming no interfering objects or humans nearby. While this allows for expressive, and potentially co-located interaction, free space interaction comes at the cost of increased fatigue [11] or inaccurate input (e.g., when using hand or gaze-based ray casting techniques [5, 17]). While a number of techniques have been proposed to facilitate object selection in presence of clutter (e.g., [19]), to increase spatial pointing accuracy [1, 12] or to mitigate fatigue of spatial gestures [9] they still do not eliminate those challenges.

We argue, that the combination of desktop-based input devices such as the physical keyboard and mouse with immersive head-mounted displays can benefit single users in immersive analytics tasks, similar to other knowledge work [8].

Eyal: *A keyboard with a touch pad might be even more useful than a mouse since it allows multi touch operation. The user may manipulate data (scale, zoom, etc.) using pinch and other gestures on the touch pad. On the other hand, touch sensitive mice such as the apple's magic mouse or Microsoft's touch mouse, can be used to sense multi touch gestures on their surface, and use their physicality in the user hand to simulate the 3D manipulation of a virtual object. Tracking a hand in space may bring the hand to an object and a finger drag on the curved surface of the mouse or a pinch may be used to manipulate the virtual object.*

Eyal: *Another option: The mouse motion is supported by the table and reduces the hand fatigue. By mapping the 2D motion of the mouse in an intuitive fashion to the 3D data, it is possible to bring the*

Figure 2: Top: 3D pointing. Bottom: key press.

virtual cursor or the user's avatar hand to a specific data point. Such mapping, may includes the map of a 2D table space to a hemisphere around the user's field of view, and projecting the cursor along the ray from the user eye through the hemisphere until it hits a virtual object, or a map to any other 2 parameters in the data space (additional dimensions may be added by dragging fingers on the mouse or by the non dominant hand..

KEYBOARD AND MOUSE FOR HMD-BASED IMMERSIVE ANALYTICS

The physical keyboard and mouse are optimized for symbolic and precise 2D input and have a long tradition in being used as standard input devices in desktop environments. While not free from challenges, they have been optimized to support long hours of work [4, 22]. However, when interacting with spatial data, they are perceived as falling short of providing efficient input capabilities, even though they are successfully used in many 3D environments (such as CAD or gaming [20]), can be modified to to allow free space interaction ([16, 21] or can outperform 3D input devices in specific tasks such as 3D object placement [2].

With the advent of self-contained immersive head-mounted displays, which allow for spatial tracking of the environment and the users hand, as well as eye-tracking, we foresee the following two areas

Switching Costs

So far, problems in switching between spatial interaction (e.g. using controllers) and keyboard and mouse interaction have limited the applicability of desktop-based input devices for immersive analytics. Even in stationary, desktop-based scenarios it might be challenging to switch motion-tracked controllers to keyboard and mouse devices. However, given the possibility to spatially track the users hands, and, the keyboard and mouse through model-based tracking [13, 14]) applicable to today's HMDs with camera-based inside-out tracking, we see the potential to seamlessly switch between mid-air interaction and mouse or keyboard input, see Figure 2. This could open up efficient switching between tasks (e.g., selecting data through spatial gestures and changing data properties through symbolic input on the keyboard) or subsequent fine-grained selection on a 2D subspace of the data using the mouse. Further, the input device can be combined for multi-modal interaction. For example, the dominant hand could be used for (uncertain) data selection again, while the non-dominant hand could be used for certain action confirmation, e.g., through key press on the physical keyboard.

Eyal: *It is possible to roam 2 3d data while being in a seated position - when using the dominant hand for operation such as selection, while the non dominant hand, or even the legs (using tools such as CyberShoes (https://www.cybershoes.io/) or VRGO(https://www.vrgomini.com/)) may be used to move the*

Figure 3: While non dominant hand may roam the data around the user the mouse and the dominant hand can be used for selection and manipulation.

data around the user (rather than move the user physically). Special care should be taken to reduce risk of motion sickness, by displaying static objects around the data.

Augmenting peripherals

Virtual data entities can also be augmented on or around the keyboard and mouse to allow for direct interaction with those virtual data items [18]. For example, in a node-link diagram, individual nodes could be associated to individual keys to allow quick selection of individual nodes (i.e. one key is mapped to one data entity), to multiple keys e.g., when only few nodes are present, or a single key could represent multiple nodes (e.g. in a dense node-link diagram with many nodes). Similarly, user interface elements for manipulating object properties, such as sliders could be mapped to either multiple keys of the keyboard, on or around the mouse or mouse-wheel. Again, the advantage of mapping these graphical elements to the physical input devices lies in the increased certainty of the input (e.g., key press, moving the mouse over a physical surface) in contrast to uncertain mid-air or gaze-based input.

Eyal: *The mouse is a great tool for augmentation: Different areas on the mouse may have different semantics. The mouse itself is a 3D object held by the hand that can be used to input 3D rotations, scaling and other gestures. Same can be done by a touch pad on a keyboard (although more limited as it can not be held and rotated.)*

CONCLUSION AND FUTURE WORK

Through this position paper, we aim at increasing the awareness about the potential that traditional desktop-based input devices such as the physical keyboard and mouse can bring into immersive analytics tasks. Those potentials lie in the combination of certain but (in terms of degrees of freedom) spatially limited input of those devices with expressive but uncertain and fatiguing spatial input as well as the ability to virtually augment keyboard and mouse for enhanced interaction in immersive analytics tasks. In future work, we aim at investigating specific immersive analytics tasks and at studying the opportunities of multi-modal interaction between spatial and keyboard and mouse-based interaction in more detail. Finally, we will also explore the opportunities of integrating stationary touch-screens (e.g. integrated in laptops) for immersive analytics tasks.

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