



New Directions I: 3D interaction with large displays

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Welcome, introduction, & roadmap
3DUIs in a nutshell
3DUI new directions introduction
New directions I
New directions II
Video Games: 3DUIs for the Masses
Beyond Visual: shape, haptics and actuation in 3DUI
From Hack to Pack
Conclusion

3D interaction in VR

Intro | large displays | hypothesis | techniques | conclusions

3D input devices

3D interaction techniques

3D user interfaces

But most CURRENT real-world VR applications don't need complex 3D interaction



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2

I've been doing research in this area for more than 10 years, and I think we've been quite successful in designing and evaluating some very usable 3D interfaces. But the problem is that almost none of this work has made it out into real-world VR applications. The work is good, but it's had very little impact outside the research community.

3D interaction outside VR?

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Augmented / mixed reality

Console gaming

Multi-display environments

Large Displays

So what are some ways that the 3D interaction knowledge and techniques, which we developed in a VR context, can be applied outside VR?

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4

We're going to focus in this talk on the last example - 3D interaction with large displays.

Large, high-resolution displays

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5

The context for this idea is the current trend towards large, high-resolution tiled displays. Here are three prototypes we are using in our lab.

Upper left: Rear-projected VisBlocks from VisBox, Inc. Each block has its own projector, and there are only minimal seams between the tiles. Moreover, each block is independent and can be moved to create new configurations of the display.

Upper right: Tiled LCD panels in reconfigurable columns of three displays. These can easily be curved around a single user, as shows in the picture, or flattened for multiple users.

Bottom: A larger tiled LCD array. This one has 50 panels in reconfigurable columns of 5 displays each. The entire display has 100 million pixels.

Benefits of large, hi-res displays

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- Reduced virtual navigation
- Increased physical navigation
- Scalability of 2D visualizations
- Faster search and comparison
- Increased awareness

Empirical work has shown that displays of this type can deliver on their promise of better visual examination and analysis of data.

Ball, R. and North, C., Effects of Tiled High-Resolution Display on Basic Visualization and Navigation Tasks. in *ACM Conference on Human Factors in Computing Systems (CHI)*, (Portland, OR, 2005), ACM Press, 1196-1199.

Ball, R., North, C. and Bowman, D., Move to Improve: Promoting Physical Navigation to Improve User Performance with Large Displays. in *SIGCHI Conference on Human Factors in Computing Systems (CHI)*, (2006), 191-200.

Ni, T., Bowman, D. and Chen, J., Increased Display Size and Resolution Improve Task Performance in Information-Rich Virtual Environments. in *Graphics Interface*, (2006), 139-146.

Applications of large displays

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Visual analytics (e.g., intelligence data)

Geospatial visualization

High-fidelity videoconferencing

Because of these benefits, such displays can be used for some high-impact applications.

Interaction with large displays

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Traditional mouse-based pointing, traditional widgets don't work:

- ▶ Cursor tracking
- ▶ Target acquisition

How to do:

- ▶ Task management?
- ▶ Menus and other widgets?

But it's also become very clear that traditional WIMP interfaces don't work very well on large, high-resolution displays.

Cursor tracking: the user loses the small cursor on the large display and has to search for it

Target acquisition: it's difficult to select small objects because the mouse acceleration is either very high, or the user has to do a lot of clutching to move far across the display

Task management: these displays support a huge number of parallel windows/tasks

Menus/widgets: traditional menus and widgets don't work because they may require moving the cursor a great distance across the display, they may be too small to select or read from a distance, etc.

Interaction techniques for large displays

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Tracking the cursor

- ▶ High-density cursor (Baudisch, INTERACT 2003)
- ▶ Spotlight (Khan, UIST 2004)

Target acquisition

- ▶ Drag-and-pop / Drag-and-pick (Baudisch, INTERACT 2003)
- ▶ Vacuum (Bezerianos, CHI 2005)
- ▶ Bubble Cursor (Grossman, CHI 2005)

What other techniques might be feasible? What about 3D input?

Because of these limitations, many researchers have developed enhanced mouse-based techniques for large, high-resolution displays. But these techniques still suffer from a fundamental problem: they tether the user to a fixed position (surface for the mouse). What if the user wants to walk around in front of the display?

Our hypothesis

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3D input can be used to address some of the problems of interaction with large, high-resolution displays, even when interacting with 2D information

- ▶ Cursors based on direct pointing at the display solve the cursor tracking problem
- ▶ Can 3D techniques provide adequate target acquisition?

Research on 3D interaction in VR is relevant to interaction with large displays

We hypothesize that 3D input (based on 6-DOF trackers) can solve some of these problems.

On a higher level, our hypothesis is that our work on 3D interaction in the context of VR is relevant to another (higher-impact?) area. That we can generalize our prior work and apply it to another real-world problem.

A bold hypothesis?

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3DUI Guideline: reduce DOFs to the minimum

3DUI Guideline: match DOFs of the input device to DOFs of the interaction task

We propose to use a 6-DOF device for a 2D pointing task!

We've already seen (in the 3D UIs in a nutshell lecture) some guidelines that indicate this might not be a great idea!

6-DOF input for 2D pointing

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Pros:

- ▶ Can be used when standing, walking
- ▶ Allows absolute and rapid pointing
- ▶ Move closer to increase precision
- ▶ Cursor tracking not an issue

Cons:

- ▶ Can induce fatigue
- ▶ Suffers from jitter
- ▶ Acquisition of small targets may be difficult

But there are some good reasons to use 6-DOF input for 2D pointing, despite the obvious disadvantages.

Baseline 3D technique: ray-casting

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Univ. of British Columbia

Well-known in VR interfaces

Problem: lack of accuracy

Problem: "Heisenberg effect"

The obvious 3D interaction technique to start with is ray-casting. This simply means pointing the input device directly at the object/location you want to select/indicate. On a large display, the "laser pointer" metaphor easily describes this technique.

The problem, as anyone who has seen someone use a laser pointer from far away on a large screen will tell you, is that ray-casting from a great distance is not very accurate, because of hand jitter and because a small movement of the hand results in a large movement of the pointer.

Another problem is that pressing a button to indicate a selection can actually cause the device to move. This has been called the "Heisenberg effect" because it's similar to the idea in physics that one can't observe something without changing it.

Simple improvements to ray-casting

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Low-pass filter

Separate pointing from clicking

But this is still not enough

We can easily improve ray-casting by applying a filter to reduce the noisiness of the data, and by pointing with one device/hand and clicking with another. But in our experience, this is not enough to make ray-casting usable on large, high-resolution displays.

3D techniques for large displays

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Based on the foundation of ray-casting, but addressing its limitations, we designed three novel techniques:

- ▶ ARM ray-casting
- ▶ ZELDA
- ▶ TabletPointing

So we set out to design techniques based on ray-casting, but addressing the accuracy issue.

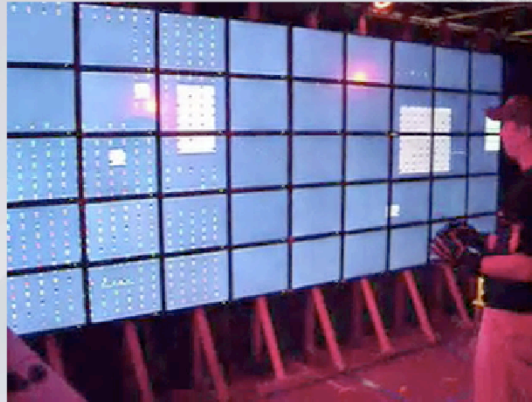
ARM ray-casting

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Absolute and Relative Mapping ray-casting

Default: absolute ray-casting

Toggle to activate relative mapping
(slow down cursor)



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16

The idea of ARM Ray-casting is to allow the user to switch between absolute (standard ray-casting) and relative mappings between the pointing direction and the cursor position. The absolute mapping affords fast, coarse-grained interaction, while the relative mapping provides higher levels of precision. When relative mapping is activated, the current ray-casting intersection point is saved as the relative mapping origin. Any further intersections are then processed as vectors from this origin to prevent the cursor from jumping when relative mapping is activated. By scaling down these vectors by a constant factor, we effectively map standard ray-casting into a smaller defined area of interaction. With our application, we used a scale factor of 10 percent, which reduced the normal area of interaction (16000 pixels by 6000 pixels) to a small area of interaction (1600 pixels by 600 pixels). When relative mapping is deactivated, the cursor jumps back to the correct position for absolute mapping.

ZELDA technique

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Zoom for Enhancing Large Display Acuity

Movable and resizable zoom window to improve precision of selection and manipulation

Non-dominant hand controls zoom window

Dominant hand controls cursor



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17

ZELDA uses a zoom window controlled by ray-casting to provide zooming capabilities. The zoom window displays underlying content – determined by the size of the window – in greater detail, which is based on the zoom factor. For example, with a zoom factor of 5 and a zoom window 1000 pixels by 1000 pixels, an underlying area of 200 pixels by 200 pixels, co-centered with the zoom window, is displayed five times larger than normal within the window. The remaining underlying area is occluded by the zoom window.

With ZELDA, we opted to use a bimanual interface for performing tasks. Many researchers have demonstrated that using the non-dominant hand for coarse tasks can be effective. Therefore, we chose to use the non-dominant hand to control the positioning of the zoom window and the manipulation of its size and zoom factor. We use the dominant hand to control the application cursor and to perform mouse-like interactions.

The scroll wheel on the non-dominant hand's input device is used to zoom in/out or resize the zoom window, depending on the device's orientation relative to the display.

ZELDA video

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TabletPointing technique

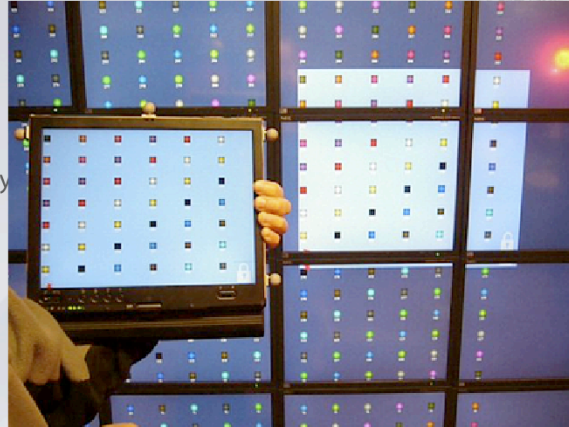
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Point tablet to indicate interaction context

Select and manipulate objects directly on tablet

Freeze context for stability



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19

The TabletPointing technique takes a different approach to improving accuracy of ray-casting. It uses a tracked tabletPC as the input device, and rather than using it to point directly to targets on the large display, it is used to point to an interaction context on the large display. Once the desired context is highlighted, the user can use 2D interaction with the stylus on the tablet to select and manipulate targets.

The user can change the size of the interaction context simply by walking closer (smaller context for more precise work) or farther away (larger context for coarser-grained tasks).

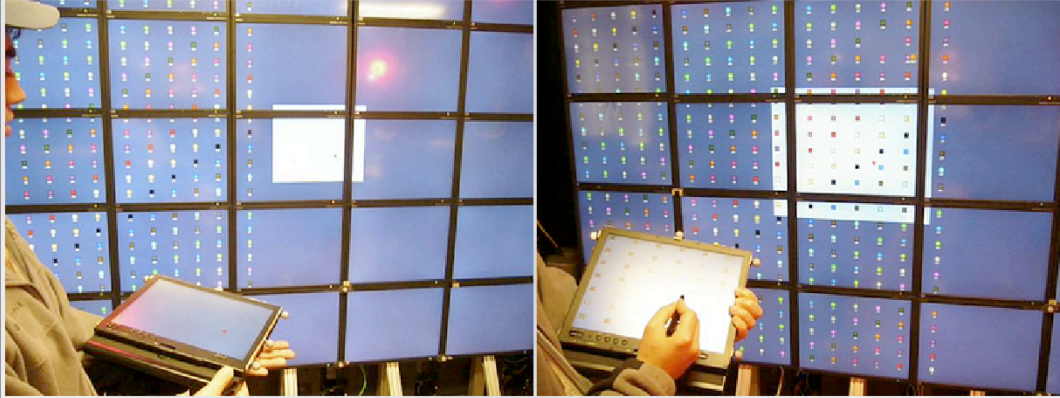
The user can also freeze the interaction context simply by covering one of the tracking markers on the tabletPC with his hand, to allow stable, precise interaction.

Moving an object across the display is easy: the user sets the interaction context, selects the object with the stylus, and then holds the stylus down while pointing the tabletPC at a different area of the large display.

TabletPointing videos

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Preliminary conclusions

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Performance depends on user strategy

Well-designed mouse-based techniques may still provide better performance, but are not conducive to standing & walking

These techniques, based on 3D interaction, are usable, natural, increase precision

At the time that these notes were printed, we were still in the midst of performing evaluations of these techniques, but here are some preliminary conclusions.

First, user strategy is extremely important for determining the usability and performance of these techniques. Thus, we are evaluating different strategies in our evaluations.

Second, these techniques typically don't yet perform quite as well as well-designed mouse-based techniques. But again, the mouse-based techniques don't lend themselves to standing and walking.

Finally, the techniques do meet their goals of being usable and natural. Cursor tracking is never a problem with these techniques because they use absolute pointing. And when high precision is needed, these techniques can achieve that.

When is 3D interaction useful?

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- Users are standing, walking
- No table surface available
- Users are far away
- Users need to indicate/select objects or locations at a distance

- Users have complex spatial navigation needs
- There are many (integrated) dimensions of control

Stepping back from the large display interaction research, we can generalize our experiences to say that 3D interaction may be a reasonable choice when these conditions exist. 3D interaction and 3D UIs are not just for VR and AR.

Lessons learned

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Broaden our definition of “3DUI research” to broaden our impact

- ▶ Look for non-VR applications of 3DUI research
- ▶ Don't unnecessarily constrain research areas or topics

3D UI researchers should not abandon AR and VR, but we should look for other opportunities to apply our expertise such as the example in this lecture. Other areas like this, such as gaming interfaces, are covered elsewhere in this course.

Acknowledgments

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